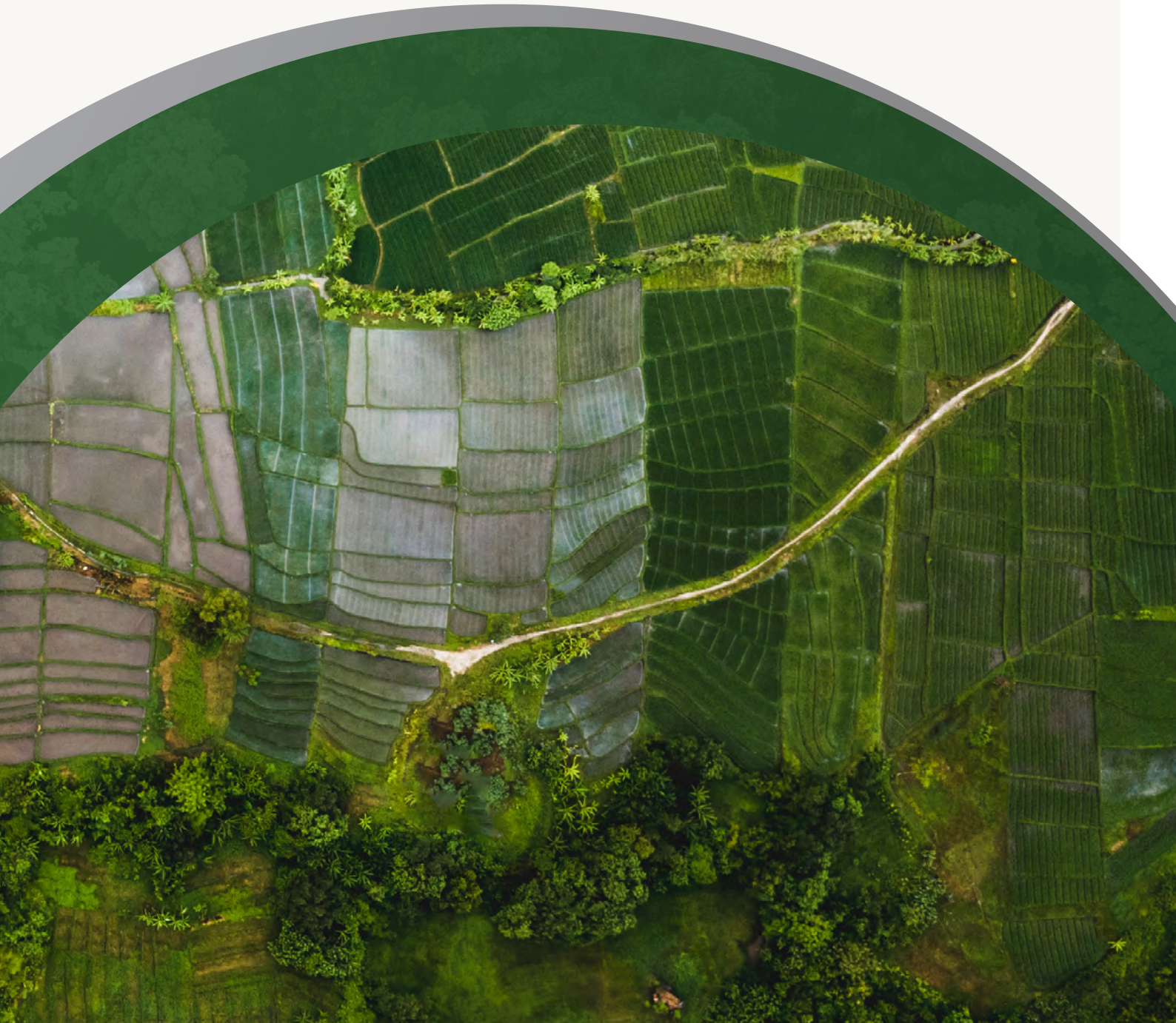
forest management
eo4sd

esa

EO4SD
Forest Management



Introduction to EO4SD

Earth Observation for Sustainable Development (EO4SD) is a European Space Agency (ESA) initiative which aims to support International Finance Institutions and their Client States to harness the benefits of EO in their development operations at national and international level. The final thematic cluster of this initiative is dedicated to Forest Management and complements a set of seven other thematic areas already addressed under the EO4SD initiative.

The EO4SD-Forest Management Cluster has the overall objective of demonstrating the utility and benefits of mainstreaming Satellite Earth Observation (EO)-based products and services for improved Forest Management. EO4SD-Forest Management was launched in September 2020 and will be financed by ESA until 2023.

EO4SD forms the basis for the new Space in Support of International Development Assistance (Space for IDA) follow-up initiative, jointly implemented by ESA, World Bank and Asian Development Bank (ADB), which aims at bringing these efforts to scale and enlarging the long-term ESA-WB/ADB partnership.

For further information on EO4SD-Forest Management see:
www.eo4sd-forest.info

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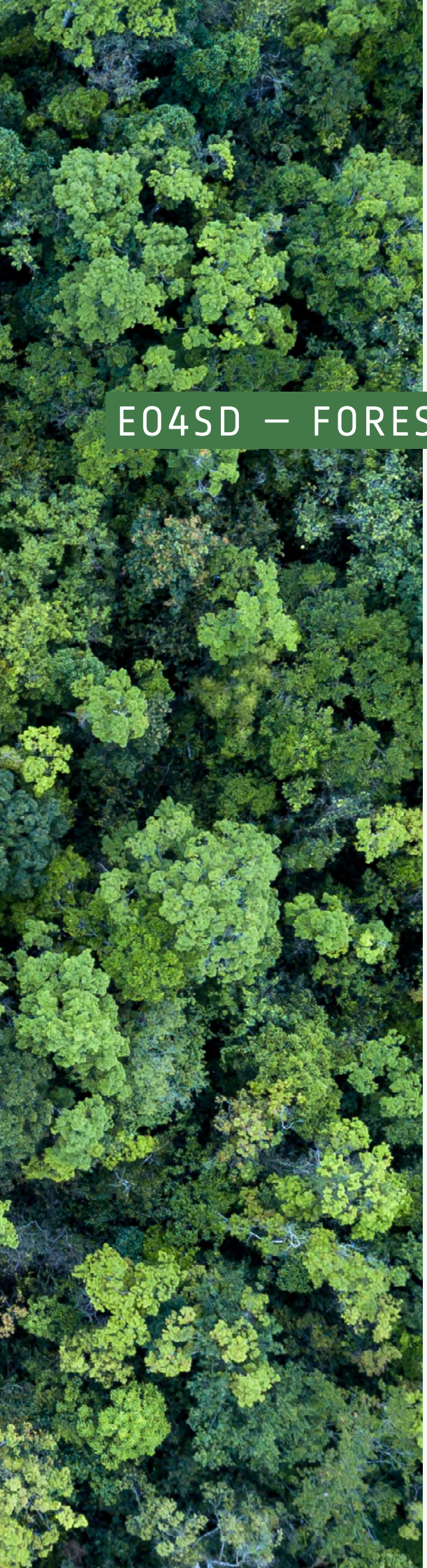


EO4SD – FOREST MANAGEMENT

The use of Earth Observation (EO) data for tropical forest monitoring is not yet operational in many countries. In this context the International Financial Institutions (IFIs) who fund forest management programmes in developing countries have a strong role in facilitating the mainstreaming of the technology in their work practices. The ESA Earth Observation for Sustainable Development (EO4SD) Programme has the overall objective to advance the current status of the EO based information services in the IFIs and Client States (CS) as a standard management tool.

The main objectives of the current project are:

- To provide convincing demonstrations of the benefit and utility of EO-based information in the Forest Management theme
- To develop and provide the EO4SD-Forest Management products and services in specific countries in Latin America, the Middle East and North Africa, South-East Asia and sub-Saharan Africa
- To ensure that the products and services are user-driven
- To generate an operational forest management portfolio offering quality-controlled EO-products
- To facilitate technology transfer via capacity building exercises in the different regions

For further information on EO4SD-Forest Management see:
www.eo4sd-forest.info

Background

Forests have multiple functions and represent an important global resource. They serve as habitats for two thirds of terrestrial animal and plant species, are home to many indigenous people and produce commodities that are fundamental to the global economy and international food system. By absorbing and storing atmospheric carbon, forests are crucial for the global carbon cycle and in the moderation of atmospheric greenhouse gases. They prevent soil erosion and water run-off and can provide the local population with a sustainable livelihood.

The global forestry sector faces many challenges, particularly in developing countries. Rapidly growing human populations require more land for agriculture, whilst demand for commodities such as timber, palm oil and soy are driving both legal and illegal deforestation, habitat and biodiversity loss. The loss of forest also leads to huge carbon emissions and are driving climate change, not to mention depriving forest-dependent communities of their livelihoods. In response to these trends, several international conventions and policy frameworks have been established to support the protection of the world's forested areas. These include the Reducing Emissions from Deforestation and Degradation (REDD+) mechanism developed by parties to the United Nations Convention on Climate Change (UNFCCC), the UN Convention on Biological Diversity (UNCBD) and the UN Sustainable Development Goal (SDG) Framework. Under the SDG Framework, there are two goals – SDG13: Climate Action and SDG15: Life on Land – that seek to minimise greenhouse gas emissions and address forest protection and management.

Forests cover huge and often inaccessible and inhospitable areas, making them difficult to observe and monitor with human teams. However, global commitments and mechanisms as outlined above call for accurate information gathering and monitoring systems to support countries to understand the changes that are taken place in order to take action to address them. Earth Observation (EO) is a cost-effective solution, which provides global, comprehensive, accurate, repeatable and timely information, and is invaluable in the planning and implementation of Forestry Management activities.

Protecting forests in developing countries

Our world's forests – and the people whose livelihoods depend on them – are facing myriad challenges. These challenges are economic, environmental and social in nature and have repercussions at a local, national and global scale.

Forests are vital as carbon sinks in regulating the global climate and are needed if the world is to avert catastrophic climate change. As deforestation and degradation rates accelerate, carbon emissions increase and there is a loss of biodiversity and disruption of the delicate balance of the natural ecosystem. Approximately 5% of tropical forest grows on peat, which stores up to 10 times more carbon than the forest which grows upon it. Clearing these forests is causing huge carbon emissions, increasing fire risk and deteriorating the local air quality. The rate of deforestation is not slowly – in 2020 alone, over 42,000 sq km of tree cover was lost – the third worst year since monitoring began.

The loss of forests also has an impact on economic livelihoods within communities and, in the case of illegal logging, on lost tax revenues for governments. Governments, the UN agencies and donors have identified the need to support and educate communities on sustainable forest management including the collection and selling of non-timber forest products (NTFPs), reforestation, diversification of community income sources and the monitoring and protection of forested areas from illegal logging.

Credit: ESA

The case for space

Whilst satellites capable of imaging forests have been in orbit for decades, the sector is currently undergoing a revolution. There is a profusion of satellites imaging the earth's surface with radar and optical sensors operating at a range of temporal and spatial resolutions, providing a huge increase in EO data. Crucially, some of the new data is being provided free of charge, for example from the European Space Agency's (ESA) Sentinel satellites.

Furthermore, there is a parallel revolution in computing and data science allowing for software to automatically process EO data to extract patterns and insights. A rapidly growing ecosystem of space analytics companies are applying technologies such as artificial intelligence, machine learning and cloud computing, to develop management solutions and decision tools for the forestry sector.

As costs fall and analytical products and platforms mature, space solutions will increasingly provide the opportunity to simultaneously tackle some of the world's largest environmental problems and improve sustainability and margins in the forestry sector.

Whilst there is a great deal of interest in achieving this in the public sector, there is also growing interest in the private sector. Automated and practical decision-support tools can be used to demonstrate adherence to environmental legislation, reduce costs, assess and value land use and improve bottom lines for private business. This will improve commercial sustainability for technology providers, supporting them to diversify away from an historical dependence on the public sector-backed financial support.

The data and products derived from EO satellites have many advantages for forestry purposes:

- **Coverage and quality**: Satellites have regular revisit times which enable consistent observations and make it possible to monitor forests at any geographic scale in an accurate and repeatable way.

- **Range**: Satellite sensors are able to provide information on a number of forest properties including canopy cover, biomass, forest health and productivity. When data is collected over a time series, these products can also detect levels of deforestation and – to a lesser extent – degradation.

- **Analysis-ready data**: Satellite data services can organise and process data to defined industry standards and offer the data in a format that allows for value-addition and analysis. There are standardised tools that allow forest properties to be derived automatically and presented in a format that is compatible with geographic information systems (GIS) or easily-interpretable maps, spreadsheets, graphs or dashboards.

- **Remoteness:** Data collection using satellites is not only faster than on-the-ground data collection, but also safer and more cost-effective, especially when dealing with remote areas or fragile or conflict-affected regions.

- **Speed**: Increasingly, data can be available days or even hours after it is acquired so that users can act quickly on the information that they receive. This is particularly useful when rapid management responses are needed, e.g. to address illegal forest clearances or tackle forest fires.

How can EO help?

The capabilities offered by Earth Observation information predominantly fall into three categories:

ACTIVE MONITORING SYSTEMS

Population growth and a rising demand for food has led to a rapid expansion of agriculture. Agriculture is now the driver of 80% of deforestation worldwide[1] with commodities including cattle and crops like soy and oil palm collectively referred to as High Deforestation Risk Commodities (HDRCs). To produce these commodities, forest is cleared and converted into fields, even within protected areas where there is insufficient enforcement.[2] The low intensity of much of the developing country agriculture means that domestic small-scale agriculture is often associated with forest degradation, rather than wholesale clearance of forest. Forest degradation probably affects a larger total area than deforestation. This is important, since forest degradation causes large carbon emissions and the remaining degraded forests experience an increased risk of fire and exhibit lower levels of biodiversity.

After agriculture, extractive industries such as mining and logging provide income for developing country governments but are also causing deforestation and forest degradation. Many forests in tropical countries grow on very thin soils, meaning that these processes of deforestation and forest degradation are followed by soil erosion, particularly in areas with steep terrain and heavy rainfall. This reduces the capacity of a forest to regenerate, or for land to be put to other use such as agriculture. The problem is exacerbated when the remaining vegetation is burned to clear the land, since fire can damage the seedbank, which reduces climate resilience. All of these processes reduce biodiversity, release carbon and drive climate change, and further impoverish forest-dependent communities.

There is a very clear and pressing need to be able to monitor and reduce deforestation and forest degradation. Yet developing country forests are typically vast and remote, meaning that poorly-funded ground-based teams can only patrol very small areas. By contrast the new generation of space solutions provide the ability to monitor deforestation and forest degradation, repeatedly, at a landscape scale with relatively low cost. Early warning systems can flag deforestation hotspots to managers, enabling emergency responses where deforestation is illegal or unplanned. Given sufficient data, deforestation can be modelled to identify high-risk areas where more resources should be spent, thereby enabling users to direct their management efforts. Longer term reporting data on forest management performance allows countries to participate in climate change mitigation programmes such as REDD+.

1 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/65505/6316-drivers-deforestation-report.pdf

2 Collins & Mitchard. 2017. *Scientific Reports* https://www.nature.com/articles/srep41902

MAPPING SYSTEMS

The vegetation in tropical countries is highly diverse. Policy makers, companies, non-governmental organisations and civil society wish to know how the vegetation varies across the landscape, how it changes over time and what the implications are for the volume of carbon emitted per hectare. By mapping different land uses and forest types, it is now possible to quantify what carbon, biodiversity and other ecosystem services are present in the landscape.

The standard method for quantifying such forest characteristics is a National Forest Inventory (NFI) based on sample plots. From these plots it is possible to differentiate forest types, based on dominant tree species, and to estimate above-ground biomass. Yet for logistical and financial reasons it is only possible to sample a very small proportion of any landscape with plots; it may take an experienced team up to a week to set up a single one-hectare plot in tropical forest. However, these sample plots can be combined with satellite data to allow huge upscaling of surveys in a way previously not possible. There are known relationships between forest patch size; forest connectivity; and biodiversity value. Hence space solutions can now provide maps of tree canopy coverage, biodiversity and ecosystem type and provide data for models about how these could change under disturbance or climate change.[3]

3 Urban et al 2016. *Science*. https://doi.org/10.1126/science.aad8466

DECISION SUPPORT TOOLS

Commercial forest management is changing rapidly. With a finite area of cultivable land, there is increased demand to improve yields and sustainability; improve fire management; and reduce costs. "Precision forestry" provides an opportunity to do this through the application of modern electronics, computers, and sensors to support site-specific operational decision-making. In the context of a changing climate, fire risk monitoring is an increasingly important aspect of precision forestry.

Multiple satellites systems can now map fire hotspots, and new solutions can rapidly deliver this data to forest managers. Further, by integrating auxiliary data, space solutions can map out future fire risk, allowing managers to better decide where to dedicate fire-fighting resources; and how to plan for future landscapes.

In terms of more standard management activities, tree crop harvesting often depends on a crop reaching a threshold height. Space solutions can now estimate forest height, and changes in that height. This can support managers in scheduling spatially-explicit thinning and pruning operations. Maps that illustrate spatial variation in forest attributes, e.g. growing volume and grade, provide detail of the forest resource supporting accurate harvest planning. Finally, mapping out productivity with remote sensing data can support managers' decision-making on planting over and above what is possible with field-level measurements.

EO4SD-FOREST MANAGEMENT GLOBAL THEMES

The EO4SD-Forest Management Cluster will develop a number of EO products in response to the stated requirements of IFI and Client State partners running forestry programmes. These products will cut across seven global themes as listed below.

REDD+

At the UNFCCC Conference of Parties in Montreal 2005, a group of tropical countries initiated a process to address the issue of reducing emissions from deforestation and degradation (REDD+), which has subsequently been embedded in the Paris Agreement. An estimated 80% of the global above-ground carbon stocks and 40% below-ground carbon stocks are stored in forests. Currently deforestation is the second highest driver of greenhouse gas emissions contributing an estimated 15% of global emissions. As such it is a priority to slow down the rate of deforestation and degradation of forests in order to effectively tackle the issue of climate change. The REDD+ policy process requires countries to have operational National Forest Monitoring Systems (NFMS) and Measuring, Reporting and Verification (MRV) systems. The role of Earth Observation (EO) in NFMS and MRV is well-established but many countries still face technical and resource challenges in implementing these programmes.

The EO4SD-Forest Management cluster provides solutions to the development of operational MRV systems, deforestation, degradation and land use change assessments and biomass mapping. These products allow for the tracking of relevant forest and carbon stock changes in a spatially explicit manner and can feed into national GHG estimation and reporting. The suite of geo-spatial products can be used for monitoring both tropical humid and dry forests globally.

SUSTAINABLE FOREST MANAGEMENT

Sustainable Forest Management (SFM) is a core pillar of Forest Management activities and ties into all other forest-related thematic areas. It calls for a balance between the resource needs of society and the preservation of forest ecosystems and biodiversity. SFM covers seven common thematic areas including: extent of forest resources, biological diversity, forest health and vitality, productive functions of forest resources, protective functions of forest resources, socio-economic functions, and legal and policy frameworks. These seven areas can be summarised into three primary pillars; Social, Environmental and Economic. The key challenge for many governments is the balance of all three pillars. Assessing progress on SFM is relevant as part of the '+' in REDD+, and for the Sustainable Development Goals (SDGs), along with other national objectives such as ensuring protected areas are functioning sustainably.

The E04SD-Forest Management cluster provides the geospatial data which can support SFM monitoring objectives. This data can identify forest changes, track logging activities and its effects on degradation and biomass, and monitor forest health and vitality as well as the productive function of the forest resources. Currently a number of global forest change and biomass products are available, however using these global products for national or subnational monitoring remains a challenge due to a lack of calibration of the global products to local contexts and applications. Integrating ground plot and logging data can be a useful approach to enable wall-to-wall mapping of forest disturbances and of biomass resources using locally calibrated earth observation datasets. This approach will be demonstrated as part of the project activities.

COASTAL ECOSYSTEMS AND MANGROVES

With a rise in the risk of coastal flooding, hurricanes and cyclones, mangrove ecosystems have been identified as one of the best natural protections for coastal communities and ecosystems in tropical and subtropical regions. Not only do they act as natural buffers against storm surges, they also play a vital role in carbon sequestration and, along with the other coastal ecosystems, provide coastal communities with many opportunities for sustainable livelihoods. Coastal ecosystems and mangroves are under threat globally from increased deforestation for timber, urban development, aquaculture farming, and pressure from a changing climate. Loss of mangrove habitat and other coastal ecosystems increases the risk of flooding and coastal abrasion, seawater intrusion, and negatively impacts biodiversity and coastal communities' livelihoods. Monitoring mangrove ecosystems to prevent further degradation or loss and to assist with conservation and restoration initiatives is a priority.

The E04SD-Forest Management cluster provides countries with geospatial products and services supporting mangrove protection and restoration activities, including mangrove extent mapping, mangrove deterioration and loss assessment, and monitoring of mangrove health and recovery.

FOREST LANDSCAPE RESTORATION/ FOREST RESTORATION

In 2011, the Government of Germany in partnership with the International Union for Conservation of Nature (IUCN) and supported by the Global Partnership on Forest Landscape Restoration (GPFLR) launched the Bonn Challenge. The Bonn Challenge calls for the restoration of 150 million hectares of degraded and deforested land by 2020, rising to 350 million hectares by 2030. These efforts might include reforestation, afforestation or agroforestry. Forest Landscape Restoration can be defined as a process that aims to regain ecological functionality and enhance human wellbeing in deforested or degraded landscapes.[4] By 2025, World Bank funding will aim to deliver support to the integrated landscape management approach for avoiding deforestation and promoting landscape restoration or sustainable forest management for 120 million hectares of forests in 50 countries.[5] FLR also goes hand in hand with many governments' focus on Protected Areas and Community Forestry, and such synergies are important for the overall rehabilitation of degraded areas.

Earth Observation (EO) has the unique capability of providing historical and current land use maps as well as reforestation and afforestation assessments across large areas. Thus, the EO4SD-Forest Management geospatial products can be used for supporting Forest Landscape Restoration and Forest Restoration projects.

PROTECTED AREAS

A protected area is a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values.[6] Protected Areas (PA) include national parks, wilderness areas, community areas and nature reserves, which have different degrees of management. Additionally, countries define PAs according to national requirements, their conservation objectives and the IUCN protected areas categories.

A major challenge in many developing countries is the land use conflicts around and within these PAs. Many PAs are surrounded by local populations who are in need of resources, which impinge on the conservation aims of these reserves; additionally agricultural expansion around the PAs result in encroachment of these areas. Thus, governments require monitoring of the overall PAs, their forest ecosystems and biodiversity to improve the management of these areas. They also need support in the assessment of high conservation value (HCV) ecosystems to aid planning and zoning of these areas, to enhance their coverage.

4 The Global Partnership on Forestry and Landscape Restoration. 'What is FLR?'. www.forestlandscaperestoration.org/what-is-flr/

5 Convention on Biological Diversity. 'World Bank Group and International Monetary Fund'. www.cbd.int/financial/wb.shtml

6 International Union for Conservation of Nature. 'About'. www.iucn.org/theme/protected-areas/about

COMMUNITY BASED FOREST MONITORING/ MANAGEMENT

Forest ecosystems across the world are under pressure from population growth. In many developing countries, local communities rely on forest resources almost entirely for their daily subsistence. Ever-increasing pressure from human populations will at some point outpace the forest's natural regeneration cycle, leading not only to the degradation and eventual collapse of the ecosystem, but also to the loss of the community's primary lifeline. Governments, the UN agencies and donors have identified the need to support and educate communities on sustainable forest management including the collection and selling of non-timber forest products (NTFPs), reforestation, diversification of community income sources and the monitoring and protection of forested areas from illegal logging.

The EO4SD-Forest Management cluster provides geospatial information, which can support the assessment of deforestation/ degradation and land use change in these areas.

EO4SD-Forest Management Products

EO4SD-Forestry Management products can be thought of as building blocks that can be used alone or in combination to address the information needs of a specific forestry challenge. Some products will be used more commonly as the 'baseline' information for further analysis, while other products will only be required to address more specific forest information needs.

- **Forest Area and Change**
- **Global Biomass**
- **Intact/ Non-Intact Forest and Change**
- **Land Use/ Land Cover and Change**
- **Mangrove Area, Change and Recovery**
- **Near Real Time (NRT) Canopy Disturbance**
- **Tree Cover Density and Tree Cover Change**

FOREST AREA AND CHANGE

These products form the basis for determining gross deforestation rates and for the detection of forest regrowth or replanting. They are used as the benchmark for deforestation/ disturbance detection by early warning systems.

The **Forest Area and Change** products can also be used as inputs for:

- Assessment of Activity Data for REDD+
- Analysis of Degradation and Deforestation
- Sustainable Forest Management (SFM)
- Forest Landscape Restoration (FLR)
- Identification of High Carbon Stock (HCS) forests
- Forest management/ planning
- Input variable to spatially explicit modelling of forest biomass and change

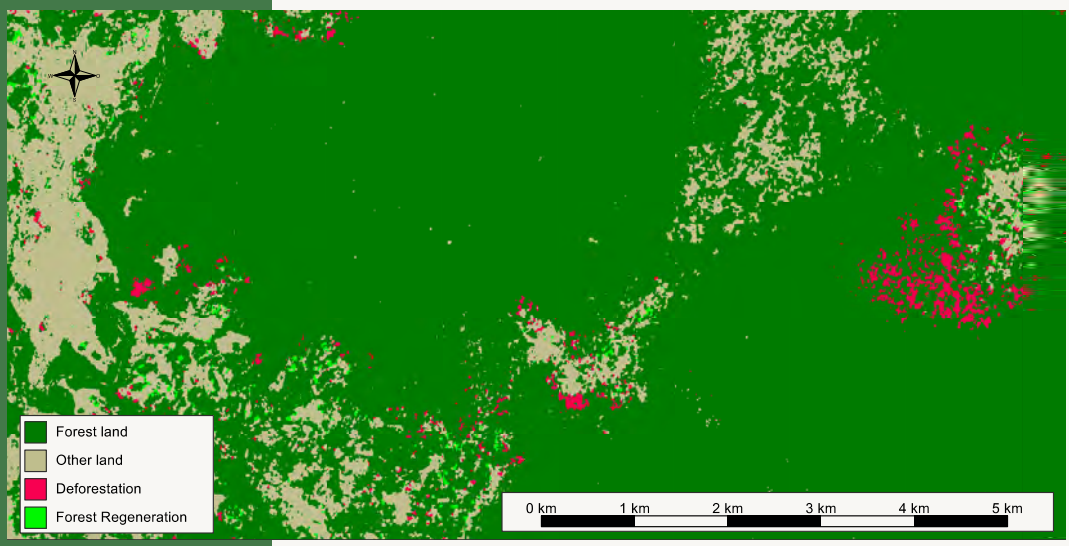
There are two related capabilities:

- The **Forest Area Status** shows the extent of the forest at a given point in time. This product takes into account country-specific forest definitions, such as the minimum area of a forest patch and minimum canopy cover density. All forest types are consolidated into a single 'forest' category; other land cover types are aggregated into a 'non-forest' category. The **Forest Area Status** product is derived from high resolution (HR) satellite data.
- The corresponding **Forest Change** product is derived by a direct time series image classification approach to identify stable and non-stable forest areas.

The products have many applications in forest management, forest restoration, REDD+ and land-use planning as it offers an accurate calculation of the spatial extent and location of forested areas and changes within those areas.

The image example below shows an example of Forest Change mapping at 10m spatial resolution. The analysis of forest cover in 2017 and 2020 revealed small-scale deforestation events around existing agriculture. The study was conducted in Ethiopia within the EO4SD-FM project.

Forest Change Showing Areas of Deforestation and Regeneration
(Credit: GAF)



GEOGRAPHICAL COVERAGE

Regional

National

Sub-national

Local

TEMPORAL COVERAGE AND FREQUENCY

Historical data and/or specific dates

Continuous update is possible (e.g. every 12 months, every 5 years), depending on availability of satellite data

EO DATA AND SPATIAL RESOLUTION

High resolution (HR) satellite data (e.g. Sentinel-1 and Sentinel-2) with 10m resolution from 2016 onwards

Historic Landsat data with 30m resolution from around 1990

ACCURACY LEVEL

Status products: >90%

Change products: >80%

Positional accuracy: <1 pixel of source imagery

Product Specifications

- **Detailed mapping of forested areas by incorporating a national- or user-defined forest definition. The product is based on a forest mask, a forest canopy cover density map and additional data to separate 'forest' land use from other land use classes.**
- **Changes can be mapped between two or more points in time, showing increase and decrease of tree cover density in percent in a landscape using discrete classes ranging from 1–100%.**

Product delivery:

- Geodata in GeoTIFF, ASCIL or similar
- With metadata (INSPIRE or ISO)
- As cartographic products in .pdf, .png or similar

Derived maps and information – available formats:

- USB, hard drive
- Download from dedicated password-protected FTP server or cloud platform
- Viewed online through password-protected web portal (Open Geospatial Consortium (OGC) compliant)

Support available:

- Quality Management Systems cover non-conformance issues, timely corrective actions and supporting services relating to reliability, flexibility and timely delivery of services. All quality relevant information and quality checks are documented and cover:
  - → Compliance of output with user requirements
  - → Completeness
  - → Thematic accuracy
  - → Thematic completeness
  - → Positional accuracy and product utility
- Tailored training can be provided on product use and integration for further geospatial analysis

GLOBAL BIOMASS

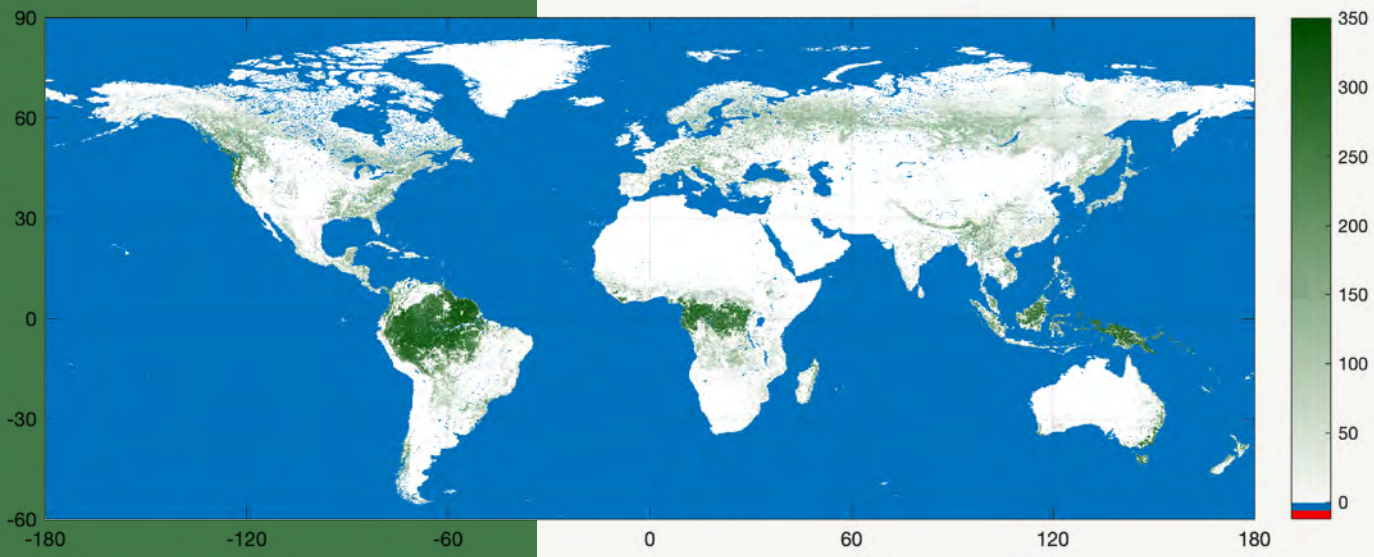
The **Global Biomass** product can also be used as an input for:

- Assessment of Activity Data for REDD+
- Sustainable Forest Management (SFM)
- Forest Landscape Restoration (FLR)
- Forest management/ planning
- Mangrove Monitoring

This product supports the quantification of **Global Biomass**, which can be used to identify degradation and forest loss for REDD+ and other forest monitoring purposes.

By combining a biomass map with a dynamic forest change map, rather than a static forest area map, it is possible to understand the change in biomass over time. Biomass maps can be used to derive emission factor (EF) information resulting from changes in land use (where land use/ land cover information is available) and can be used in reporting for a number of mechanisms. Areas of high carbon stock, and potential emission hotspots (if deforestation were to occur) can also be identified.

Global Above Ground Biomass Estimates 2017 (tonnes/hectare)
(Credit: ESA Climate Change Initiative (CCI))



GEOGRAPHICAL COVERAGE

Global

Regional

National

Sub-national

Wall-to-wall global products available for several time periods

TEMPORAL COVERAGE AND FREQUENCY

Three time periods are currently available: 2010, 2017 and 2018

EO DATA AND SPATIAL RESOLUTION

Sentinel-1 and ALOS-2 PALSAR-2 data (inputs)

SCANSAR data, ICESAT data and Moderate Resolution Imaging Spectroradiometer (MODIS) Vegetation Continuous Fields (VCF) or MOD444B for map production

ACCURACY LEVEL

Global AGB map tends to over-estimate biomass at low biomass ranges (50–100 tonnes per hectare) and under-estimate at high biomass ranges (> 250 tonnes per hectare)

Between 50 and 300 tonnes per hectare, mean differences between the map and reference dataset are well within 20% of the map values

Per pixel error values expressed as standard error are provided

Positional accuracy needs to be validated at a national level

Product Specifications

- **A global terrestrial biomass map of 100m resolution was produced for 2010, 2017 and 2018.**

Product delivery:

- OGC compliant service (e.g. WMS, WFS)
- Geodata in NetCDF-4, GeoTIFF, ASCII or similar
- With metadata (INSPIRE or ISO)
- As cartographic products in .pdf, .png or similar

Regionally tuned biomass maps and information available:

- USB, hard drive
- Download from dedicated password-protected ftp server or cloud platform
- Viewed online through password-protected web portal (Open Geospatial Consortium (OGC) compliant. The web portal can be customised to include various online analysis options, time series plots, statistical plots and to integrate user-defined datasets

Support available:

- Quality Management Systems cover non-conformance issues, timely corrective actions and supporting services relating to reliability, flexibility and timely delivery of services. All quality relevant information and quality checks are documented and cover:
  - → Compliance of output with user requirements,
  - → Completeness
  - → Thematic accuracy
  - → Thematic completeness
  - → Positional accuracy
  - → Product utility
- Tailored training can be provided on product use and integration for further geospatial analysis

INTACT/ NON-INTACT FOREST STATUS

The **Intact/ Non-Intact Forest Status** product can also be used as an input for:

- Assessment of Activity Data for REDD+
- Analysis of Degradation and Deforestation
- Sustainable Forest Management (SFM)
- Planning of Forest Landscape Restoration (FLR)
- Community-based REDD+
- Identification of High Carbon Stock (HCS) forests

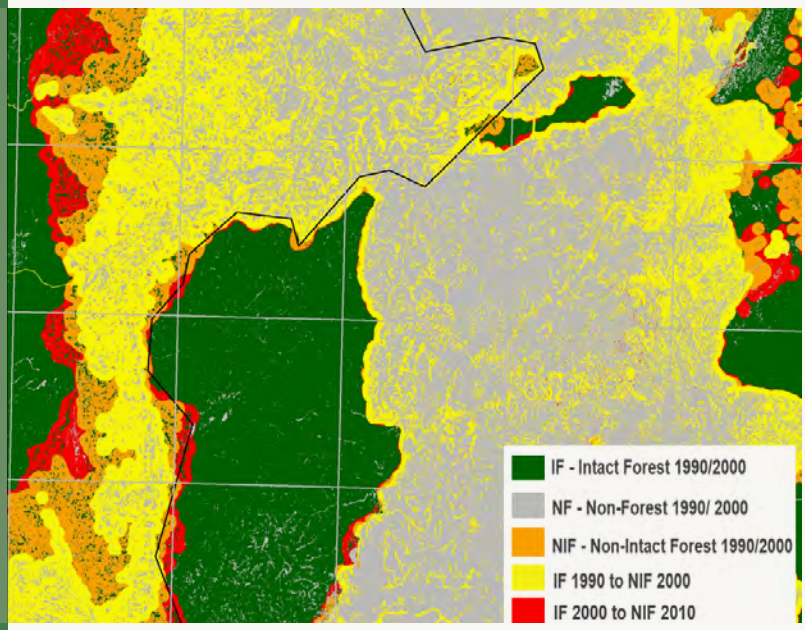
This product shows fully-stocked and degraded forest areas at a given point in time.

The **Intact/ Non-Intact Forest Status** is derived through an indirect approach where land use/cover classification results from high resolution satellite data and ancillary data (e.g. roads, waterways, settlements, etc.) are assessed through geospatial analyses within a Geographic Information System (GIS). EO-based forest cover maps or land use/ land cover maps from different years (usually at the beginning and the end of a reporting period) can be classified into intact and non-intact forest areas as input for Emission Factor (EF) assessments.

Intact forest is fully-stocked, which means that the forest has tree cover between the minimum percentage that is required to be defined as 'forest' (e.g. 10%) and complete coverage (100%). An intact forest must be undisturbed, i.e. there has been no timber extraction.

Non-intact forest is not fully-stocked but tree cover must still be above the minimum tree cover percentage threshold of the applied forest definition (e.g. 10%) to qualify as 'forest'. A non-intact forest has undergone some level of exploitation or canopy degradation. The Emission Factor (EF) assessment in these two classifications can most efficiently be implemented through terrestrial sample inventories. The difference in carbon stock per hectare between the two classifications will be the emission factor for the degradation change area between two different years.

Showing Time Series of Intact Forest (Credit: GAF)



In the context of REDD+ the estimation of forest **degradation** caused by anthropogenic activities over a given time period can be represented by a decrease in canopy cover that does not qualify as deforestation. The main causes of forest degradation are usually exploitation of fuel wood, subsistence agriculture, fire, selective exploitation of commercial wood, etc. Monitoring degradation-related changes using EO methods is complex as this generally entails relatively dynamic processes as opposed to permanent land use changes.

In woodland or dry forest ecosystems, the changes in forest canopy cover will only be apparent in satellite images when they are not small and when they produce systematic patterns in the imagery. Therefore, a time series of terrestrial inventories, combined with a forest area change mapping would be the optimal tool to properly identify and quantify changes in forested area and related carbon stock.

GEOGRAPHICAL COVERAGE

Regional

National

Sub-national

Local

TEMPORAL COVERAGE AND FREQUENCY

Historical data and/or specific dates (e.g. 2010) can be used

Continuous update is possible (e.g. every 12 months, 5 years), depending on availability of satellite data

EO DATA AND SPATIAL RESOLUTION

High resolution (HR) satellite data e.g. Sentinel-2 with 10m resolution

Historic Landsat data with 30m resolution

ACCURACY LEVEL

Overall thematic accuracy: Not applicable

Positional accuracy: <1 pixel of source imagery

Product Specifications

- **Detailed mapping of intact and non-intact forest within a forested area. This can be based on the input of a forest land and non-forest land product or on a detailed land-use/ land cover product with multiple classifications such as forestland, cropland, grassland, wetland, settlement (status product).**
- **Mapping showing changes of intact to non-intact forest and of non-intact forest to intact forest over a period of time (change product).**

Product delivery:

- Geodata in NetCDF-4, GeoTIFF, ASCII or similar
- With metadata (INSPIRE or ISO)
- As cartographic products in .pdf, .png or similar

Derived maps and information – available formats:

- USB, hard disc
- Download from dedicated password-protected FTP server or cloud platform
- Viewed online through password-protected web portal Open Geospatial Consortium (OGC) compliant. The web portal can be customised to include various online analysis options, time series plots, statistical plots and to integrate user-defined datasets.

Support available:

- Quality Management Systems cover non-conformance issues, timely corrective actions and supporting services relating to reliability, flexibility and timely delivery of services. All quality relevant information and quality checks are documented and cover:
  - → Compliance of output with user requirements,
  - → Completeness
  - → Thematic accuracy
  - → Thematic completeness
  - → Positional accuracy
  - → Product utility
- Tailored training can be provided on product use and integration for further geospatial analysis

LAND USE/ LAND COVER AND CHANGE

The **Land Use/ Land Cover and Change (LULCC)** products enable an accurate assessment of forest extent, loss and gain, and to identify areas of deforestation. They can also be used in combination with Emission Factors (EF) to assess the greenhouse gas (GHG) emissions associated with land and forest change:

- Assessment of Activity Data for REDD+
- Analysis of Degradation and Deforestation
- Sustainable Forest Management (SFM)
- Forest Management/ Planning
- Planning of Forest Landscape Restoration (FLR)

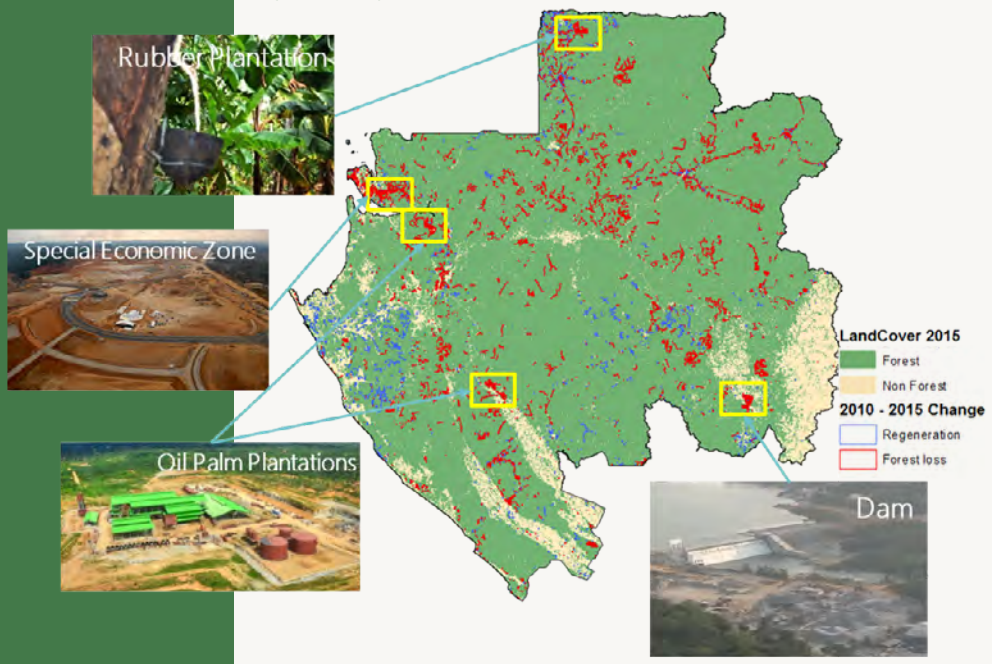
These products presents the status of, and changes in, land use and land cover. The information is derived from high resolution (HR) satellite data of a spatial resolution between five and thirty meters.

The **Land Use/ Land Cover Status** product uses a (hierarchical) land use/ land cover classification scheme, where land cover and/or functional use of land is presented at a granularity level that matches that of the satellite data.

The **Land Use/ Land Cover and Change (LULCC)** product shows the conversion of land use/ land cover from one class to another between two points in time. The classification scheme for a status and a change product can be adapted to user requirements.

Land use/ land cover and change maps provide fundamental base information for a wide variety of forest monitoring and spatial planning tasks.

Gabon Forest Cover 2015 and Change from 2010 to 2015
(Credit: CLS)



GEOGRAPHICAL COVERAGE

Regional

National

Sub-national

Local

TEMPORAL COVERAGE AND FREQUENCY

Historical data and/or specific dates (e.g. 2010) can be used

Continuous update is possible (e.g. every 12 months, 5 years), depending on availability of satellite data

EO DATA AND SPATIAL RESOLUTION

High resolution (HR) satellite data e.g. Sentinel-2 with 10m resolution

Historic Landsat data with 30m resolution

ACCURACY LEVEL

Overall thematic accuracy: > 85% to 90%

Positional accuracy: <1 pixel of source imagery

Product Specifications

- **Detailed mapping of land use/ land cover into classes such as forest land, crop land, grassland, wetland, settlement.**
- **Changes can be mapped between two or more points in time, showing changes from one type of land use to any other type of land use, or vice versa.**

Product delivery:

- Geodata in NetCDF-4, GeoTIFF, ASCII or similar
- With metadata (INSPIRE or ISO)
- As cartographic products in .pdf, .png or similar

Derived maps and information – available formats:

- USB, hard drive
- Download from dedicated password-protected FTP server or cloud platform
- Viewed online through password-protected web portal (Open Geospatial Consortium (OGC) compliant. The web portal can be customised to include various online analysis options, time series plots, statistical plots and to integrate user-defined datasets

Support available:

- Quality Management Systems cover non-conformance issues, timely corrective actions and supporting services relating to reliability, flexibility and timely delivery of services. All quality relevant information and quality checks are documented and cover:
  - → Compliance of output with user requirements
  - → Completeness
  - → Thematic accuracy
  - → Thematic completeness
  - → Positional accuracy
  - → Product utility
- Tailored training can be provided on product use and integration for further geospatial analysis

MANGROVE AREA, CHANGE AND RECOVERY

Mangrove Area, Change and Recovery information generated could be used to inform coastal and marine spatial planning and blue economy processes through multi-criteria spatial analysis in GIS, particularly to balance the multiple competing uses of coastal regions.

The mangrove products can also be used as an input for:

- Assessment of Activity Data for REDD+
- Analysis of Degradation and Deforestation
- Identification of High Carbon Stock (HCS) forests
- Forest management/ planning
- Input variable to spatially explicit modelling of forest biomass and change

Mangrove assessment comprises of three related products which are used to determine important biophysical characteristics of mangrove and their change over time:

- **Mangrove Area** – shows the extent of the mangrove and a classification by species type. The classification approach consists of a machine learning algorithm combining high resolution (HR) radar, optical imagery and in-situ data to discern different mangrove types.
- **Mangrove Change** – shows the loss, gain or preservation of mangrove within a defined area and is derived from a combination of mangrove maps over several consecutive years and spectral trend information. Additional parameters that can be derived include canopy closure, timing of mangrove loss, and median patch loss area.
- **Mangrove Recovery** – begins with analysis to help prioritise areas for mangrove restoration, integrating information on coastline change, sea level, and existing mangrove extent and condition. Monitoring the mangrove using a time-series of high resolution optical imagery informs the success of restoration efforts. Innovative analysis can estimate time-to-recovery using undisturbed and recovered mangrove templates as a reference point.

Mangrove forests are an important component of coastal ecosystems and the products can be integrated into a landscape approach, contributing to blue economy planning and management of coastal land use for aquaculture, tourism, and communities and infrastructure.

Accurate mapping of mangrove extent, type, and other biophysical characteristics support the management, protection, and restoration of mangroves to maintain the ecosystem services they provide. When investments are made in mangrove restoration, the performance of those investments can be monitored. Recovery assessment will enable the success of ongoing mangrove rehabilitation activities to be quantified, and facilitates improved understanding of recovery trends after natural and anthropogenic disturbances and from longer-term climatic effects.

GEOGRAPHICAL COVERAGE

Regional

National

Sub-national

Local

TEMPORAL COVERAGE AND FREQUENCY

Historical data and/or specific dates

Continuous update is possible (e.g. every 12 months, every 5 years), depending on availability of satellite data

EO DATA AND SPATIAL RESOLUTION

High resolution (HR) satellite data (e.g. Sentinel-1 and Sentinel-2) with 10m resolution

Landsat data with 30m resolution

ACCURACY LEVEL

Overall thematic accuracy: >90% for mangrove area mapping

Positional accuracy: <1 pixel of source imagery

Product Specifications

- **Detailed mapping of mangrove extent, type, canopy cover, and other biophysical characteristics and how they change over time. Changes can be characterised within a single year or over multiple consecutive years.**
- **Identification of priority sites for mangrove restoration and monitoring of mangrove recovery trajectory to support mangrove restoration and recovery assessment.**

Product delivery:

- Geodata in GeoTIFF, ASCIL or similar
- With metadata (INSPIRE or ISO)
- As cartographic products in .pdf, .png or similar

Derived maps and information – available formats:

- USB, hard drive
- Download from dedicated password-protected FTP server or cloud platform
- Viewed online through password-protected web portal (Open Geospatial Consortium (OGC) compliant)

Support available:

- Quality Management Systems cover non-conformance issues, timely corrective actions and supporting services relating to reliability, flexibility and timely delivery of services. All quality relevant information and quality checks are documented and cover:
  - → Compliance of output with user requirements
  - → Completeness
  - → Thematic accuracy
  - → Thematic completeness
  - → Positional accuracy and product utility
- Tailored training can be provided on product use and integration for further geospatial analysis

NEAR REAL-TIME (NRT) CANOPY DISTURBANCE

The **Near Real-Time Canopy Disturbance** service can also be used as an input for:

- Assessment of Activity Data for REDD+
- Analysis of Degradation and Deforestation
- Sustainable Forest Management (SFM)
- Forest Landscape Restoration (FLR)
- Forest management/ planning
- Mangrove monitoring

This product identifies new forest canopy disturbances on a high temporal frequency basis. A **Near Real Time (NRT) Forest Monitoring System** is continuously running and Earth Observation (EO) data is processed as soon as it is available, meaning that the system is activated and updated by each newly-acquired EO data set. The type of EO sensors used in the processing chain and their individual repeat pass intervals define the possible frequency of updates to the service.

Detected forest disturbances are mapped and provided by a web mapping service (WMS) or ingested into a user-defined database. Forest canopy disturbances are then monitored over time and classified according to their permanence and size as either “deforestation” (permanent and exceeding a minimum size) or “forest degradation” (non-permanent, or below a minimum size).

A NRT system brings the advantage of timely information on the location and intensity of forest canopy disturbances. The sensitivity of such a system can be adapted to the user needs by defining thresholds and the number of consecutive change events for each pixel location before publishing an alert. Usually, NRT systems are more reliable at identifying the place of an observed activity and less on the precise spatial extent of it. For an accurate land cover change assessment EO4SD-FM provides products like Forest Area Change maps or Land Cover Change maps that are delivered with detailed accuracy figures.

Near Real Time Disturbance of Forest
(Credit: Wageningen University)

GEOGRAPHICAL COVERAGE

Regional

National

Sub-national

Local

TEMPORAL COVERAGE AND FREQUENCY

Historical data and/or specific dates

Continuous update is possible (e.g. every 5 days, every month), depending on availability of satellite data

EO DATA AND SPATIAL RESOLUTION

High resolution (HR) satellite data (e.g. Sentinel-1 and Sentinel-2) with 10m resolution

Historic Landsat data with 30m resolution

ACCURACY LEVEL

Overall thematic accuracy: 70% to 85%

Positional accuracy: <~1 pixel of source imagery

Product Specifications

- **This product provides decision-makers with timely information on forest cover changes e.g. to monitor ongoing logging activities or to plan measures against illegal logging, and to protect forests from unsustainable use.**
- **It also allows improved deforestation and degradation mapping in forests with rapid regrowth and forms the basis of deforestation early warning systems.**

Product delivery:

- OGC compliant service (e.g. WMS, WFS)
- In Vector data format (Shapefile)
- Automated ingestion into a database
- Geodata in GeoTIFF, ASCIL or similar
- With metadata (INSPIRE or ISO)
- As cartographic products in .pdf, .png or similar

Derived maps and information – available formats:

- USB, hard drive
- Download from dedicated password-protected FTP server or cloud platform
- Viewed online through password-protected web portal (Open Geospatial Consortium (OGC) compliant)

Support available:

- Quality Management Systems cover non-conformance issues, timely corrective actions and supporting services relating to reliability, flexibility and timely delivery of services. All quality relevant information and quality checks are documented and cover:
  - → Compliance of output with user requirements
  - → Completeness
  - → Thematic accuracy
  - → Thematic completeness
  - → Positional accuracy
  - → Product utility
- Tailored training can be provided on product use and integration for further geospatial analysis

TREE COVER DENSITY AND TREE COVER CHANGE

The **Tree Canopy Cover Density and Tree Cover Change** product can also be used as an input for:

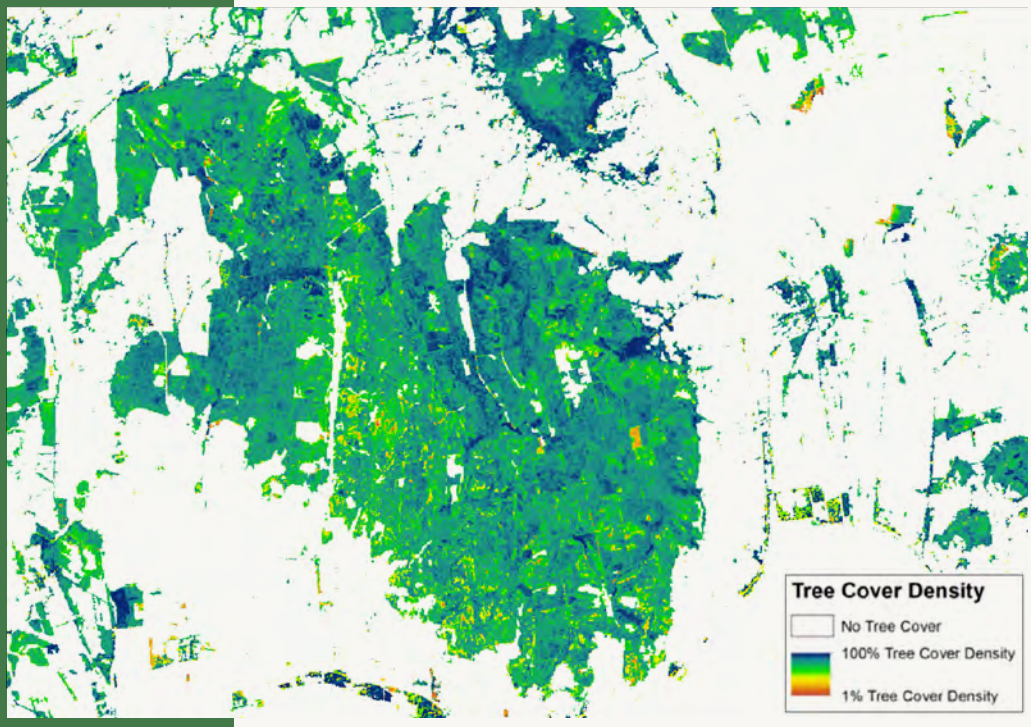
- Assessment of Activity Data for REDD+
- Analysis of Degradation and Deforestation
- Sustainable Forest Management (SFM)
- Forest Landscape Restoration (FLR)
- Identification of High Carbon Stock (HCS) forests
- Forest management/ planning
- Input variable to spatially explicit modelling of forest biomass and change

The **Tree Cover Density** product (TCD) is directly derived from high resolution (HR) satellite data and provides information on the proportional canopy coverage per satellite pixel in a range of 0 to 100%. When the TCD assessment is based on the Copernicus Sentinel-2 satellite imagery then the information can be provided in a 10m by 10m resolution on a regular basis in a spatially explicit wall-to-wall representation.

The TCD product is a key input/ precursor for deriving forest maps following a specific forest definition, e.g. FAO definition, national definition. By applying geospatial operations with key parameters of forest definitions, like minimum area, minimum width and minimum canopy cover density, very accurate forest area maps can be achieved.

The corresponding **Tree Cover Change** product is derived by combining the Tree Canopy Densities of two or more points in time into a Tree Cover Change Map. A decrease of Tree Cover within the forest area can be considered as a proxy for forest degradation.

Tree Cover Density (Credit: GAF)



GEOGRAPHICAL COVERAGE

Regional

National

Sub-national

Local

TEMPORAL COVERAGE AND FREQUENCY

Historical data and/or specific dates

Continuous update is possible (e.g. every 12 months, every 5 years), depending on availability of satellite data

EO DATA AND SPATIAL RESOLUTION

High resolution (HR) satellite data (e.g. Sentinel-2) with 10m resolution

Historic Landsat data with 30m resolution

ACCURACY LEVEL

Overall thematic accuracy: > 85% to 90%

Positional accuracy: <1 pixel of source imagery

Product Specifications

- **Detailed mapping of tree cover density (in percent) over a certain area using discrete classess ranging from 1 to 100%.**
- **Changes can be mapped between two or more points in time, showing increase and decrease of tree cover density (in percent) over a certain area using discrete classes ranging from 1 to 100%.**

Product delivery:

- Geodata in GeoTIFF, ASCIL or similar
- With metadata (INSPIRE or ISO)
- As cartographic products in .pdf, .png or similar

Derived maps and information – available formats:

- USB, hard drive
- Download from dedicated password-protected FTP server or cloud platform
- Viewed online through password-protected web portal (Open Geospatial Consortium (OGC) compliant). The web portal can be customised to include various online analysis options, time series plots, statistical plots and to integrate user-defined datasets

Support available:

- Quality Management Systems cover non-conformance issues, timely corrective actions and supporting services relating to reliability, flexibility and timely delivery of services. All quality relevant information and quality checks are documented and cover:
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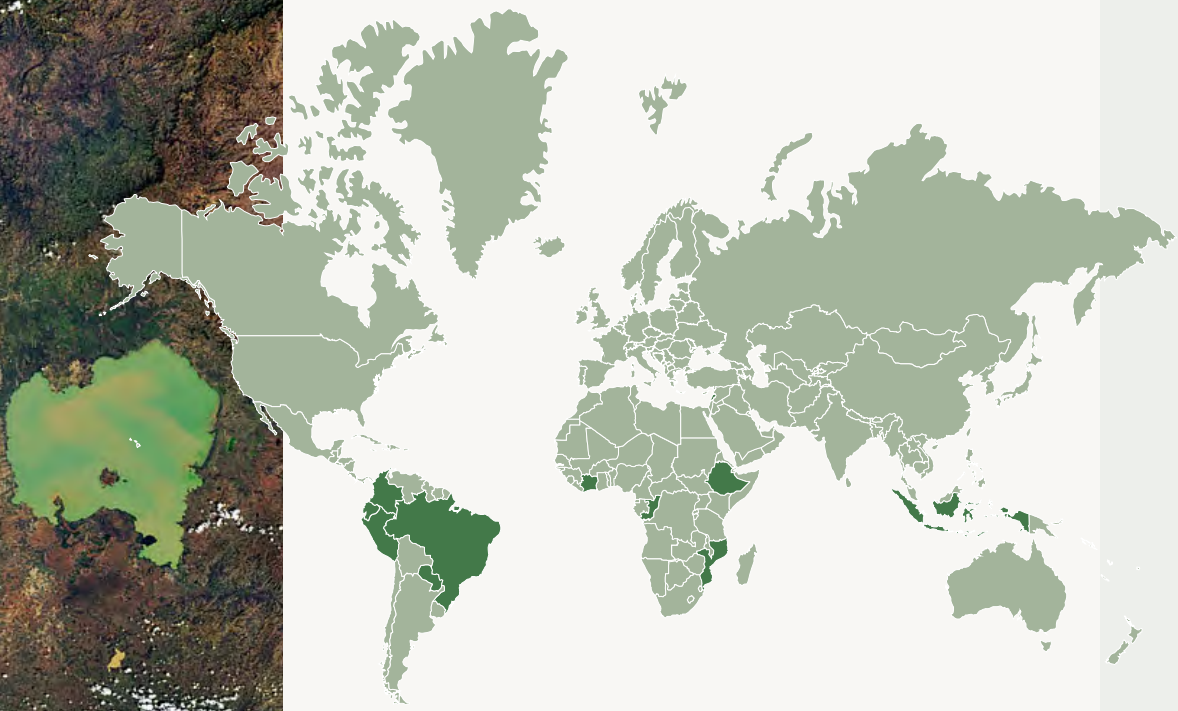
  - → Thematic accuracy
  - → Thematic completeness
  - → Positional accuracy
  - → Product utility
- Tailored training can be provided on product use and integration for further geospatial analysis

EO4SD – FOREST MANAGEMENT

The EO4SD-Forestry Management cluster is partnering with a total of ten IFI programmes to provide EO products for a wide range of applications. The consortium is working with relevant teams at the World Bank and at the Asian Development Bank who have expressed an interest in integrating these EO products into their programme implementations.

The map below shows the countries for the EO4SD-Forest Management implementations.

Map Showing EO4SD-Forest Management Implementations



REDD+ EMISSIONS REDUCTION PROGRAMME IN SANGHA AND LIKOUALA DEPARTMENTS

International Financial Institution
World Bank

Target country
Republic of Congo

Implementing agencies
Ministry of Forest Economy and National REDD Coordination (CN-REDD)

Objectives of EO4SD-Forest Management engagement

EO4SD-Forest Management is providing a set of standardised EO products to the Ministry of Forest Economy to verify the emission data reported by forestry companies in relation to their objective to implement reduced impact logging and forest protection.

SUMMARY

The programme objective is to make payments for measured, reported, and verified greenhouse gas emission reductions from reduced deforestation, degradation, and the enhancement of forest carbon stocks in Sangha and Likouala, and to distribute these payments in accordance with an agreed Benefit Sharing Plan (BSP). A combination of activities will be supported and include: (a) supporting companies implement reduced impact logging and forest protection (b) reduce emissions in palm oil concessions by avoiding the conversion of forests with high conservation value through agreements and promotion of certification under the Roundtable for Sustainable Palm Oil (RSPO) standard, (c) supporting alternative livelihoods (e.g. agro-forestry and providing payments for Environmental Services to individuals and communities that protect forests and wetlands) and (d) improve management of existing protected forest.

THEME

- REDD+

EO4SD-FOREST MANAGEMENT PRODUCTS

- Forest Area and Change
- Global Biomass
  Intact/ Non-Intact Forest and Change
  Land Use/ Land Cover and Change
  Mangrove Area, Change and Recovery
- Near Real Time (NRT) Canopy Disturbance
- Tree Cover Density and Tree Cover Change

POTENTIAL IMPACT OF EO4SD-FOREST MANAGEMENT ENGAGEMENT

Following the engagement with EO4SD-Forest Management, the Ministry of Forest Economy and CN-REDD will have access to a standardised and automated set of EO products to verify the implementation of activities relating to REDD+. As several of the parameters to monitor these activities were manually estimated, the EO4SD-Forest Management products will enable time and cost efficiencies and the efficient identification of illegal deforestation activities occurring in the designated area.

MOZAMBIQUE PORTFOLIO

- FOREST INVESTMENT PROGRAMME (MozFIP)
- MOZAMBIQUE CONSERVATION AREAS FOR BIODIVERSITY AND DEVELOPMENT PROJECT (MozBIO)
- MOZAMBIQUE ZAMBEZIA EMISSIONS REDUCTION PROGRAMME (ZILMP)

International Financial Institution	Target country	Implementing agencies
World Bank	**Mozambique**	**Ministry of Lands and Environment, National Directorate of Forestry Monitoring, Reporting and Verification Unit**

Objectives of EO4SD-Forest Management engagement

EO4SD-Forest Management will provide Tree Cover Density products for three Areas of Interest: (1) 11,600km² of Mopane Forest cover, (2) 7,100km² of mangrove and tropical dry forests and, (3) 2,600km² of an area with recent forest cover changes. The Tree Cover Density product will be used as an input by the implementing agencies to improve the detection of open and closed forest classes.

THEME

- REDD++
- Protected areas
- Sustainable Forest Management

EO4SD-FOREST MANAGEMENT PRODUCTS

› Forest Area and Change
Global Biomass
Intact/ Non-Intact Forest and Change
Land Use/ Land Cover and Change
Mangrove Area, Change and Recovery
Near Real Time (NRT) Canopy Disturbance
› Tree Cover Density and Tree Cover Change

SUMMARY OF THE IFI MOZAMBIQUE FOREST INVESTMENT PROGRAMME (MozFIP)

The MozFIP aims to improve the practices and enabling environment for forest and land management in targeted landscapes. There are three components: (1) Promoting integrated landscape management. (2) Strengthening the enabling conditions for sustainable forest management. (3) Project coordination and management. The integrated landscape management approach is core and brings together different stakeholders to tackle the major drivers of deforestation in the country through the various sectors (forestry, agriculture, and energy).

SUMMARY OF THE MOZAMBIQUE CONSERVATION AREAS FOR BIODIVERSITY AND DEVELOPMENT PROJECT (MozBIO)

MozBio's main objective is to increase the effectiveness of conservation area management and improve the living conditions of resident communities. MozBio consists of three components: (1) Strengthen the capacity and financial sustainability of national conservation institutions via training and payment for ecosystem services and biodiversity offsets. (2) Improve conservation area management including human resource development, infrastructure construction and maintenance, resource surveillance, community organisations strengthening and payments for ecosystem services. (3) Promoting conservation-compatible rural development.

SUMMARY OF THE MOZAMBIQUE ZAMBÉZIA EMISSIONS REDUCTION PROGRAMME

The Zambézia Integrated Landscape Management Programme is a jurisdictional REDD+ programme designed by the Government of Mozambique to contribute to long-term sustainable management of forest, to reduce deforestation in the Province of Zambézia, and to improve the wellbeing of rural populations. It is the first programme of results-based payments for Emission Reductions in Mozambique. It is being implemented via the following World Bank-financed projects: (1) The Agriculture and Natural Resources Landscape project, (2) MozBio project, (3) MozFIP project and, (4) The Dedicated Grant Mechanism (MozDGM) project. This programme measures, reports, and verifies emissions reductions, oversees and allocates payments set out in the defined Benefits Sharing Plan.

POTENTIAL IMPACT OF EO4SD-FOREST MANAGEMENT ENGAGEMENT

The Tree Cover Density and Tree Cover Change product can be used to distinguish between the closed and open forest classes more precisely. As mapping the Mopane and tropical dry forests in Mozambique remains challenging, the EO4SD-Forest Management products—which are locally adapted—can support the production of more accurate maps, and thus are a contribution for more efficient national forest monitoring and will support the REDD+ reporting.

REDD+ EMISSION REDUCTIONS PROGRAMME (ERP) IN TAÏ NATIONAL PARK AREA

International Financial Institution
World Bank

Target country
Republic of Côte d'Ivoire

Implementing agencies
REDD+ Permanent Executive Secretariat (SEP-REDD+).

Objectives of EO4SD-Forest Management engagement

EO4SD-Forest Management is providing support to the SEP-REDD+ for the revision of the Forest Reference Emission Level of the ERP, via updating current deforestation and forest degradation definitions and applying these definitions for the estimation of the activity data within the area using stratified mapping. Additionally, support for the enhancement of the existing Near Real Time system of the country to detect deforestation through its platform IMAGES is provided.

SUMMARY

The Taï National Park Area Emission Reductions Programme (Taï ER-P) is the first phase of the national Emission Reduction Programme. It aims to make payments for measured, reported, and verified emissions reductions from reduced deforestation in the Taï National Park Area and distribute those payments according to an agreed Benefit Sharing Plan. It is estimated that the implementation of the emissions reduction activities during the Emission Reduction Programme Agreement (ERPA) term will lead to a generation of 21.7 million tonnes CO_2 equivalent emission reductions, while also supporting alternative incomes for local communities living adjacent to the forests to reduce human pressure on natural resources.

THEME

- REDD+
- Protected Areas

EO4SD-FOREST MANAGEMENT PRODUCTS

› Forest Area and Change
Global Biomass
Intact/ Non-Intact Forest and Change
› Land Use/ Land Cover and Change
Mangrove Area, Change and Recovery
› Near Real Time (NRT) Canopy Disturbance
› Tree Cover Density and Tree Cover Change

POTENTIAL IMPACT OF EO4SD-FOREST MANAGEMENT ENGAGEMENT

Following the engagement with EO4SD-Forest Management, the SEP-REDD+ team will be able to expand their reporting within the REDD+ framework and improve accuracy levels in the estimation of activity data. Furthermore, by enhancing the country's forest monitoring system using the Tree Cover Density product, the implementing agencies will have an improved view on activities occurring (legal and illegal) within the country's forests.

OROMIA FORESTED LANDSCAPE PROGRAMME (OFLP)

International Financial Institution
World Bank

Target country
Ethiopia

Implementing agencies
Oromia Forest and Wildlife Enterprise (OFWE), Oromia Environment, Forest, and Climate Change Authority (OEFCCA), and regional bureaus.

Objectives of EO4SD-Forest Management engagement

EO4SD-Forest Management is providing technical support and products to national and state agencies to enable them to design and implement improved plantation and natural forest monitoring and management, to reduce deforestation and forest degradation and deliver emission reductions.

SUMMARY

OFLP seeks to reduce deforestation by improving sustainable forest management and lowering GHG emissions from land use—including from the livestock sector—by encouraging better herd management. The OFLP has three components: (1) Enabling investment, including land-use planning support and investment and extension services in deforestation hotspots. (2) Enhancing the enabling environment by financing complementary activities to increase the effectiveness and impact of institutions, policies, marketing, benefit sharing, measurement, reporting and verification. (3) Delivering emission reductions payments once results have been achieved, verified by a third party, and formally reported to the World Bank.

THEME

- REDD+
- Sustainable Forest Management

EO4SD-FOREST MANAGEMENT PRODUCTS

› Forest Area and Change
Global Biomass
Intact/ Non-Intact Forest and Change
Land Use/ Land Cover and Change
Mangrove Area, Change and Recovery
Near Real Time (NRT) Canopy Disturbance
› Tree Cover Density and Tree Cover Change

POTENTIAL IMPACT OF EO4SD-FOREST MANAGEMENT ENGAGEMENT

EO4SD-Forest Management products coupled with technical support are expected to improve the quality and quantity of insights available to support the implementation of sustainable forest management. This includes insights on historical change in forest resources, early detection of changes in forest and plantation status, and the status of forest recovery. The use of EO can reduce the current time and cost investment in gathering such insights.

FOREST INVESTMENT PROGRAMME 1 (FIP-1) COMMUNITY-FOCUSED INVESTMENTS TO ADDRESS DEFORESTATION AND FOREST DEGRADATION

International Financial Institution
ADB

Target country
Indonesia

Implementing agencies
Ministry of Environment and Forestry, West Kalimantan REDD+ Working Group

Objectives of EO4SD-Forest Management engagement

EO4SD-Forest Management is providing forest change products to the Ministry of Environment and Forestry to support their implementation of community-focused investments to reduce deforestation and forest degradation.

SUMMARY

The FIP-1 seeks to support the Indonesian government and indigenous peoples in sustainable forest management and reducing greenhouse gas emission. The *Community-Focused Investments to Address Deforestation and Forest Degradation* project supports capacity and livelihood building of local communities around the forest and is expected to provide environmental and livelihood benefits for the community. This will be implemented through community-focused REDD+ pilots, such as community-based land use planning, community-led forest monitoring and forest fire management, community-assisted forest regeneration and maintenance, and community-based ecotourism. In addition, the programme aims to strengthen institutional capacity in REDD+ implementation and contribute to the effectiveness of REDD+ fiscal strategy and harmonisation at the provincial and national levels.

THEME

- REDD+
- Community Based Forest Monitoring and Management

EO4SD-FOREST MANAGEMENT PRODUCTS

- Forest Area and Change
  - Global Biomass
- Intact/ Non-Intact Forest and Change
  - Land Use/ Land Cover and Change
- Mangrove Area, Change and Recovery
  - Near Real Time (NRT) Canopy Disturbance
  - Tree Cover Density and Tree Cover Change

POTENTIAL IMPACT OF EO4SD-FOREST MANAGEMENT ENGAGEMENT

EO4SD-Forest Management products coupled with technical support are expected to improve the Ministry of Environment and Forestry capacity to generate REDD+ activity data and verify emission reduction more efficiently and accurately.

OCEANS FOR PROSPERITY PROGRAMME — LAUTRA PHASE 1

International Financial Institution
World Bank

Target country
Indonesia

Implementing agencies
Peatland and Mangrove Restoration Agency, Ministry of National Development Planning, Ministry of Marine Affairs and Fisheries, Ministry of Environment and Forestry

Objectives of EO4SD-Forest Management engagement

EO4SD-Forest Management is providing products and technical support to advance EO capabilities within Indonesian institutions to support mangrove ecosystem assessment, restoration planning, and monitoring.

SUMMARY

The LAUTRA Phase 1 programme aims to improve the management and governance of fisheries and coastal ecosystems and to improve the livelihoods of coastal communities. Linked to this aim, the programme consists of three components: (1) Strengthening the enabling environment and capacity to manage target fisheries and balancing the aim of maximising economic yields with ensuring fishing efforts align with the regenerative capacity of stocks. (2) Contribute to improving livelihoods, facilitating jobs creation, and strengthening the resilience of coastal communities to sudden shocks and long-term changes. Activities would aim at promoting alternative sources of livelihoods and offsetting potential losses from strengthened fishery management. (3) Maintain and enhance the resilience of coastal and marine ecosystems within target management areas to ensure that essential supporting ecosystem services and functions can withstand shocks and pressures, both natural and anthropogenic.

THEME

- Coastal Ecosystems and Mangroves
- Forest Rehabilitation

EO4SD-FOREST MANAGEMENT PRODUCTS

Forest Area and Change
Global Biomass
Intact/ Non-Intact Forest and Change
Land Use/ Land Cover and Change
› Mangrove Area, Change and Recovery
Near Real Time (NRT) Canopy Disturbance
› Tree Cover Density and Tree Cover Change

POTENTIAL IMPACT OF EO4SD-FOREST MANAGEMENT ENGAGEMENT

Indonesia has the most extensive mangrove ecosystems in the world and planning mangrove rehabilitation is a challenge and a significant investment. EO4SD-Forest Management will provide more robust and accurate information on changes in mangrove ecosystems, supplementing important global datasets. Coastal information will support selection of rehabilitation areas across the country. These inputs will help to ensure that investments are successful and maximise social, economic, and ecological benefits.

AMAZON SUSTAINABLE LANDSCAPES INITIATIVE (ASL) PHASE ONE AND TWO

International Financial Institution
World Bank

Target country
Brazil, Colombia, Ecuador and Peru

Implementing agencies
World Bank, World Wide Fund for Nature (WWF), United Nations Development Programme (UNDP), and UN FAO

Objectives of EO4SD-Forest Management engagement

EO4SD-Forest Management is providing three demonstration products to support the forest monitoring and management aims in the Putumayo-Içá cross border region. These products together can provide insights on status and changes to the forest resources, on the drivers of change and information on emissions related to disturbances.

SUMMARY

The Amazon Sustainable Landscapes Initiative in its first phase aims to protect globally significant biodiversity and implement policies to foster sustainable land use and restoration of native vegetation cover. In its second phase, the initiative aims to improve integrated landscape management and conservation of ecosystems in targeted areas in the Amazon. One of these target areas is the Putumayo Içá river basin. The initiative comprises national projects executed by countries in the region including Brazil, Colombia, Ecuador and Peru and regional coordinating projects.

THEME

- REDD+
- Protected Areas

EO4SD-FOREST MANAGEMENT PRODUCTS

- Forest Area and Change
- Global Biomass
  Intact/ Non-Intact Forest and Change
- Land Use/ Land Cover and Change
  Mangrove Area, Change and Recovery
- Near Real Time (NRT) Canopy Disturbance
- Tree Cover Density and Tree Cover Change

POTENTIAL IMPACT OF EO4SD-FOREST MANAGEMENT ENGAGEMENT

The products delivered by EO4SD-Forest Management will be designed to meet the forest monitoring needs of the four countries that are part of the ASL Programme. Joint monitoring in the Putumayo-Içá cross border area will be strengthened, as partners have worked together to define the needs, select suitable products, and use them. Joint training sessions will seek to strengthen these ties. Several specific benefits will be delivered including an assessment of the status of forest carbon stocks in the region, information on the main drivers of deforestation and forest degradation, and an insight into the impact which artisanal mining has on forest area and carbon stocks.

PARAGUAY FOREST PROJECT

International Financial Institution: **World Bank**

Target country: **Paraguay**

Implementing agencies: **Instituto Nacional Forestal (INFONA) and the Ministry of Environment**

Objectives of EO4SD-Forest Management engagement

EO4SD-Forest Management will provide INFONA with the Tree Cover Density and Tree Cover Change product for a demonstration area (of 26,000 km²), covering the Chaco ecosystem in Boquerón Province. This product will be used to improve the ability to assess deforestation in dry forest ecosystems and thus support INFONA increase the accuracy of data on forest loss for the national forest monitoring and REDD+ process.

SUMMARY

The Paraguay Forest Project seeks to strengthen governance in the forestry sector supporting a more efficient and effective National Forest Institute (INFONA) and fostering policy reforms along with reforestation and restoration, thus moving the country towards more sustainable forest management. Initial activities will build INFONA's capacity to monitor and manage Paraguay's forests, through creating a forest monitoring system and strengthening capacity. This is expected to reduce deforestation, improve fire-detection, and strengthen response capacity. Complementary investments in administrative systems will result in efficiency gains, freeing up INFONA's resources to support the private sector through extension services. A subsequent set of activities aim to support private producers by providing credit coupled with technical assistance for sustainable production and development of sustainability certification standards. This is expected to lead to increased sustainable forest production, with a potential for job creation and export market development and diversification.

THEME

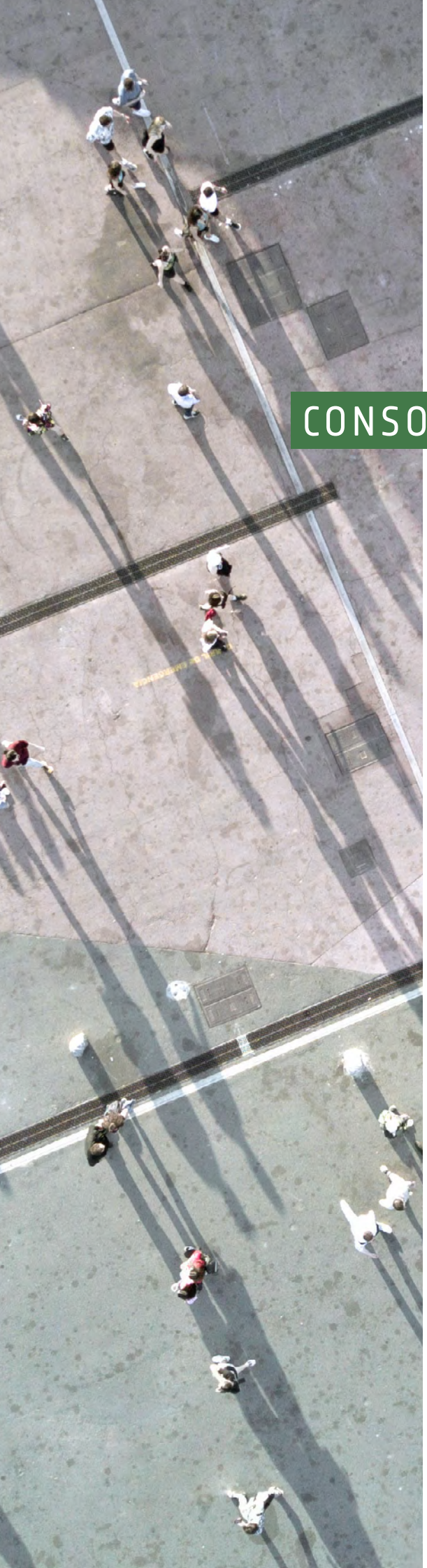
- REDD+
- Sustainable Forest Management

EO4SD-FOREST MANAGEMENT PRODUCTS

› Forest Area and Change
Global Biomass
Intact/ Non-Intact Forest and Change
Land Use/ Land Cover and Change
Mangrove Area, Change and Recovery
Near Real Time (NRT) Canopy Disturbance
› Tree Cover Density and Tree Cover Change

POTENTIAL IMPACT OF EO4SD-FOREST MANAGEMENT ENGAGEMENT

The use of the Tree Cover Density and Tree Cover Change product will be the basis for providing INFONA with an increasingly automated provision of a forest mask which is particularly beneficial in assessing forest area losses in dry forest ecosystems. When used, these products will enable INFONA to gain time and cost efficiencies within their national forest assessment processes.



CONSORTIUM DESCRIPTION

GAF AG (Germany)

GAF a private sector enterprise founded in 1985 in Germany is one of the leading European consulting firms in the field of geo-information offering a broad range of geo-information services and applications, ranging from geo-data procurement (satellite data, DEM, land use and land cover data), image processing and analysis, information processing and software development, to the provision of turn-key technical assistance projects and customized spatial land management and monitoring solutions.

GAF has 36 years of international experience in working with EO data, covering all technical aspects in the fields of forestry, mining/ geology, telecommunications, infrastructure management, urban mapping, agriculture, and water management. Since its inception, GAF has been involved in the development and application of thematic image processing and analysis routines. Through its subsidiary GAF Neustrelitz (known previously as Euromap GmbH), GAF additionally has well established EO data reception and distribution facilities. GAF is also an independent EO data re-seller.

GAF is part of the multi-national Telespazio Group and is strategically integrated in the Space Alliance consisting of Leonardo and Thales. GAF is owned by e-GEOS S.p.A. (Rome, Italy) and thus part of an international network of companies with strong financial backing.

www.gaf.de

Système d'Information a Référence Spatiale SAS (France)

CLS Group (www.cls.fr) is a global company and pioneer provider of monitoring and surveillance solutions for the Earth. Created in 1986, with annual revenue of nearly 135 M€ (2019), it is a subsidiary of the French Space Agency (CNES) and CNP, with the mission to create innovative space-based solutions to understand and protect our planet and to manage its resources sustainably. CLS employs 800 people at its headquarters in Toulouse (FR) and in 26 other sites around the world, working in five strategic areas: sustainable fisheries management, environmental monitoring, maritime surveillance, fleet management, and energy & mining. CLS processes data from 100,000 transponders per month (such as drifting buoys, animal tags, VMS transponders, and LRIT tracking) and observes the oceans and inland waters (more than 20 instruments onboard satellites daily deliver information to CLS on the world's seas and oceans). In addition, CLS monitors land and sea activities by satellite (nearly 10,000 radar images and several hundred company drone flights are processed each year). With a 30-year experience in environmental monitoring by remote sensing techniques, CLS has been continuously acting in EO projects providing services to French and European space agencies (CNES, ESA, EUMETSAT) and European stakeholders, through research programmes (FP5, FP6, FP7, H2020), and more recently through the operational Copernicus Programme.

Since 1st January 2021, CLS has been merged with SIRS, with the goal of developing solutions to study and protect our planet and long term managing of resources and territories. SIRS activities, dedicated to environment applications related to continental surfaces, e.g., land cover mapping, crop monitoring, forest management, urban planning, continental hydrology, risk and emergency mapping, have been transferred to the Land & Hydrology department of CLS.

Wageningen University (The Netherlands)

Wageningen University is the only university in the Netherlands that specifically focuses on the theme 'healthy food and living environment', doing so by working closely together with governments and the business community. Research and education are based on a fundamental scientific approach and accordingly strongly geared toward application in practice. WU is the leading research institution in the field of Agriculture and Forestry where it remains the world's best according to the QS World University Rankings 2019.

Both Wageningen University's research and education are highly acclaimed. The top quality of research at Wageningen University is crowned with the university's position within the top 6 of the important citation indexes of its domain. This combination of knowledge and experience enables WUR to contribute actively to solving scientific, social and commercial problems in the fields of life sciences, environmental sciences and natural resources.

The Laboratory of Geo-Information and Remote Sensing (GRS) at WU is under the leadership of Prof Herold for the Remote Sensing theme. This group specializes in the domain of quantitative retrieval of land surface parameters, time-series analysis and near-real time integrated land cover and land change monitoring and assessments. As part of our forest and land change monitoring research, we are currently further developing land cover monitoring and land cover change detection algorithms capable of dealing with multiple data streams i.e. in-situ observations and satellite measurements. The algorithms and operational monitoring systems are tested in a number of countries, such as the Netherlands, Ethiopia, Peru and Indonesia where we have active research projects. The WU team provides expertise in forest cover/ use mapping and land change monitoring using multi-sensor satellite data and novel approaches developed within the group. The team has a wide range of expertise in large area land and forest cover mapping, product comparison and data integration and actively involved with international advisory communities such as GFOI. The team also has experience in capacity building initiatives through the recent World Bank / GOFC-GOLD project.

WU has an extensive network which comprises of researchers from around the world in the GOFC-GOLD research teams and through the regional networks, and numerous other stakeholders through the GFOI network. This provides insight into the best available methods, products and technologies from the producer side, as well as user-needs from countries and donors. WU has around 10,000 BSc and MSc students and more than 1,900 PhD students. For more information about WU, see: www.wur.nl/en/wageningen-university.htm and for overall information on WUR, see: www.wur.nl/en.htm

Hatfield (Canada)

Hatfield is a privately-owned environmental and geomatics consulting company with extensive experience delivering environmental services. Established in 1974, Hatfield has undertaken over 4,000 projects in North and South America, Asia, Europe and Africa for public and private sector clients. Hatfield's head office is in Vancouver, Canada, with three Canadian branch offices. Hatfield has international experience in more than 40 countries and maintains international offices in Botswana; Indonesia; and Lao PDR. Hatfield's core expertise is environmental monitoring and assessment, particularly the design and deployment of evaluation and monitoring programs.

Hatfield has a demonstrated track record in the successful management, coordination, and delivery of EO services that require expertise in optical and radar EO, ICT, and forestry management domain knowledge. Hatfield has developed web-based information management systems for a variety of projects, ranging from large multi-year environmental monitoring programs to institutional strengthening and community development applications.

Hatfield's strength is an understanding of international development and finance organisations and the project cycle, including identification, design, implementation, and evaluation. Hatfield has demonstrated abilities in integration of EO services within the context of sustainable forest management, social forestry and community development, and participatory natural resources management.

Indufor (Finland)

Indufor Oy is an independent international consulting company with the head office in Helsinki, Finland and regional offices in Auckland, New Zealand; Melbourne, Australia; Washington DC, United States, and a representation in China.

Indufor's key strategic services are:

- Strategic industrial development within wood and fibre-based industry & bio-products
- Sustainable natural resources and fibre sourcing strategies and optimisation
- Business and investment strategies with M&A support
- Due diligence with forest resource assessment and mapping
- Natural capital and forest valuations
- Sustainable finance
- Climate change and ecosystem services in forest landscapes
- Sustainable natural resources management with smallholders.

Indufor has a wide and long-term experience in community-based natural resource management, participatory approaches and community consultation, sustainable forest management, forest landscape approaches, community-based forest monitoring, forest carbon and environmental services projects. Indufor has specialized in designing and developing National Forest Monitoring Systems (NFMS) and developing Forest Reference Emission Level (FREL) measurements to meet the strategic needs of REDD Countries. Indufor also has extensive experience in assessments of deforestation and forest degradation, analysis of land use change, remote sensing and MRV.

Caribou Space (UK)

Caribou Space supports organisations to bridge the space and development worlds by working with governments, space agencies, development agencies, and private sector space companies. Caribou Space provides:

- Official Development Assistance (ODA) fund and programme strategy: Strategic recommendations for the design and delivery of ODA programmes.
- Fund and/or programme management: Delivery and/or management of large-scale and often complex, multi-country programmes to ensure the effective deployment of funds.
- Monitoring and Evaluation (M&E): Design of M&E systems, delivery of process and impact evaluations, and M&E training.
- Research, communications, and knowledge sharing: Conducting research on market opportunities, user needs, use cases, and impact of space solutions, and publicly sharing knowledge of what works, doesn't work, and why. Using diverse communications channels including press and media, publications, social media, conferences and workshops.
- Product strategy: Supporting strategy for the sustainability and commercialisation of space solutions for developing countries.
- Economic evaluation: Quantification of the economic case and impacts of space technology.

For further information on Caribou Space see www.caribou.space.