

# Capacity for Copernicus REDD+ and Forest Monitoring Services

## Tree Cover Density and Forest Type Products based on Sentinel - 2 Data

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Supported by:



Partners:



- **Introduction**
  - Challenges in AD Reporting and EO Forest Monitoring
  - The Tree Cover Density Product
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- **Demonstration of the Tree Cover Density Product in Indonesia**
  - Areas of Interest
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# Challenges in REDD+ AD Reporting

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The UNFCCC Technical Assessment Reports on the FRELs submitted by countries identified a variety of implementation challenges, which include:

- Deforestation is assessed by visual Interpretation instead of digital classification
- Single observation EO images are used instead of exploitation of time series
- Changes are assessed by comparison of maps from two points in time instead of direct comparison of satellite images
- High uncertainties in Activity Data
- Differences of forest definitions Activity Data with National Definitions (e.g. when global EO data products are used)

Sources: FCCC/TAR/2016/ZMB; FCCC/SBI/ICA/2019/TATR.1/IDN; FCCC/TAR/2016/IDN; FCCC/TAR/2017/TZA; FCCC/TAR/2018/MOZ

# Challenges in EO Forest Monitoring

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Technical challenges of using EO for **Tropical Humid Forests** mapping are:

- Heavy cloud cover
- Fast natural regrowth after deforestation events
- Spectral similarity of woody and herbaceous vegetation (e.g. Bamboo)

Technical challenges of using EO for **Deciduous Forest** mapping are:

- Phenology of woodlands (canopy cover)
- Seasonal leaf fall in dry season
- Limitations of EO sensor systems regarding frequent data availability

These challenges can be addressed by:

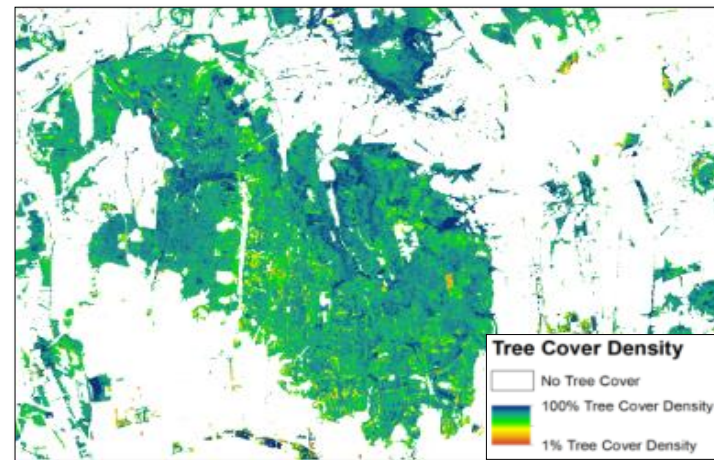
- Using multi-temporal time series EO data,
- Algorithms for processing dense time series to
  - map areas with frequent cloud cover
  - consider phenology and seasonality
- Using Copernicus and Sentinel-2 data and derived products



# Tree Cover Density Product

## Tree Cover Density

- 10m spatial resolution
- Tree Canopy Cover Density range of 0-100%
- 90% User's and Producer's Accuracy
- Minimum Mapping Unit 1 Pixel (10 m)



**Tree Cover Density** is defined as the „vertical projection of tree crowns to a horizontal earth's surface and provides information on the proportional tree canopy coverage per pixel.

- The Tree Cover Density product is a spatial representation of the key parameter of most forest definitions
- The product allows the creation of forest masks making direct use of tree crown cover, instead of the indirect use in traditional classification based forest masks through training data.

# Application of Forest Definition

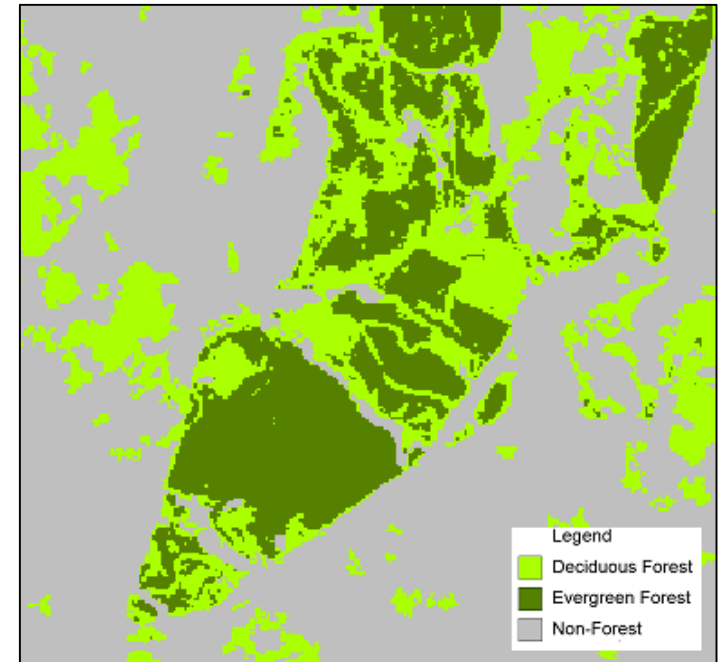
- The thresholds used in the Forest definitions of different countries can differ, e.g. in order to reflect specific ecosystem characteristics
- It is important that EO products used as Activity Data match the National Definition of the User Country (see UNFCCC TARs)
- The Tree Cover Density Product allows a flexible application of the required parameters when deriving Forest Masks.

Country	Min Crown Cover %	Minimum area [ha]	Minimum width [m]
Indonesia	30%	6.25 ha	---
Vietnam	10%	0.5 ha	---
Laos	20%	0.5 ha	---
Spain	5%	0.25 ha	20m
Austria	30%	0.05 ha	10m
FAO	10%	0.5 ha	20m

# Forest Type Product

## Forest Type Product

- 10 m spatial resolution
- 90% User's and Producer's Accuracy
- Minimum Mapping Unit 0.5 ha (50 pixel)
- Minimum Forest Width 2 Pixel (20m)
- 3 Classes:
  - **Deciduous Forest**
  - **Evergreen Forest**
  - **Non-Forest**



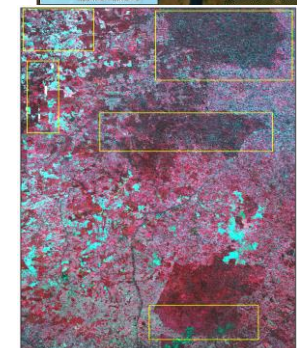
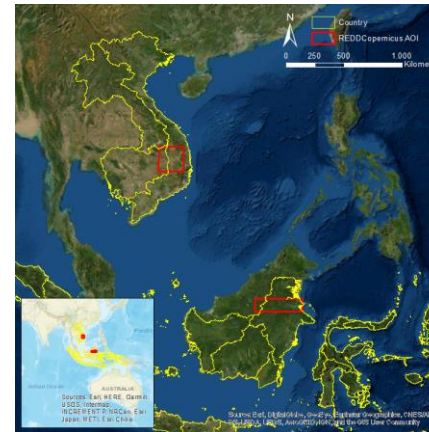
The **Forest Type** Product is derived from the TCD Product, using the FAO forest definition. The Forest has a minimum of 10% Tree Cover Density (TCD), a MMU of 0.5 ha, a minimum Forest Width of 20m.

Forest is distinguished according to leaf fall characteristics into Evergreen and Deciduous Forest.

# Demonstration of the Tree Cover Density and Forest Type Products

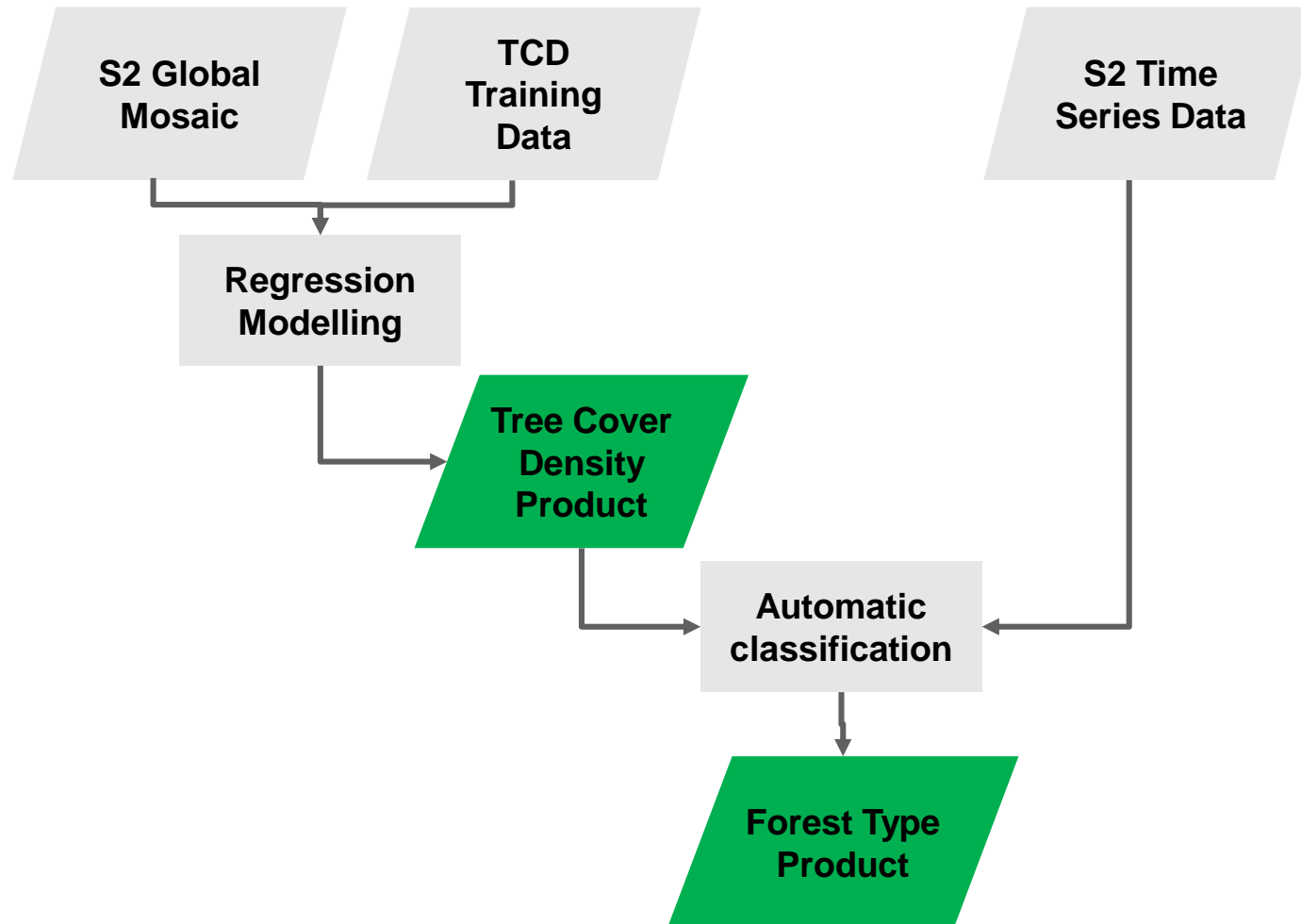
Test sites were provided by JRC for a demonstration of Tree Cover Density Modelling in seven AOIs in five regions:

- **Kalimantan, ca. 45,000 km<sup>2</sup>**
- **Continental Southeast Asia, 40,000 km<sup>2</sup>**
- **SADC Region (Malawi), ca. 60,000 km<sup>2</sup>**
- **East Kenya, ca. 34,000 km<sup>2</sup>**
- **Tanzania, ca. 36,000 km<sup>2</sup>**
- **Central Africa, ca. 24,000 km<sup>2</sup>**
- **Brazil, ca. 24,000 km<sup>2</sup>**





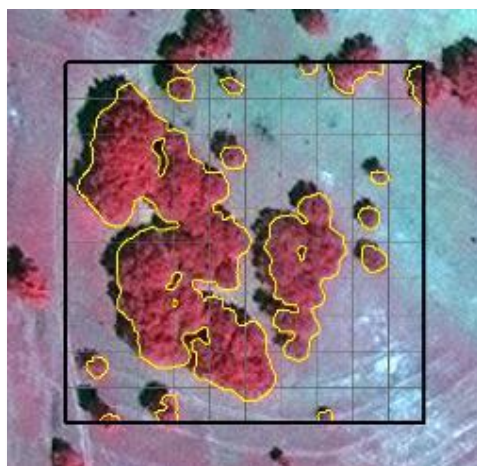
# Methodology Workflow



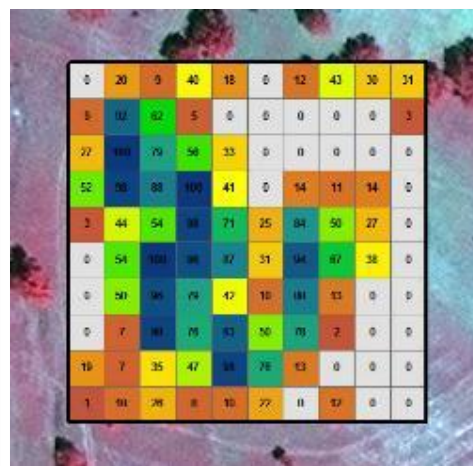
# Methodology: Tree Cover Density

## The Copernicus Land Monitoring Service (CLMS) Definition:

Tree Cover Density (TCD) is the „vertical projection of tree crowns to a horizontal earth’s surface“. It provides information on the proportional crown coverage per pixel in a range of 0 to 100%.



Visually delineated tree cover on VHR data (yellow outline) overlaid by a 10m raster grid



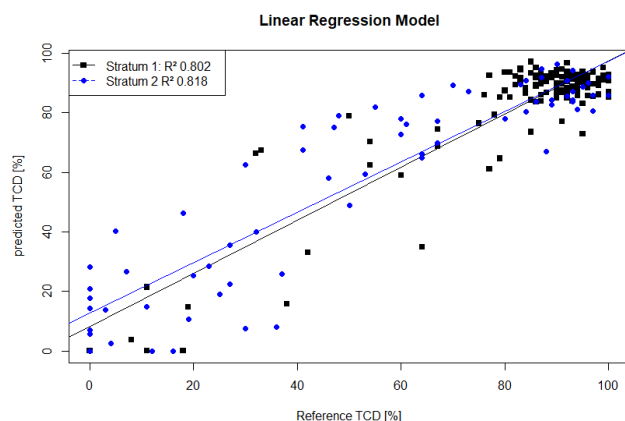
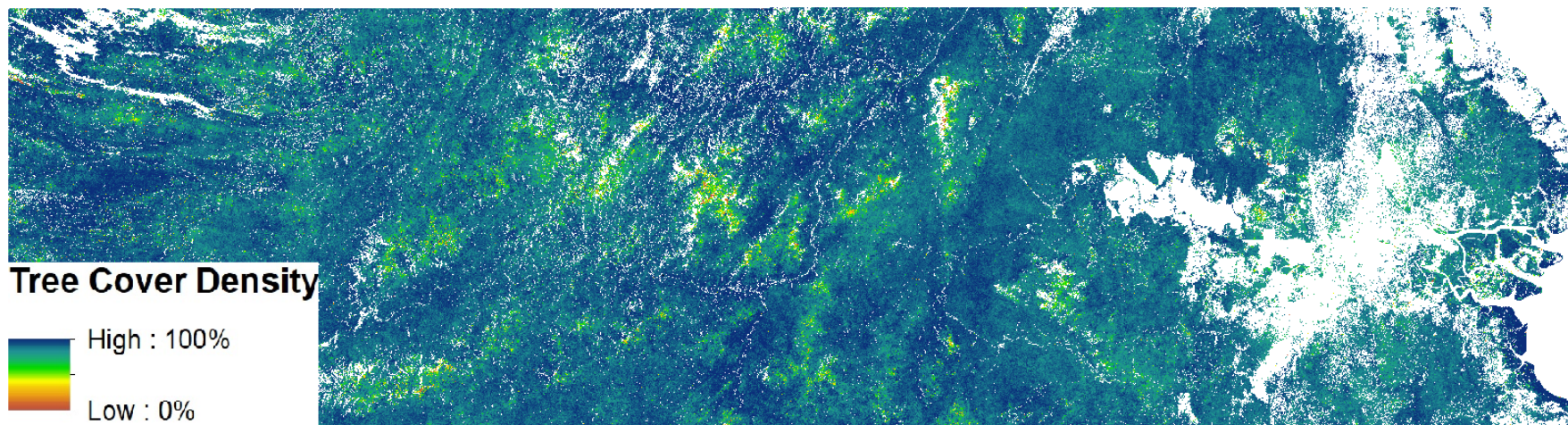
Tree cover translated to Tree Cover Densities (0-100%) on a 10m raster grid



10m Tree Cover Density raster overlaid by VHR tree cover delineation

# Product: Tree Cover Density for Kalimantan Site

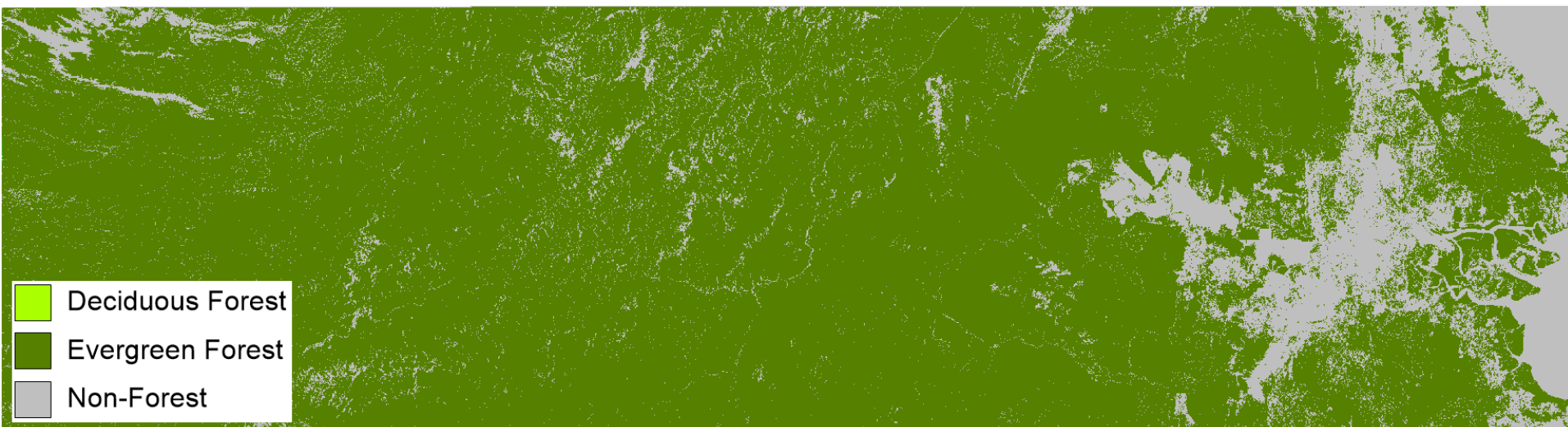
Final Tree Cover Density product 2019 in 10m resolution for the Kalimantan test site.



	Stratum 1	Stratum 2
Samples	170	126
RMS	13.420	20.655
MAE	8.488	17.123
$R^2$	80.139	81.567

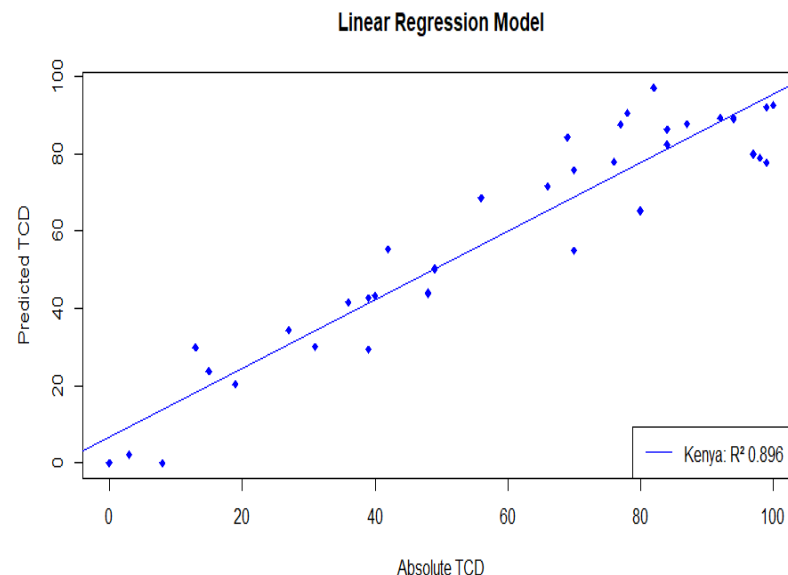
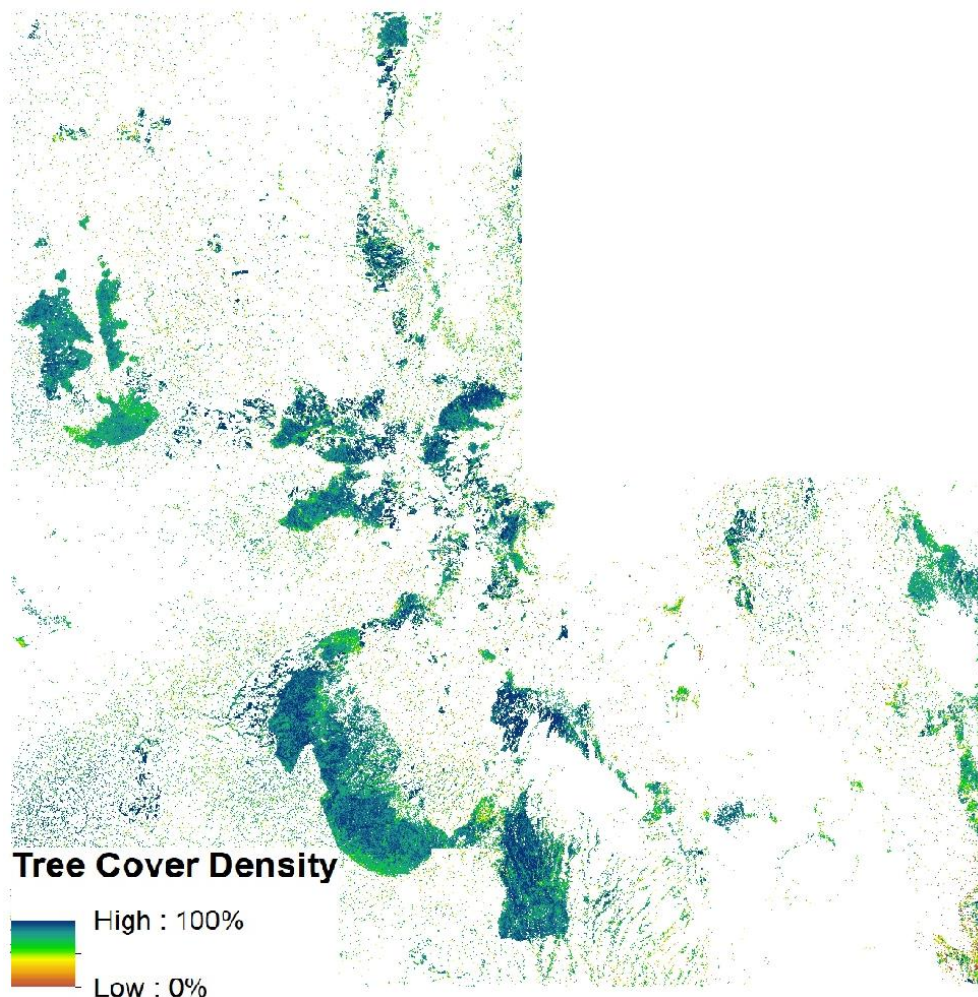
# Product: Forest Type for Kalimantan Site

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# Product: Tree Cover Density for West Kenya Site

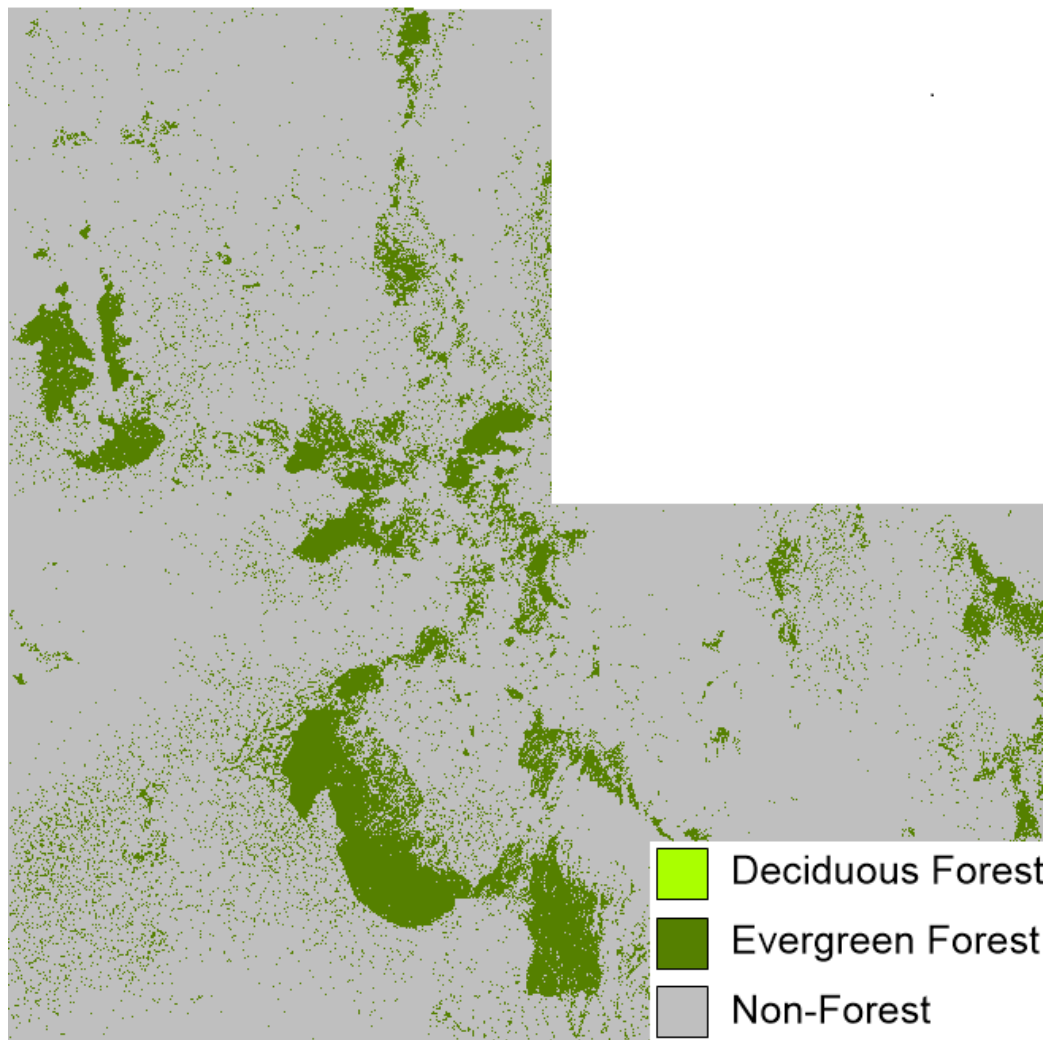


	Linear Regression
Samples	70
RMS	10.954
MAE	8.435
R <sup>2</sup>	89.62

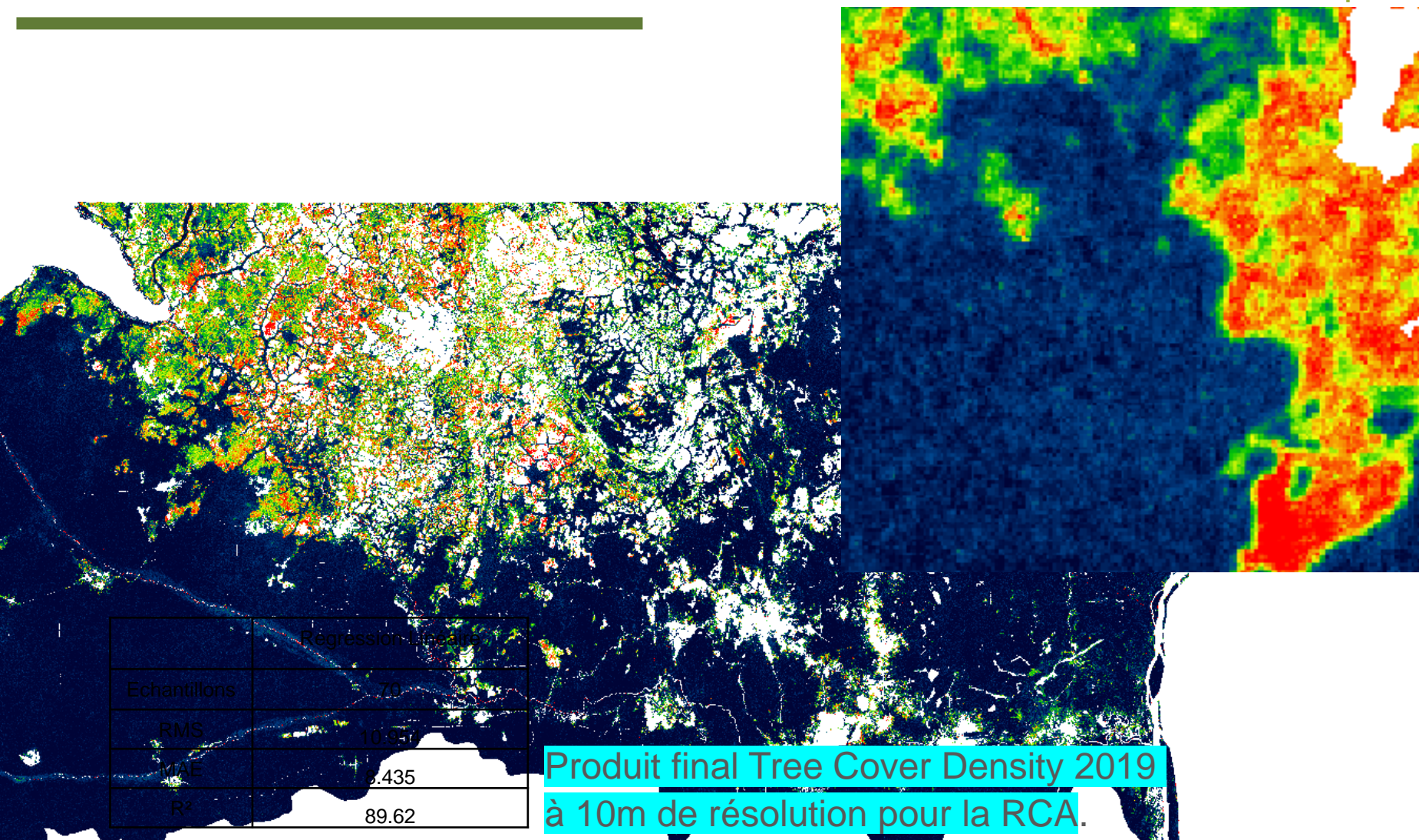
Final Tree Cover Density product 2019 in 10m resolution for the West Kenya test site.



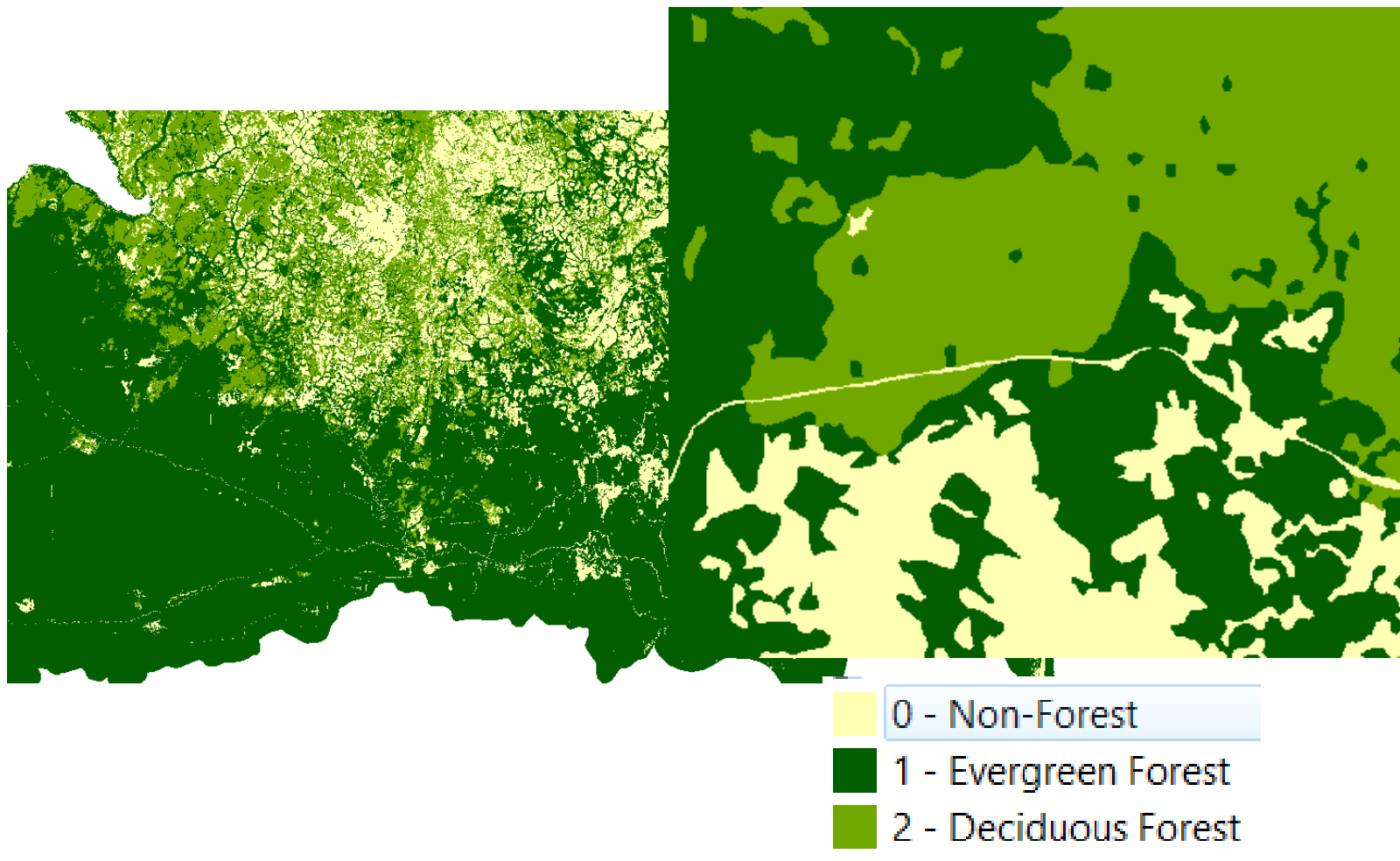
# Product: Forest Type for West Kenya Site



# Product: Tree Cover Density Central Africa



# Product: Forest Type Central Africa



# Conclusions

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- The Tree Cover Density Products based on Sentinel-2 addresses main challenges in tropical forest (humid/dry) forest mapping
- Enables accurate mapping of both, humid forests characterized frequent cloud cover, and dry forests with seasonal leaf fall patterns
- The TCD product addresses some of the challenges identified in the Technical Assessments of FRELs submitted to UNFCCC:
  - Use of the full time series of Sentinel-2 instead of single date images
  - Enables the creation of forest maps through digital techniques instead of visual interpretation
  - Provides high accuracy (~90%) which is a precondition for deriving Activity Data with low Uncertainty.
  - Allows direct application of key parameters of most forest definitions (Crown Cover, Minimum Forest Area, Minimum Width) and thus the creation of Forest Maps consistent with National Definitions





**Thank you for your attention**

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