Combination of satellite and ground based digital data for automatic illegal logging detection

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Introduction

Illegal logging is an environmental crime on a global scale, and the cost of this criminal practice extends far beyond financial losses; in fact it involves environmental devastation, deforestation, habitat fragmentation, and the extinction of irreplaceable species. Addressing this issue involves implementing various solutions, including active control of forest areas and certification of the origin of timber from sustainably and legally managed resources. The EU project SINTETIC fosters the development of a highly detailed traceability system of timber products, from the standing tree to the final wooden product. This system leverages both on the ground data from the value chain and remotely sensed data to develop an early alert system for automatic detection of illegal logging operations, which in case of low intensity harvest (selective cut of best trees) produce little signal and are particularly difficult to detect with statistical models.

Aims and Objectives

o Deployment of AI to develop a detection model of illegal logging occurrences;
o Service based on Sentinel satellite data (Optical and SAR);
o Model training based on ground-truthing data provided in close-to-real time by proximal sensors;
o Integration of ground data in final service to highlight legal operations, focusing the alert on unexpected land cover changes.
o Production of a semi-automatic alert report for law enforcement authorities.

Methodology

The model will be developed using Machine learning algorithms to develop a parametric harmonic regression function [1,2] of the Normalized Difference Vegetation Index (NDVI) constructed from observations acquired by Sentinel 1-2 satellites. SAR data will be used for an intermediate validation round. The system will enable the detection of the small variations induced by the forest harvesting operations and assess whether these discrepancies are consistent with the frequencies and amplitudes assumed by the function in the same seasons in different years.

Ground truthing data will be provided automatically by the prototypes developed in SINTETIC. These will include both forest machinery (harvester) and smartphones running dedicated APP for chainsaw operators, both providing digital data in Standard for Forest machine Data and Communication format (StanForD). The latter encloses relevant data such as timestamp, geographic position and the main dimensional parameters of each felled tree.

In the model development stage, the ground data will be used to train the system to the detection of land cover changes based on known position and intensity (number and diameter of felled trees) of forest operations. The refresh rate of the system will be synchronized with the time resolution of Sentinel 1-2 satellites.

Finally, the operative service will generate a semi-automatic alert report of position and size of unexpected land cover changes.

These will be classified according to probability of illegal logging features, while legal logging operations will be automatically filtered out based on StanForD information.

The first test will focus on a representative forested area in Romania, where illegal logging significantly impacts the conservation of forest resources and protected ecosystems.

Workflow diagram

[1] Liang Sun, Feng Gao, Donghui Xie, Martha Anderson, Ruiqing Chen, Yun Yang, Yang Yang, and Zhongxin Chen. Reconstructing daily 30 m ndvi over complex agricultural landscapes using a crop reference curve approach. Remote Sensing of Environment, 253, 2 2021.
[2] Qiang Zhou, Zhe Zhu, George Xian, and Congcong Li. A novel regression method for harmonic analysis of time series. ISPRS Journal of Photogrammetry and Remote Sensing, 185:48–61, 3 2022

The SINTETIC project

The **project Single Item Identification for Forest Production, Protection and Management** (SINTETIC) [1] was funded by the Horizon Europe program to promote the digitalization of the EU forest value chains, introduce cost-effective traceability technologies and increase the economic and environmental services provided by European forests.
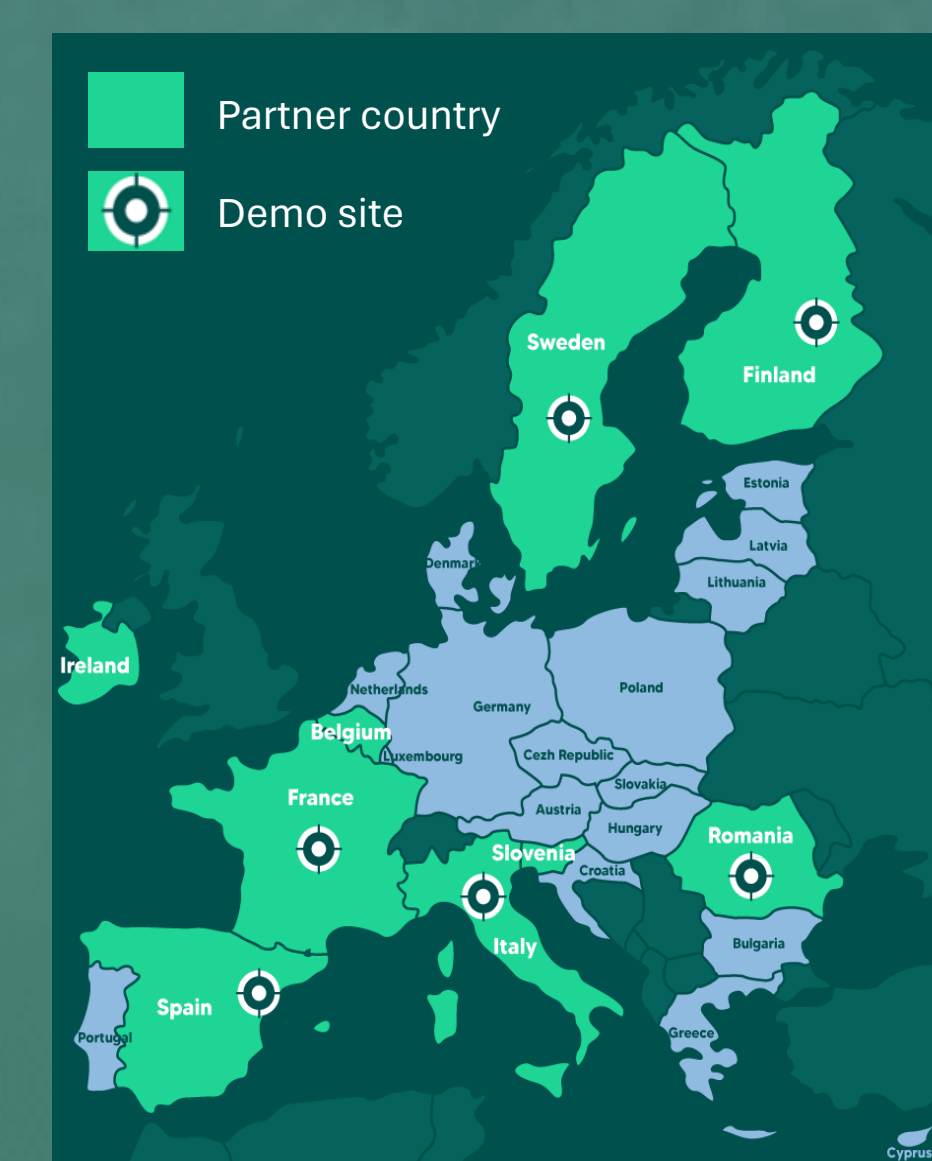
Coordinator: Forest Science and Technology Centre of Catalonia (CTFC), Spain		
9 EU countries	21 partners	Total cost 8,853,625 €
Duration 48 months	Start 1st June 2023	End 31st May 2027

[1] Single item identification for forest production, protection and management Europe - Call ID: HORIZON-CL6-2022-CIRCBIO-02-06-; two-stage Harnessing the digital revolution in the forest-based sector)

Main aims of the project

• extend traceability from the standing tree to the final timber product coupled with timber quality assessment (Fig. 1);
• promote a quality-oriented supply chain and maximize the yield of transformation processes to cover the costs of traceability;
• increase forest productivity and health by modeling the reaction trees to climate, silviculture and adversities (pests, drought, etc.);
• set up a satellite detection system to contrast illegal logging;
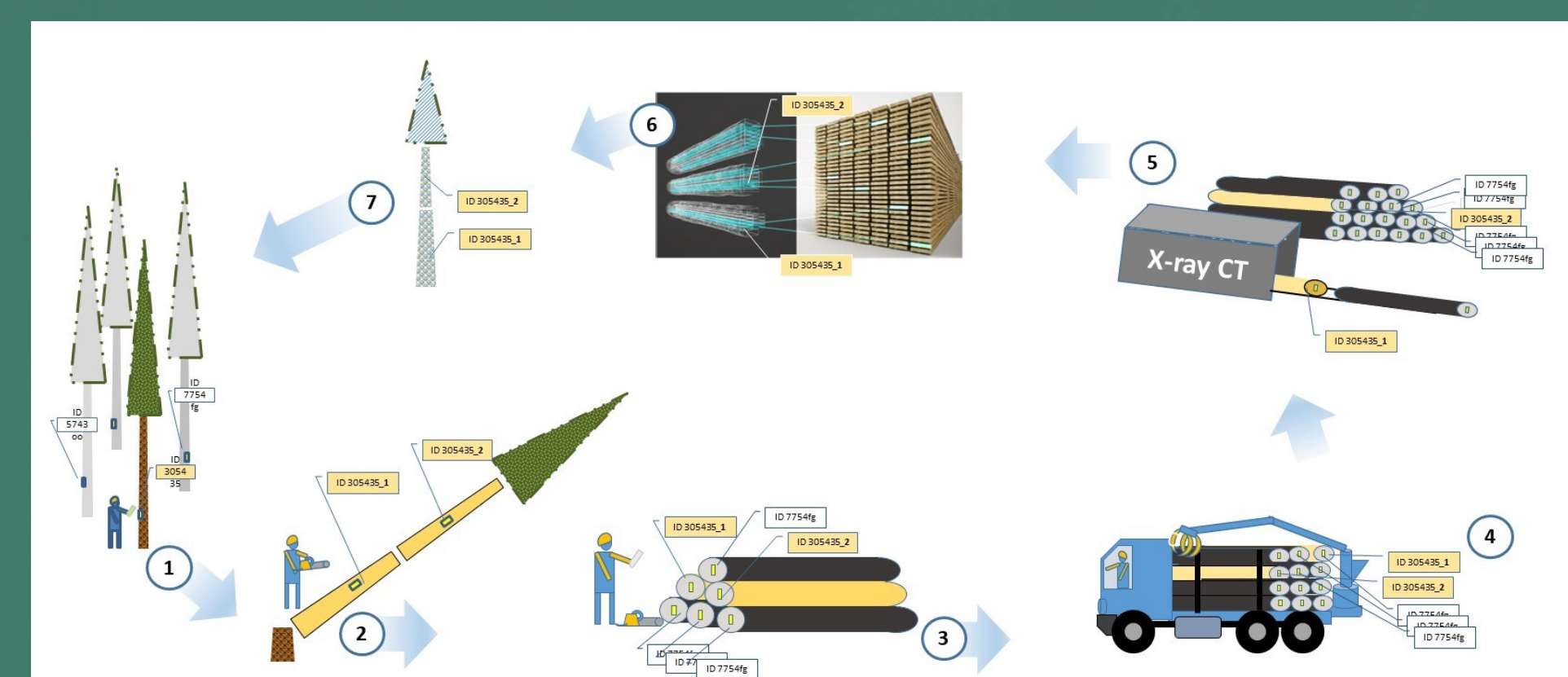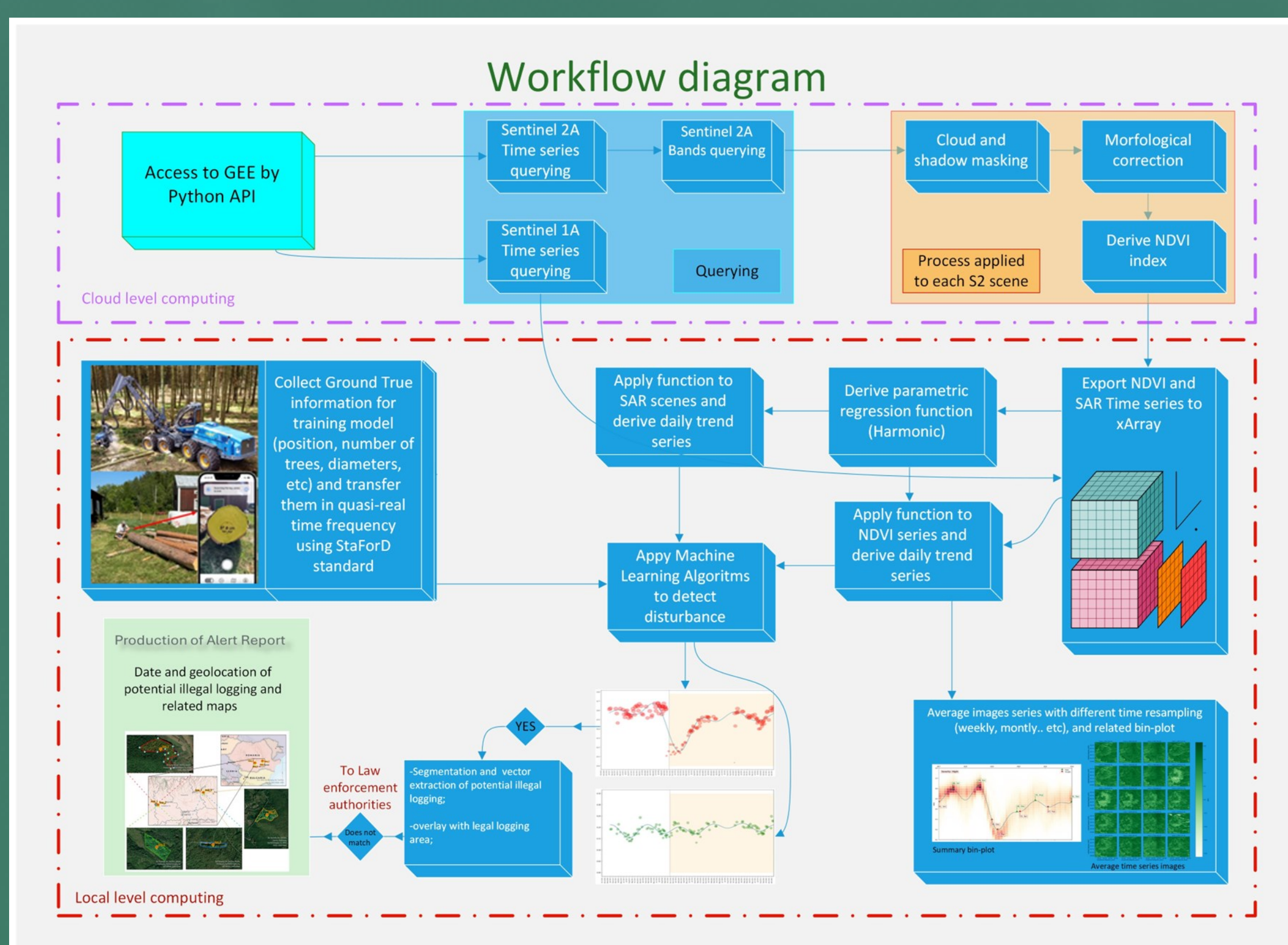• deploy digital tools to facilitate aggregation and active management of fragmented forest ownership.

Figure 1: planned traceability service (example of manual system). 1- marking of standing trees associating a unique ID; 2- felling and processing of trees, associating new items/logs to the original tree; 3- retrieving IDs at roadside; 4 – smart quality-based logistics; 5 - X-ray tomography of logs and association of 3D image to original ID; 6 – tracing sawnwood products up to the final user; 7 – use of digital twin of the original tree to model its reaction to climate, forest management and adversities.

Conclusions

SINTETIC project develops intelligent forest harvest equipment providing digital ground data in near real-time. These data can also be used to continuously feed a monitoring system using AI to develop a Disturbance Detection System (forest cover change). The potential is twofold:
- In the development stage fosterthe ground (true) data is used to train the detection algorithm based on remotely sensed data (Sentinel 1&2 satellites);
- In final application, the information provided by legal logging sites will be used to focus the alert report on unexpected forest cover variations, optimizing the intervention of law enforcement authorities.
Once operative, the integrated system will enhance illegal logging control, foster the traceability of sustainably sourced timber products and the sustainable management of forest resources.