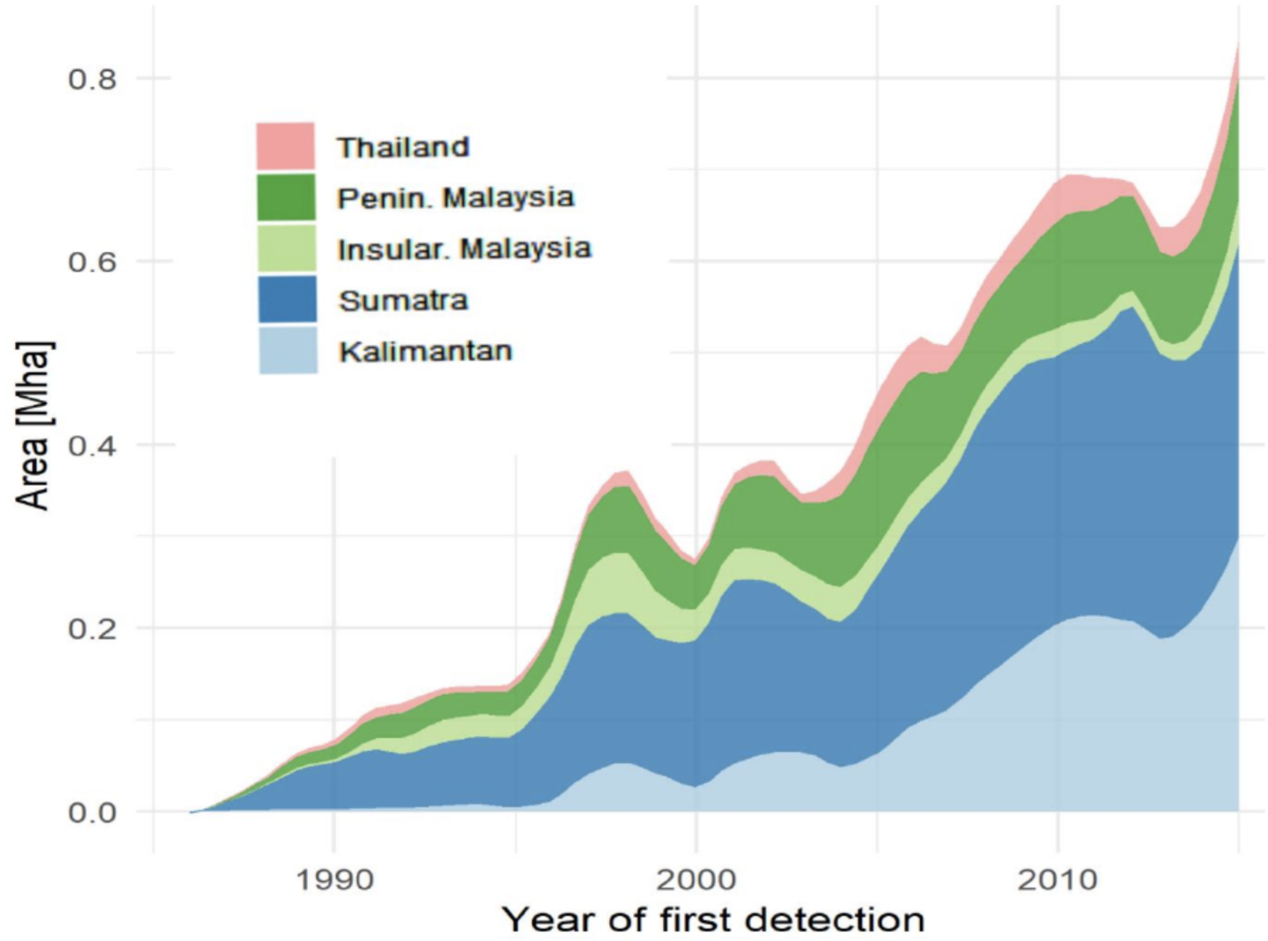
OBSERVER: How do Copernicus data help monitor and understand the impacts of palm oil plantations?

Palm oil production constitutes one of the most rapidly expanding forms of agricultural land use, engendering significant environmental pressure while benefiting regional economies and exceeding yields of similar vegetable oils. Policy makers who aim to strike a balance in meeting increasing palm oil demand while limiting its negative environmental impact can now turn to Earth Observation data to inform their decision making.

Palm oil has become an unsaid staple in diets across the world, as half of all packaged goods in supermarkets contain some form of this vegetable product. Its application in diverse industries, including agriculture energy, combined with the crop’s high productivity has led global palm oil production to increase from 4.5 million tonnes to 70 million tonnes since 1980. By 2050, production is expected to reach 240m tonnes. This significant increase in production has had important environmental and social consequences. However, its economic benefit, especially in impoverished areas, combined with its versatility in food products and superior land use efficiency to similar plant oils increasingly leads farmers to prefer palm oil crops. Monitoring the extent of new plantations is therefore key to making the sector more sustainable.



Dynamics of plantation establishment across Southeast Asia since 1984.(Published in https://www.researchgate.net/publication/339350803_Satellite_reveals_age_and_extent_of_oil_palm_plantations_in_Southeast_Asia)

Currently, almost 90% of oil palms cultivated worldwide are located in Southeast Asia, with Indonesia and Malaysia as the largest producers. While small production of palm oil can be done in a sustainable manner, large plantations pose a greater problem for the environment.

In order to start a new plantation, companies must clear existing vegetation. In Indonesia and Malaysia, this usually means clearing primary forest that is an important source of biodiversity. For example, the number of Sumatran orangutans, the species that has been most affected by this process, has dropped during the last century and is now listed as Critically Endangered.

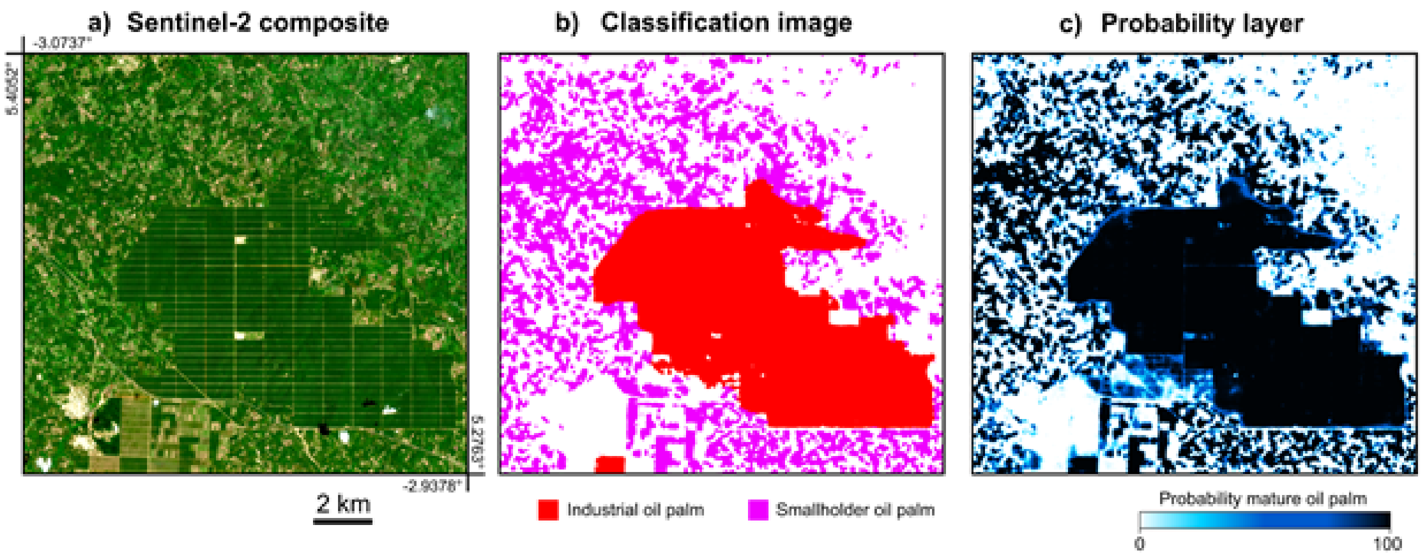
This important environment impact has led many consumers around the world to boycott products containing palm oil. However, banning all palm oil imports, or ending palm oil cultivation, is not a solution. The IUCN, in a 2018 report warns that "*banning palm oil would most likely increase the production of other oil crops to meet demand for oil, displacing, rather than halting, the significant global biodiversity losses caused by palm oil*".

Sustainable production of palm oil is therefore key. For this reason, tracing palm oil production and monitoring existing and new plantations is important. In this context, Copernicus data provide tools that can be used to facilitate this process.

Several organisations around the world are involved in monitoring palm plantations and related issues. Reliable, free and open access data on land cover and land use at the global scale are key to monitor and warn of unsustainable farming practices on palm plantations.

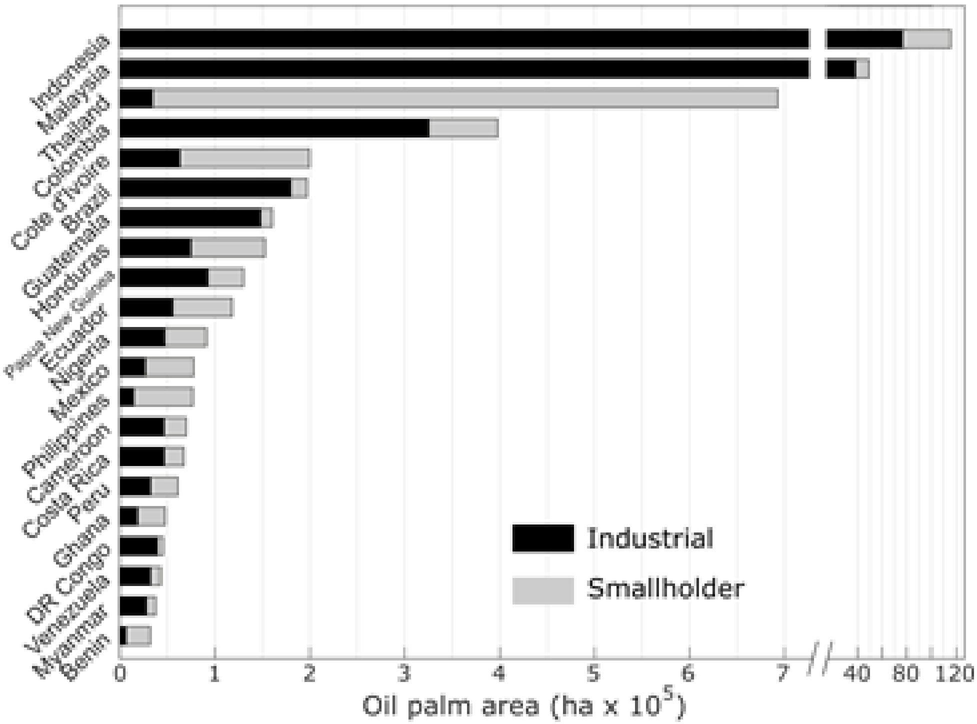
How to find an oil palm plantation?

The availability of new satellite datasets and the advances in machine learning technologies have only recently enabled accurate and updateable maps to detect and measure the area oil palm covers globally. The most recent global oil palm map was published in 2020 (Descals et al., 2020), which employs a state-of-the-art machine learning algorithm (Convolutional Neural Network) and freely available satellite data through the Copernicus programme (Sentinel-1 and Sentinel-2). By combining two different satellite data sources (radar and optical data) this project can accurately detect and quantify oil palm plantations globally. Additionally, it reveals if a plantation is large scale (i.e., industrial) or small scale (i.e., small farm). Moreover, the work also provides a global “probability” map, which indicates how likely it is that a location on the map is an oil palm plantation.



Example of the global oil palm layer in Cote d’Ivoire. The figure shows the clear separation of the industrial and small holder plantations in the area (b) as well as the probability that a location in the map is oil palm farm (c), (from Descals et al., 2020)

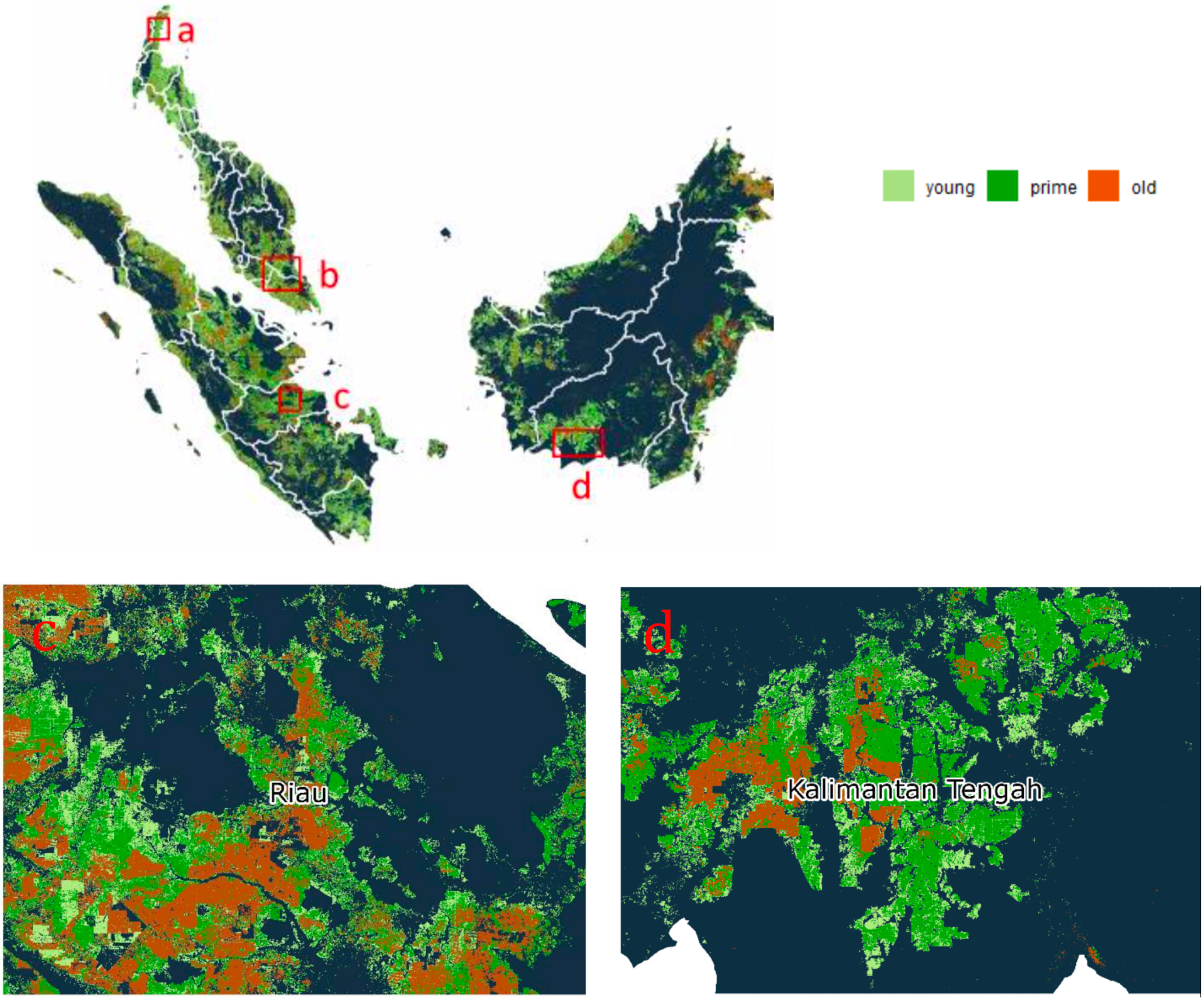
The global oil palm map detected plantations in 47 tropical countries. Southeast Asia showed the largest share of plantations with an area of 17.47 x 106 ha, up to 90%. Results illustrate regional variations, especially between large- and small-scale plantations. The overall oil palm areas at the country-level score close to the FAO reporting. However, Western Africa shows some differences, which the authors connected to the large areas with feral oil palm plantations.



Country level oil palm plantation area per country and typology (large- and small-scale) for the second half-year of 2019 (from Descals et al., 2020)

In another recent paper, Danylo and co-authors (2020) used semi-automatic approaches combining satellite and field information in order to identify palm oil plantations. The availability of free and open Copernicus Sentinel data was key to detecting small farms and importantly, the age of the identified plantations. Age is a significant parameter of a plantation, as it determines perspectives for current and future yields. Palm trees reach their highest oil yield between the ages of 7-15, at which point, oil yield declines and palms have to be replaced by new ones by the age of 25-30.

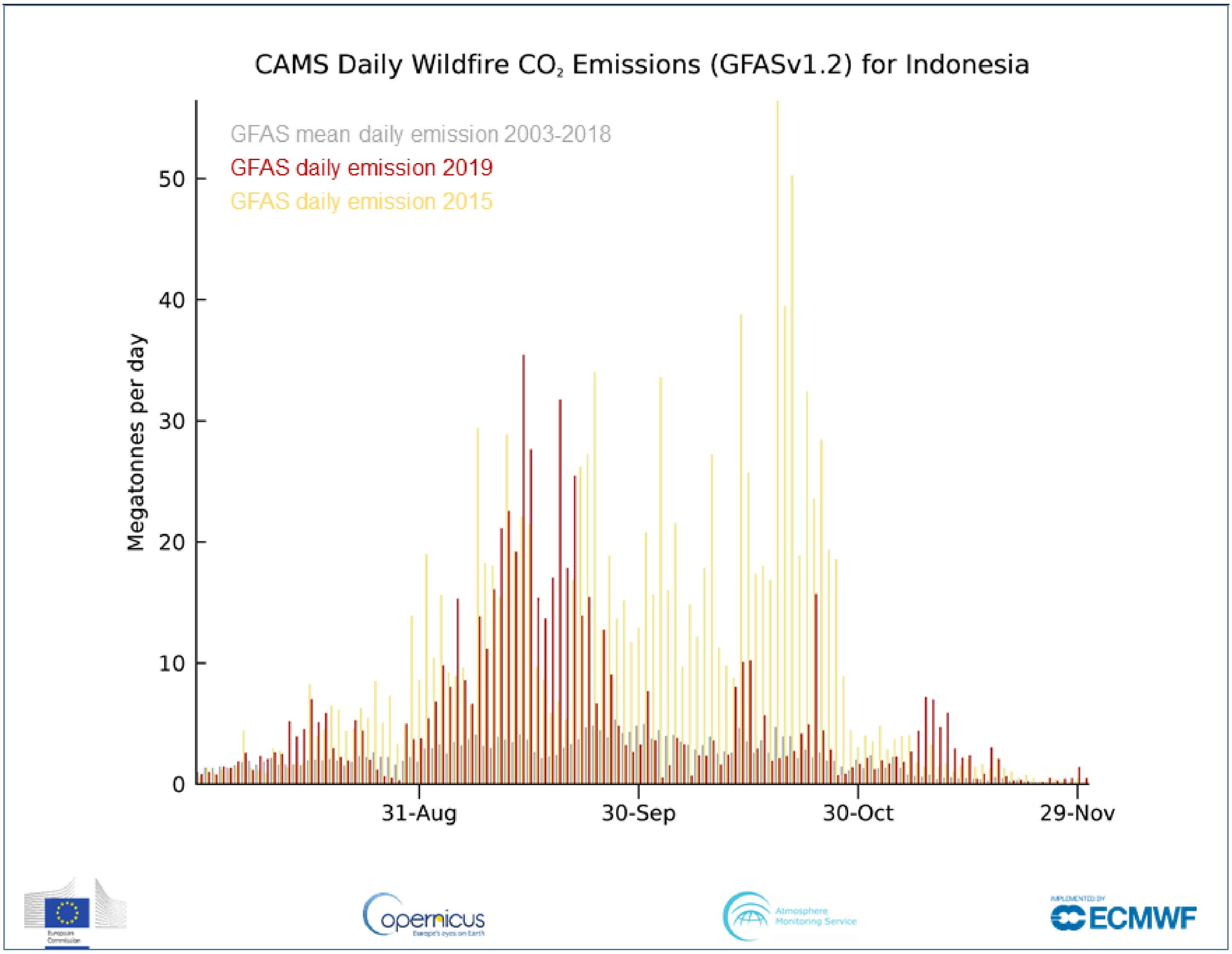
In the paper, the authors used satellite data to detect 11.66 (± 2.10) million hectares of palm oil plantations. Time series of Copernicus Sentinel-1 radar images were used to deploy an algorithm detecting palm oil plantation texture. Subsequently, Copernicus Sentinel-2 high resolution multispectral images were used for post-classification filtering of the oil palm map. According to the authors, more than half the plantations on Kalimantan (Borneo) are younger than 7. On the other hand, on Insular Malaysia, 45% of plantations are older than 15. These results confirm the current trend of increasing production of palm oil in Indonesia.



Extent of oil palm plantations classified by age, as detected by Sentinel data. Maps of extent of oil palm plantations (young <7 years; prime 7-15; old >15 years) across Southeast Asia (top left) and zooming into Indonesia (c) the province Riau in Sumatra, and (d) Southern Kalimantan (published at https://www.researchgate.net/publication/339350803_Satellite_reveals_age_and_extent_of_oil_palm_plantations_in_Southeast_Asia)

Future plantations

Large-scale conversion of rainforests into agricultural land takes place mainly in flat areas with peat soils, the most productive land for agriculture. Land conversion is usually carried out by removing trees and then burning the residues, and is a cheap way of clearing land on a large scale. Thus, once a new plantation is established, the damage to the environment is severe. The Copernicus Atmosphere Monitoring Service (CAMS) can be used to detect fires from the clearing of forests. Indeed, establishing a new plantation usually starts by burning large forested areas. The burning rainforest generates high levels of Green House Gasses, particulate matter and other pollutants. Some common constituents of smoke emissions are PM2.5 (fine particulate matter), NOx and HCN – hydrogen cyanide – especially in the case of peat fires such as those in Indonesia. If the intensity of the burning vegetation is high enough for an active fire to be observed by satellite, this information is used in the CAMS Global Fire Assimilation System, to estimate the equivalent CO2 emissions.



CAMS daily total estimated wildfire CO2 emissions for Indonesia, comparing 2019 (in red) with 2015 (in yellow) and the 2003-2018 mean (in grey), showing the comparability of recent emissions to the same days in 2015. It should be noted that the data recorded in 2015 and 2019 were unusually high as they are related respectively to the El Niño and to the Indian Ocean Dipole phenomena. Indeed, while September-October represents the peak of the dry/fire season in Indonesia emissions are not often this high (Copernicus Atmosphere Monitoring Service/ECMWF https://atmosphere.copernicus.eu/copernicus-atmosphere-monitoring-service-tracks-extent-and-pollution-fires-across-indonesia).

According to CAMS, fires detected by the service across Indonesia "*have been started deliberately in order to clear land for agriculture, in particular for paper and palm oil*". In addition to the destruction and degradation of the landscape and forests, there is also an increase in air pollution. "*Smoke from the fires is polluting the air in Malaysia and neighbouring states, threatening the health of the local population as well as the natural forests and wildlife*". CAMS monitors global fires and estimates the emissions they cause using satellite observations of active fires. Forecasts of the impacts on atmospheric composition and air quality are available both globally and regionally. For example, Southern Asia surface level PM2.5 forecast and biomass burning aerosol optical depths forecast are available.

Additionally, fire monitoring is also among the products provided by the global component of the Copernicus Land Monitoring Service. The Burnt Area product monitors burnt scars and gives temporal information on the fire season. It can provide valuable data regarding forests being burned to establish new palm plantations. The product is available in 1km and 300m spatial resolution at the global scale.

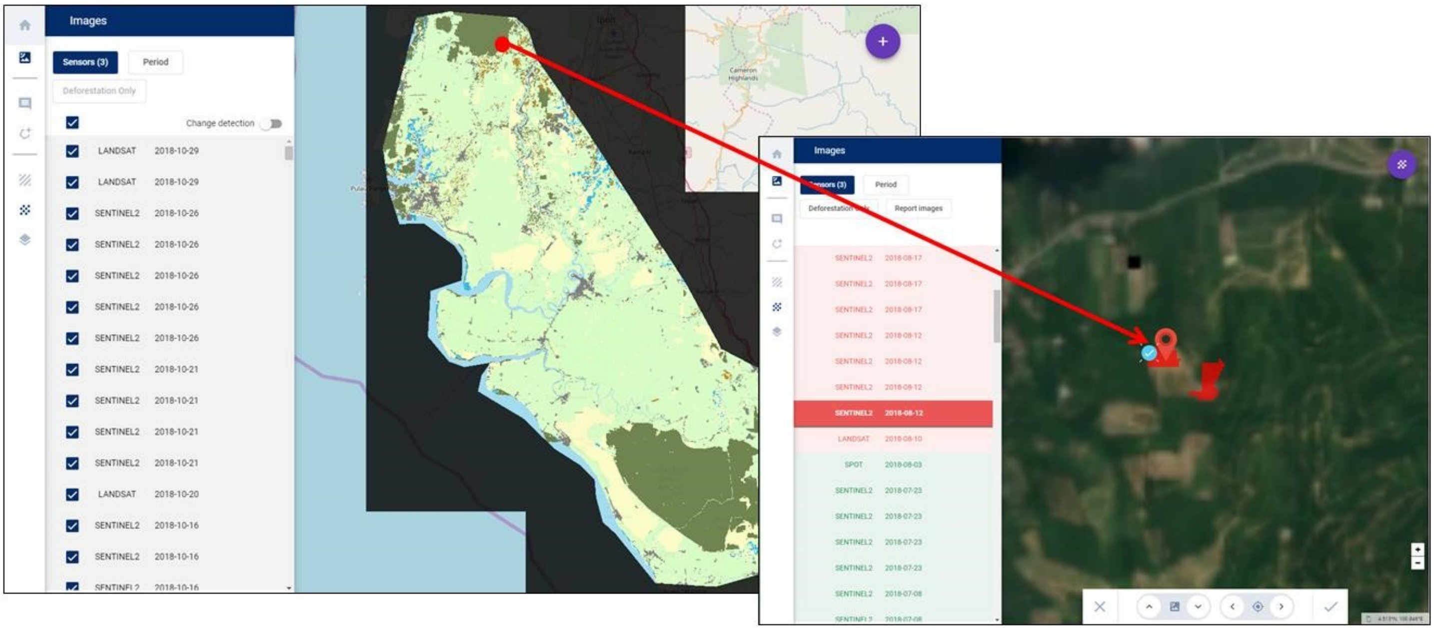
FIg X Sentinel-2 image showing the various stages of the deforestation process — the green patches in the plantations are the well-established palm oil farms, while the light brown patches show the newly-harvested land. The surrounding lush rainforest is visible in dark green. https://www.esa.int/ESA_Multimedia/Images/2019/07/Palm_oil_plantations

Monitoring conservation commitments

It is challenging to make sure that palm oil is being sustainably produced, but companies in different industrial sectors are leading the transition and push for change.

Satellite-based systems can play an important role in monitoring their commitments. Copernicus Sentinel satellites play a significant role in the Starling service, which was created by Airbus and The Forest Trust (TFT) in 2017. The service has provided a monitoring tool for food supply chain companies that have made ambitious forestry conservation commitments. Satellite images from Copernicus and others, provide accurate information complementing traditional in situ auditing methods, which are limited in spatial coverage and frequency. The Starling service can detect changes made to forest cover as small as 0.5 ha and provides a base map of forest classes, and land cover evolution. This tool monitors forest cover change and creates reports that can shared with company's customers and other stakeholders.

A major challenge faced in monitoring tropical deforestation using satellite imagery is quasi-permanent cloud cover over tropical areas. Despite the challenging atmospheric conditions, 98% of localities covered by the Starling service can be observed cloud-free more than four times a year. To overcome limitations posed by clouds, the service has used a combination of optical and radar satellites from Copernicus Sentinels, Landsat, SPOT and other sources. During the first 18 months of operation, the service processed thousands of Copernicus Sentinel-2 images. For example, they processed 3500 Sentinel-2 scenes for the Sumatra Island alone.



A Basemap of an Indonesian site which was produced using Copernicus Sentinel-2, Landsat, and SPOT images, at 20m resolution. All images were used for change detection in forest classification (dark green area). (*published* here*)*

Similar efforts are conducted by Satelligence, a space company focused on deforestation, and Robeco, an international asset management company. They aim to address sustainability issues in the palm oil industry by using the amount of land under cultivation that has been certified by the Roundtable on Sustainable Palm Oil (RSPO) as the key benchmark for measuring the progress in the sector. For the analytics, Satelligence used data from Copernicus satellites (especially Copernicus Sentinel 1).

Placing environmental research on Palm Oil impacts in context

The salience of palm oil production in environmental discourse has directed research and media attention onto the crop’s effect on biodiversity while largely ignoring the impact of other vegetable oils. Alternative vegetable oil crops can cause similar, to more severe environmental damage to a region and its biodiversity. Soybean, as a comparable crop, needs 5 times as much land area to produce a litre of oil than oil palm. Yet, oil palm remains the most researched crop. According to a recently published study with scientific contributors working also for Copernicus Global Land, additional research (and mapping) is needed on alternative vegetable oil crops in order to objectively evaluate the effectiveness and impact of palm oil production. The study maintains that palm oil plantations pose a serious threat to biodiversity and add additional factors for consideration; including climate emissions, regional demands, economic and socio-cultural aspects. In doing so, the authors envision a holistic methodology to assess and understand the trade-offs selecting a particular vegetable oil crop.

What does the future hold?

Palm oil is both an integral product for diverse industries and a high earning export crop for developing economies. However, if the current state of production continues, ancient forests and endangered species will disappear. If companies and consumers are more aware of the production process and costs to the environment, sustainable production of palm oil is more likely to become the norm.

The Copernicus Land Service and Global Land component actively promote the uptake of their free and open services to support the European Green Deal. Achieving this Commission priority, and others related to land use and biodiversity, requires Earth Observation data to inform policy decisions and empower industry geospatial tools. To make this information and technology more accessible to stakeholders, scientists from the European Commission's Joint Research Centre, which currently operates the Global Land component of the Copernicus Land Service have designed and created the foundation of a new system for monitoring palm oil crops. This new system supports on-demand, customised land cover products at various scales. What remains now is the initiation of a dedicated scientific programme.

The tools of knowledge and progress for environmental and social stewardship in vegetable oil production exist in the Copernicus Services. Uptake of this information by the public and private sector bring the EU and global community closer to achieving their sustainable development goals. Demand for palm oil seems unlikely to wane; therefore, informed decision making remains essential to the success to the land, life, and way of life of peoples around the globe.