

# Forest monitoring in the global climate change context: Added value of remote sensing for REDD+ and beyond

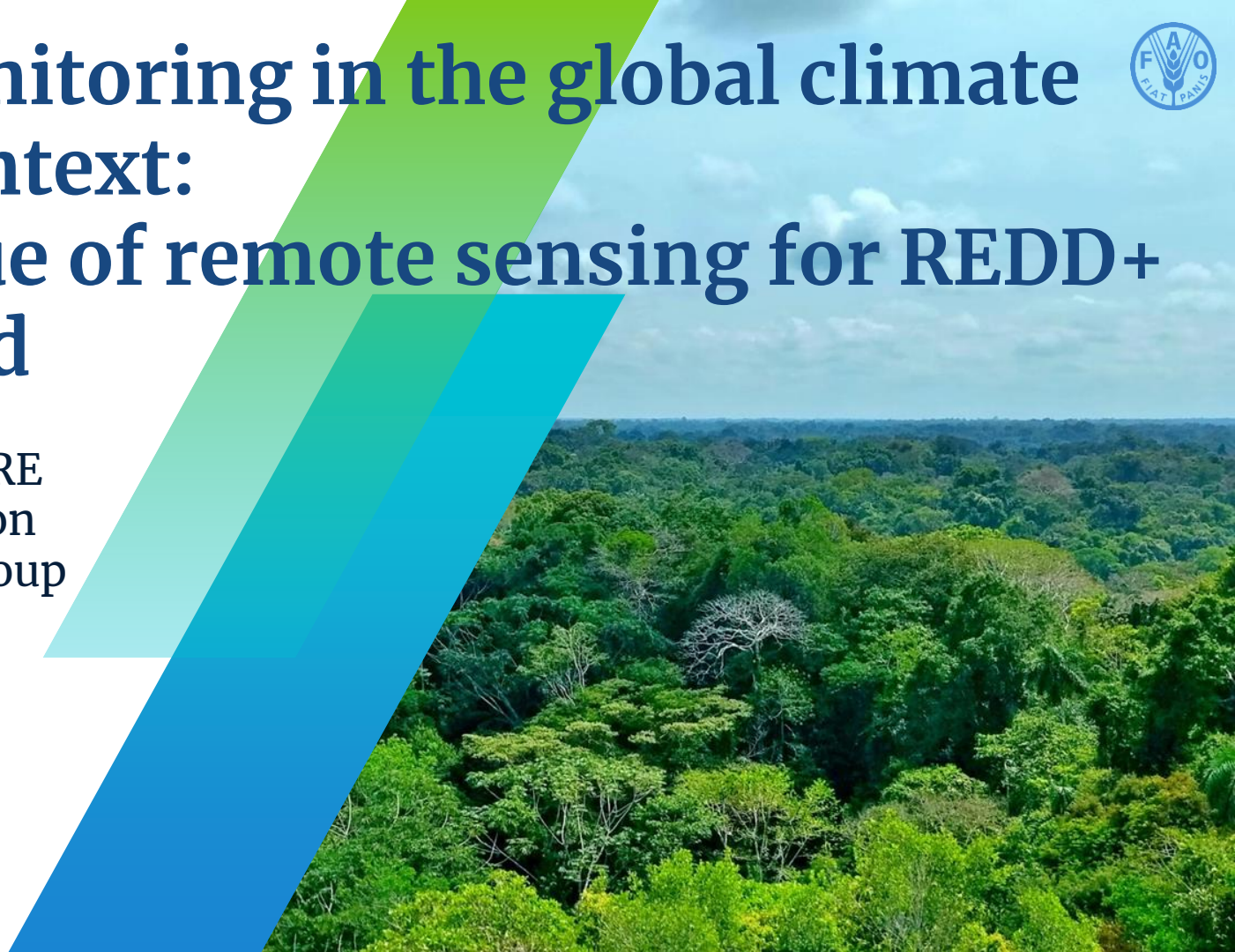


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Forest & Climate Group

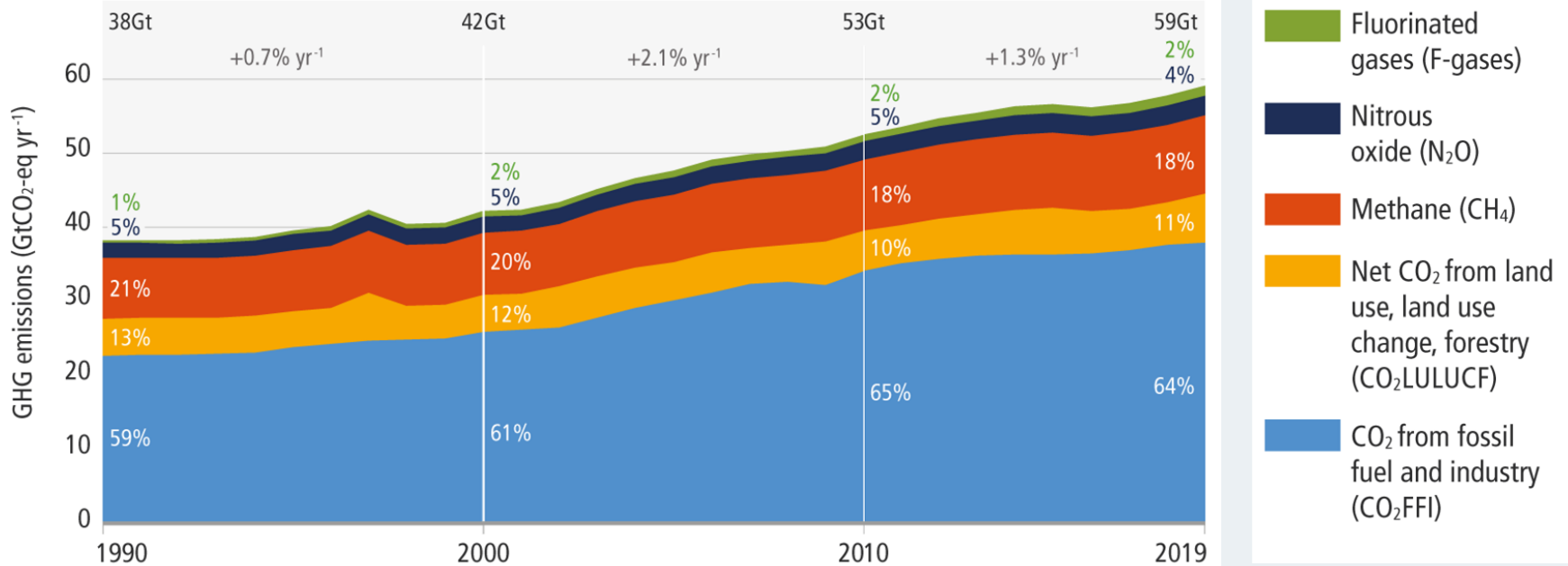
ESA ESRIN, October 2022

 SilvaCarbon

 THE WORLD BANK



# We are not on track to limit warming to 1.5 °C.



# Background



Environmental change: climate crisis is here and now (IPCC, 2022): monitoring & forecasting land (cover/use) has become crucial more than ever to

**Global scale:** variety of data/data sources

**National scale:** global data used nationally or national data for different (international) reporting frameworks

FAO/SilvaCarbon in collaboration with ESA, academia and other partners have developed tools to assist countries in measurement, reporting, and verification (MRV) through GFOI

# REDD+ reporting to the UNFCCC

Reference level submissions to the UNFCCC

Belize  
 Bhutan  
 Burkina Faso  
 Colombia  
 Dominican Republic  
 Ecuador  
 Equatorial Guinea  
 Honduras  
 Kenya  
 Liberia  
 Malawi  
 Mexico  
 Pakistan  
 Sudan  
 Togo

Brazil  
 DRC  
 India  
 Lao PDR  
 Madagascar  
 Malaysia  
 Mongolia  
 Mozambique  
 Myanmar  
 Nigeria  
 Panama  
 Suriname

Argentina  
 Bangladesh  
 Guinea-Bissau  
 Malaysia  
 Nicaragua  
 Nigeria  
 Solomon Islands

Cambodia  
 El Salvador  
 Gabon  
 Ghana  
 Peru  
 Saint Lucia  
 Suriname  
 Thailand  
 Zambia

Dominica  
 Dom. Republic  
 Guatemala  
 Indonesia  
 Panama  
 Paraguay

Brazil  
 Colombia  
 Ecuador  
 Guyana  
 Malaysia  
 Mexico

Chile  
 Congo  
 Costa Rica  
 Ethiopia  
 Indonesia  
 Paraguay  
 Peru  
 Viet Nam  
 Zambia

Brazil  
 Cambodia  
 Côte d'Ivoire  
 Ghana  
 Honduras  
 Madagascar  
 Nepal  
 PNG  
 Sri Lanka  
 Uganda  
 Tanzania

**2014**

Brazil

**2015**

**2016**

Colombia  
 Malaysia  
 Ecuador

**2017**

Brazil

**2018**

Chile  
 Colombia  
 Indonesia  
 Paraguay

**2019**

Brazil  
 PNG  
 Argentina  
 Costa Rica

**2020**

Uganda  
 Lao PDR  
 Cambodia

**2021**

Honduras  
 Brazil  
 Vietnam  
 Belize  
 Indonesia  
 Gabon

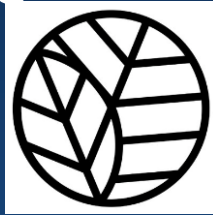
**2022**

Argentina  
 PNG  
 Mexico

UNFCCC REDD+ results:  
 11.5 billion t CO<sub>2</sub>

# The complicated landscape of carbon finance opportunities

Results-based payments



Compliance markets



Voluntary carbon markets



## Monitoring and policy needs (here and now)

- Better data, better decisions? E.g. 10 years of UN-REDD
- Need for (better) integration of measurable field, airborne and space borne RS parameters with practical land/forest (monitoring) solutions and policy implementation
- Support research needed in the domains of agriculture, food security, raw materials, soils, biodiversity, environmental degradation and hazards, inland and coastal waters, and forestry
- **Mitigation** efforts versus **adaptation**: new monitoring field to be explored, f. e. agricultural practices/management through Chl, N in soils

# FAO Applications and Resources

A short overview

# Open Foris initiative

[www.openforis.org](http://www.openforis.org)

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Free and open source tools and methods for data collection, analysis and reporting



## Arena

Online platform for survey design, data management, utilization and processing



## Collect

Easy and flexible survey design and data management



## Collect Mobile

Intuitive data collection and validation in the field



## Calc

Efficient and collaborative data analysis and results dissemination



## Collect Earth

Easy and flexible survey design and data management



## Collect Earth Online

Online Land Monitoring tool for crowd-sourcing of augmented visually interpreted data



## Earth Map

The power of Google Earth Engine without coding. A user friendly tool for complex land monitoring



## SEPAL

System for earth observation, data access, processing, analysis for land monitoring



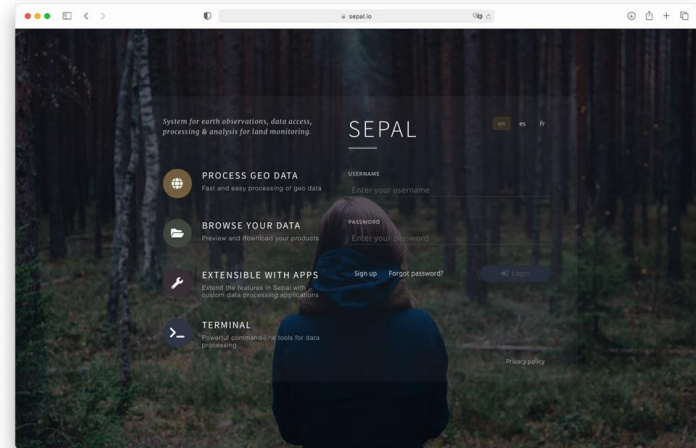
# Key principles

- **FAO-led initiative**
- **Free and open source:** approx. 30,000 downloads since 2016; source codes are available in [GitHub](#).
- **Software development:** new and improved versions of the tools are released periodically.
- **Collaboration:** FAO [Hand-in-Hand](#) Initiative; private and public partners (e.g. Google, NASA-Servir); academic institutions; projects.
- **Country testing:** OF tools have been used in more than 130 countries.
- **Capacity building:** training sessions on all OF tools in all regions of the world.
- **Implementation:** more than 44 countries have integrated OF tools in their forest monitoring systems.

# SEPAL: Earth Observation and cloud computing



- SEPAL is a cloud based platform for accessing, processing and analysing geospatial data for land monitoring
- SEPAL is free and open: anyone can register for access to its features: <https://sepal.io>
- All you need is an Internet connection to access the SEPAL website



esa

ETH zürich



KFW

SilvaCarbon



Google



# SEPAL

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*System for earth observations, data access, processing & analysis for land monitoring.*

Signup

Launch



# SEPAL <https://sepal.io>

## SEPAL provides many capabilities



Search and process  
satellites imagery



Access super computers

Mobile and tablet  
compatibility

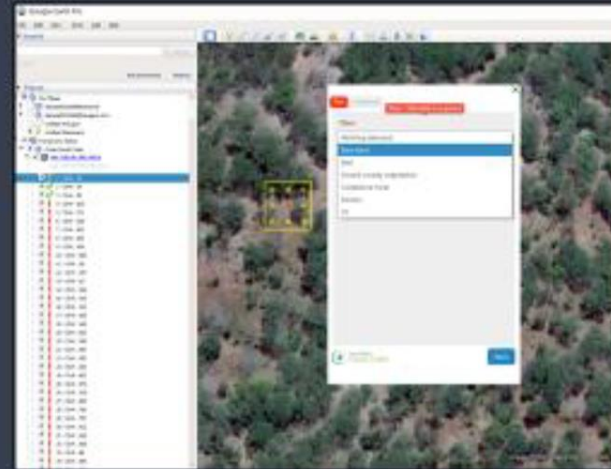
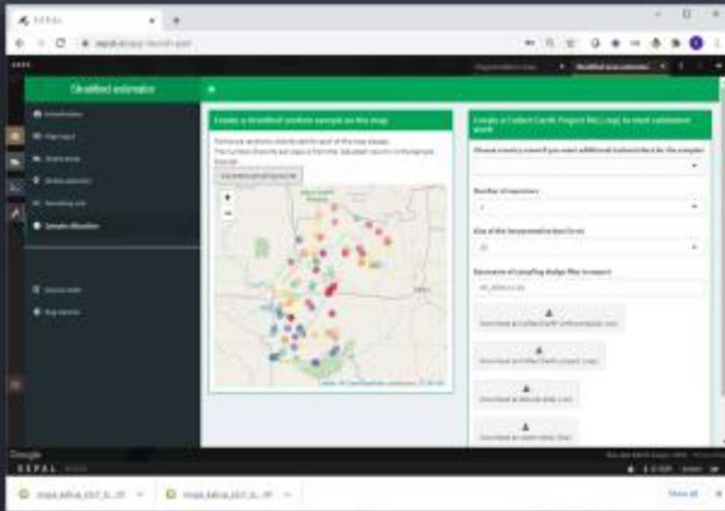


Store and access data



Analyze data using predefined  
processing chains

# SEPAL -module example



module name :  
Stratified estimator design

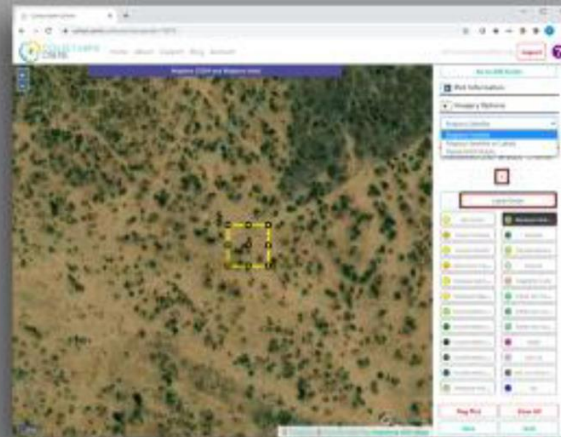
Stratified Random Sampling for Accuracy Assessment

# SEPAL

## Link to Collect Earth and Collect Earth Online

Collect Earth can be used with  
Sepal to produce training data.

Follow our tutorials for more  
information





# Collect Earth

Visual interpretation tool for land use/cover classification and change detection with access to high and very high resolution satellite imagery

# Augmented Visual Interpretation

Data Collection tool integrated in Google Earth.

Free access to Very High Resolution imagery.

Multitemporal imagery thanks to Google Earth, Bing Maps and High Resolution

The screenshot displays the Google Earth Pro interface with a data collection tool. The main window shows a 3D terrain map of a mountainous region with a grid of yellow markers. A sidebar on the left lists 29 data points with their IDs. A zoomed-in view of a grid cell shows a yellow box around a red marker. A pop-up window on the right provides a detailed view of the selected cell, showing the latest available image (2016) and a table of vegetation cover percentages for various types: Tree (40-49%), Shrub (0%), Palm (0%), Bamboo (0%), and Crop (0%). The Tree Count is 17 and the Shrub Count is 0.

Vegetation type	Vegetation cover
Tree	40-49%
Shrub	0%
Palm	0%
Bamboo	0%
Crop	0%

Tree Count: 17  
Shrub Count: 0





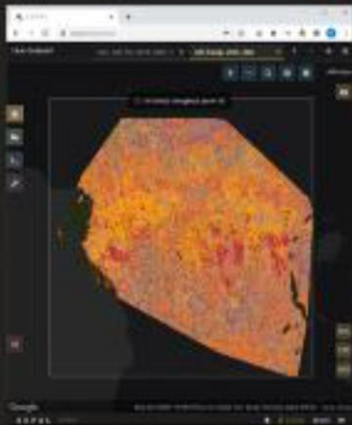
# Collect Earth Online

Visual interpretation tool for land use/cover classification and change detection with access to high and very high resolution satellite imagery

Used globally

## Fusion Optical and radar data

ALOS



LANDSAT 8



ALOS + LANDSAT 8



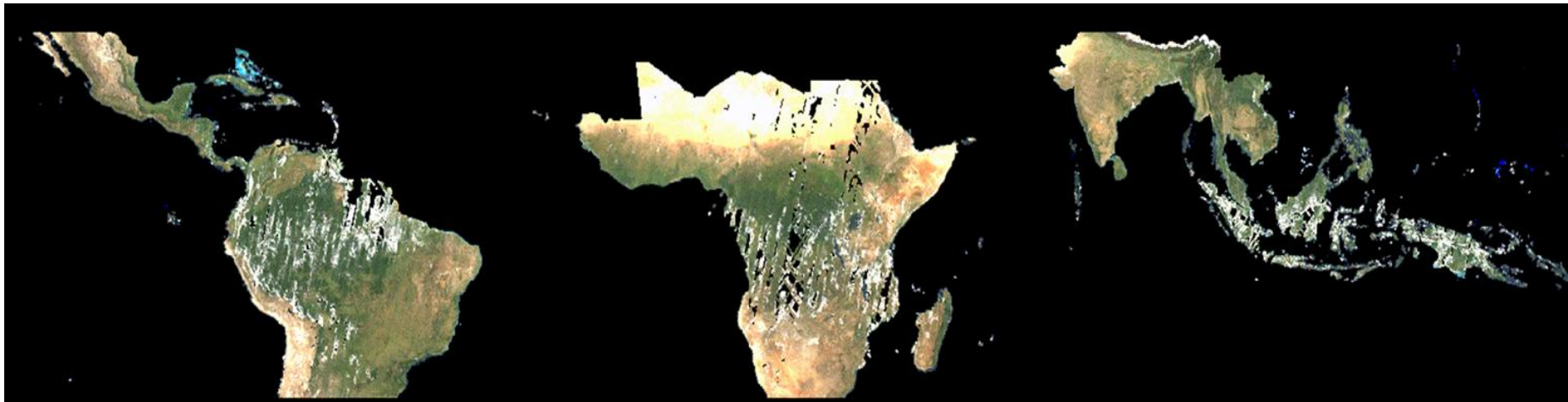
Carrasco, L., O'Neil, A.W., Morton, R.D., Rowland, C.S. Evaluating Combinations of Temporally Aggregated Sentinel-1, Sentinel-2 and Landsat 8 for Land Cover Mapping with Google Earth Engine. *Remote Sens.* 2019, 11, 288. <https://www.mdpi.com/2072-4292/11/3/288>

Hirschmugl, M., Sobie, C., Deutscher, J. and Schardt, M., 2018. Combined use of optical and synthetic aperture radar data for REDD+ applications in Malawi. *Land*, 7(4), p.116.

Joshi, N.; Baumann, M.; Hammer, A.; Fensholt, R.; Grogan, K.; Hostert, P.; Jepsen, M.R.; Kuemmerle, T.; Meyfroidt, P.; Mitchard, E.T.A.; Reiche, J.; Ryan, C.M.; Wasko, B. A Review of the Application of Optical and Radar Remote Sensing Data Fusion to Land Use Mapping and Monitoring. *Remote Sens.* 2016, 8, 70.

Chang, Chis-Hao & Hsieh, Yi-Ta & Wu, Shou-Tsung & Chen, Chau-Tzuin & Chen, Jan-Chang. (2015). Applying Image Fusion to Integrate Radar Images and SPOT Multi-spectral Satellite Images for Forest Type Classification. *Taiwan Journal of Forest Science.* 30. 201-209.

## Planet data



Pan-tropical, high-resolution data offer amazing opportunities

(Slides courtesy of R. D'Annunzio)

▼ Filter Change Type



Select Change Type

- All -

▼ Filter Country



Select Country Code

Select Driver(s)

Artisanal Agriculture



Settlements



Infrastruture



Artisanal Mine



Industrial Mine



Artisanal Forestry



Industrial Forestry



Industrial Agriculture

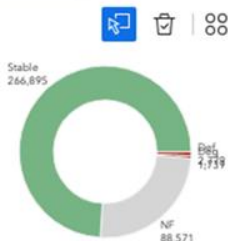
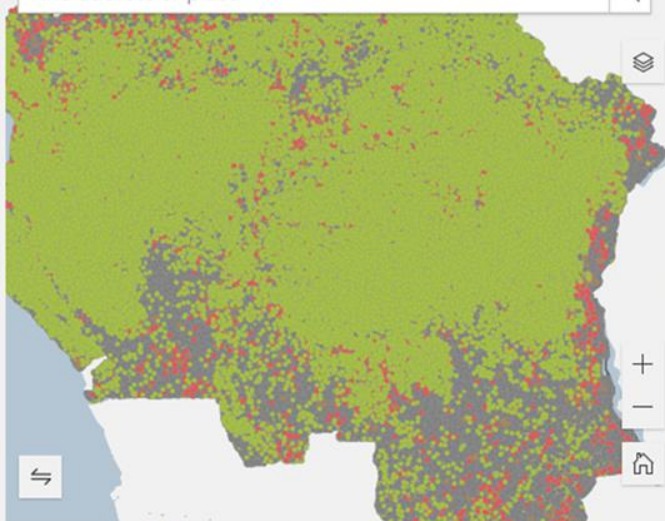


Other



Total points: 359,978

Find address or place



Change Type

Add additional information

Comment on validation data



To enter information on a plot, select it in the map



< 1 of 359984 >



Validation Plot: 1

ISO	COG
LON	15.667202
LAT	-0.916955
CUSUM Code	203
CUSUM date	2019.5369873
REACT C...	*

Validation data

Planet Data

- Planet Medres Normalized Analytic 2020-12 Mosaic
- Planet Medres Normalized Analytic 2020-11 Mosaic





# LandTrendr summary

## Example: What you'll learn about mapping forest disturbance

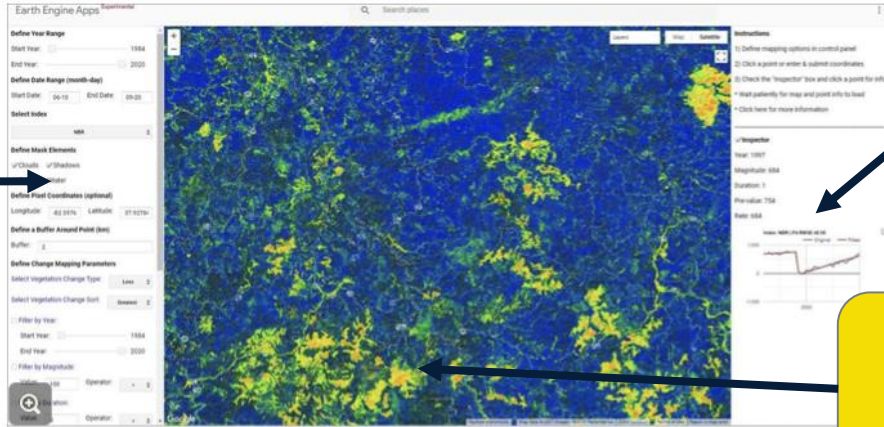


Use a graphical user interface

b. UI LandTrendr Change Mapper

Change Mapper Algorithm

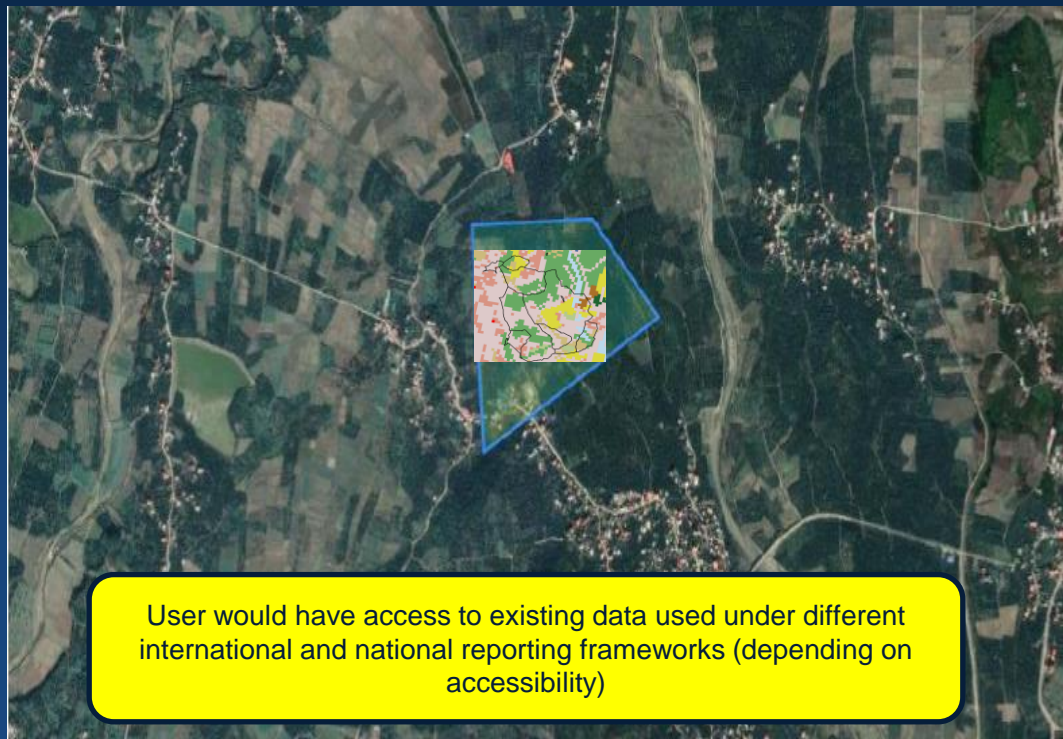
Control algorithm behavior



Interpret time-series data

Make maps of disturbance

# A FERM Platform for monitoring terrestrial ecosystem restoration



User would have access to existing data used under different international and national reporting frameworks (depending on accessibility)

## Area of Interest

- GADM/GAUL
- Upload your AOI
- Design your AOI

## Layers by ecosystem components

- Soil
- Water
- Vegetation

## Layers by climatic zone

- Subtropical
- Temperate
- Dry
- Tropical

## Prepare your indices

- Link to modules in SEPAL
- Download (.shp, .tif, .kml, .xls, etc.)

# Different frameworks, similar indicators, same data?



Convention on  
Biological Diversity



United Nations  
Framework Convention on  
Climate Change



United Nations  
Convention to Combat  
Desertification



And others

We map frameworks related to ecosystem restoration and develop a database which contains the data, indicators, criteria, targets, etc.



Food and Agriculture  
Organization of the  
United Nations

# TAKE HOME MESSAGES and link with EO

-**Agriculture, forestry and other land use** can not only **provide large-scale GHG emissions reductions, but also absorb and store CO<sub>2</sub> at scale**. Well-designed measures can benefit biodiversity, help us adapt to climate change, secure livelihoods, improve food security and wood supplies. Agroforestry, reforestation, avoiding deforestation, managing soils and sustainable livestock management can enhance productivity, improve livelihoods and provide renewable energy.

-Positive impacts of certain **international and climate policies** on reducing emissions have been shown as for example deforestation, it argues that it is too early to say whether zero-deforestation pledges from the public and private sectors can be effective.

-- Achieving ambitious climate goals relies on **international cooperation**. Transnational partnerships are playing a growing role as technology, knowledge and experience are shared.

-**Earth Observation with long data records** and data over remote places can help in

- Validation of (climate and other) models
- Monitoring and early warning: imaging spectroscopy!
- Process understanding
- Importance of free and open EO data



## RS for global climate change : our wish list from policy side

- Support in mapping **changes in land cover/use** and help sustainable forest management and agricultural practices:  
ADAPTATION
- Detect **soil properties** for action on improving soil health
- Support **forest management** and assessments on biodiversity, ecosystem sustainability and environmental degradation, and to monitor lake and coastal ecosystems including water quality.
- New products and services in the domain of agriculture, food security, raw materials, soils, biodiversity, environmental degradation and hazards, inland and coastal waters, and forestry.

## Way forward interlinking end users and scientific community

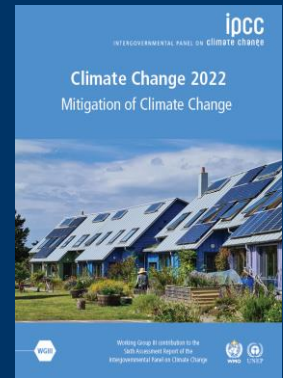
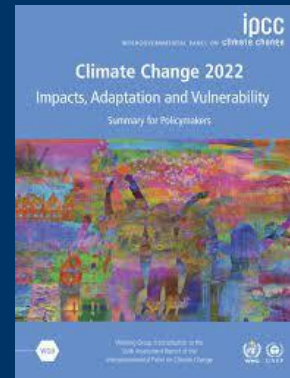
- Taking into account **user requirements** in the domains of forest monitoring
- **User inclusion** from the concrete (project) start
- **Data ownership** for end users
- Important **policy frameworks**, among others

UN SDGs [(Sustainable Development Goals), SDGs 2, 12 and 15], the EU Common Agricultural Policy (CAP), the EU Raw Materials Initiative, the UN Convention for Combating Desertification and Land Degradation, the Soil Thematic Strategy and the Soil Framework Directive, the EU Water Framework Directive and the UN Convention on Biodiversity (Aichi Targets).

# Sixth Assessment Report

WORKING GROUP II & III – ADAPTATION & MITIGATION OF CLIMATE CHANGE

“ The evidence is clear:  
The time for action is now



Thanks for your attention!

More info on [www.fao.org](http://www.fao.org)

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