The role of Earth Observation and AI in forest monitoring

Way forward for climate mitigation and adaptation

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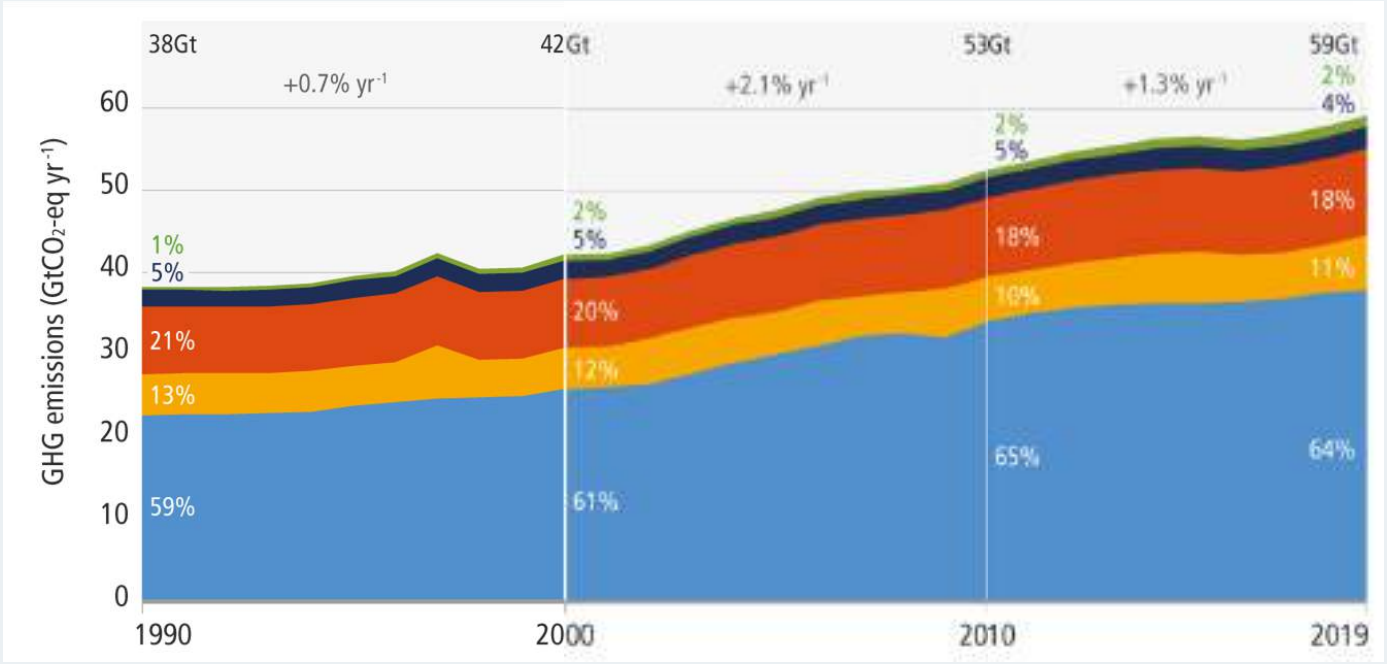
FAO Forestry Division
Forest & Climate Group

Project Meeting, Windhoek, Nambia
20 Sept 2023

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 forest and 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/NASA, academia and other partners have developed tools to assist countries in measurement, reporting, and verification (MRV) through GFOI

It all starts with...

...data!

to predict, mitigate and respond to forest disturbances, and enable more effective and sustainable forest management as well as adaptive measures.

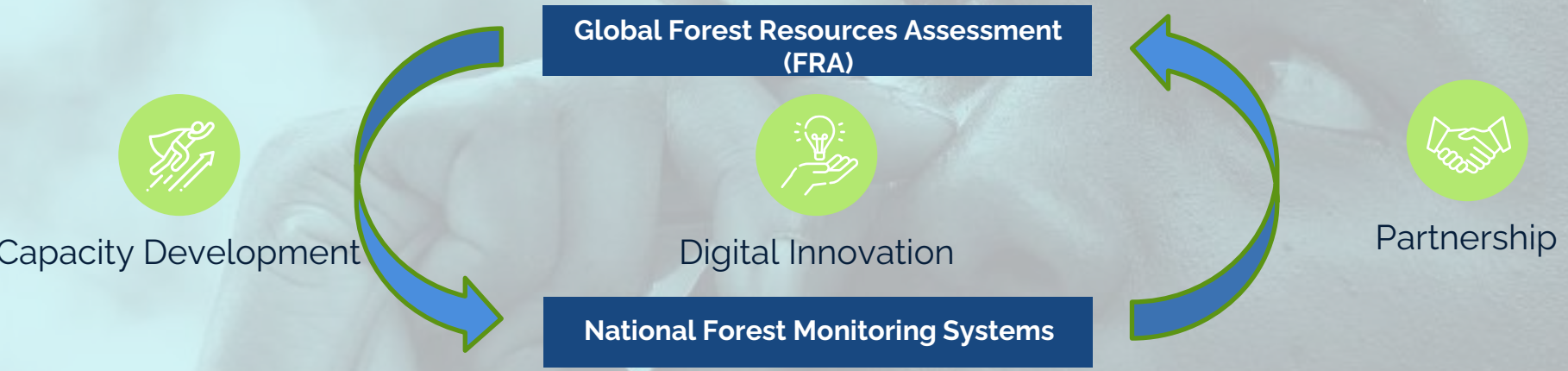
National Forest Monitoring, MRV and Platforms

VISION: Innovative, accurate, and transparent forest monitoring can unlock the potential of forests for climate action and many of the other benefits that forests provide.

HOW WE WORK: We build platforms and capacity for the collection of data, for the creation of critical forest information by those who manage forests and are at the front line in mitigating and adapting to climate change.

50 years of support and expertise

In ***National Forest Monitoring***



satellite land monitoring systems	national forest inventory	greenhouse gas inventories	forest reference emission levels

Open Foris

Developed in collaboration with over 70 countries and partners

FAO's first open-source initiative launched in 2011

Now open-sourced DPGs mainstreamed across FAO

35,000

Users

of Open Foris

>195

Countries

Used Open Foris

FAO membership to the Digital Public Goods Alliance

OpEd - How Digital Innovation Has Accelerated Monitoring of the World's Forests

COFO Information Note on Digital innovation for data collection and dissemination on forest resources, their management and uses

10 years work on MRV - reporting (UNFCCC, FCPF, GCF etc.)
90% of countries used *OpenForis*
70% received Technical Assistance from NFM

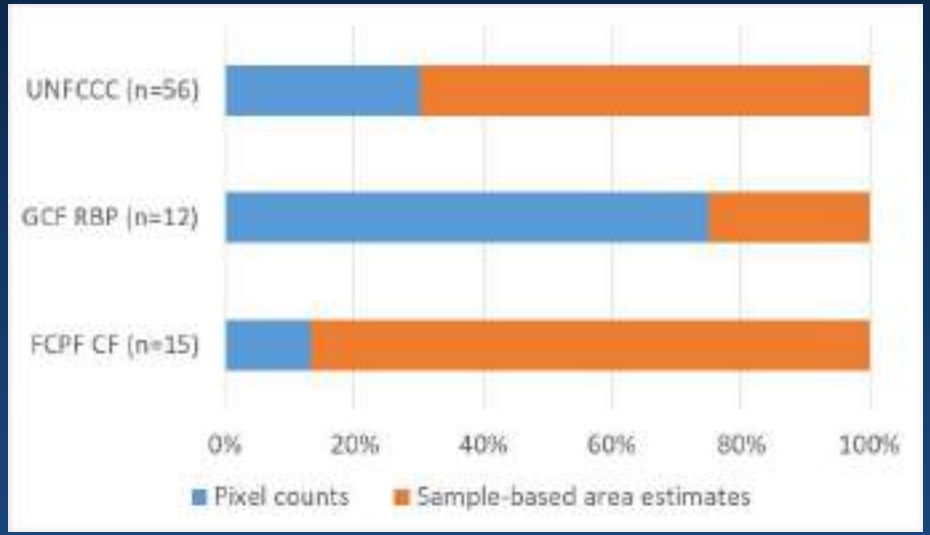
87 FRL submissions

28 REDD+ result submissions

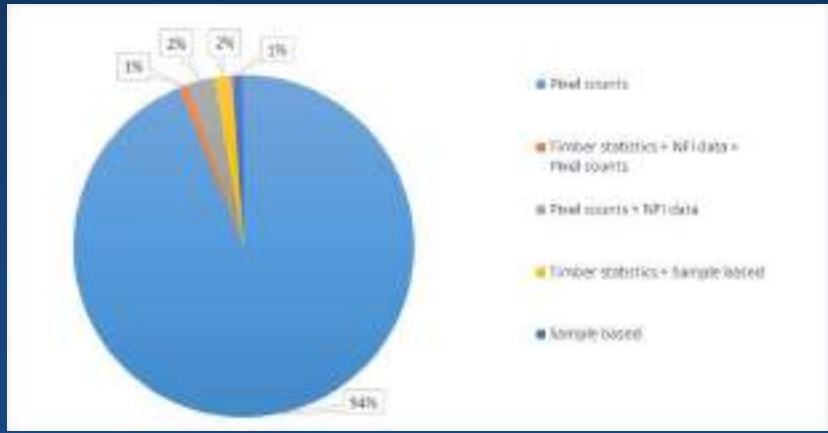
13.7 billion t CO_2 reductions / enhancements

Methods Activity Data

Reference levels

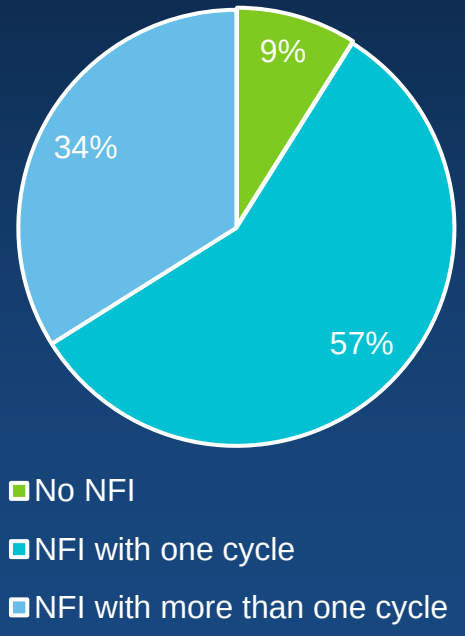


Results reported UNFCCC



Methods Emission Factors

countries submitting reference level to UNFCCC:

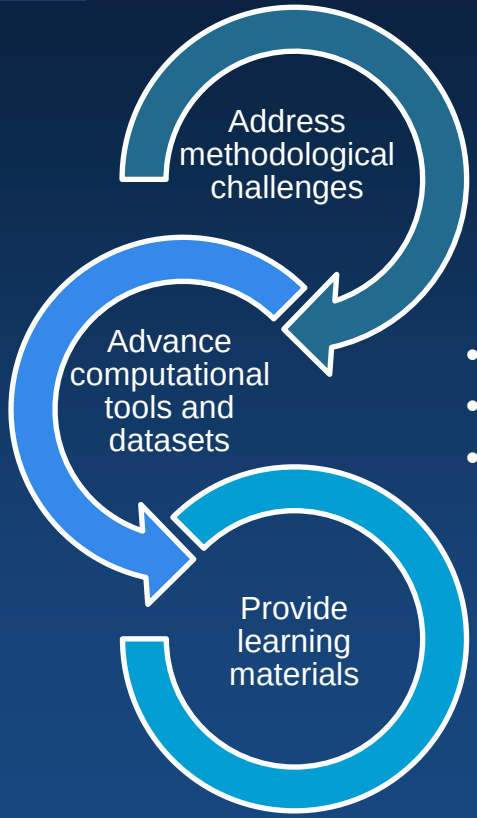


Most countries have NFI or inventory data suitable for deforestation EF

Challenges:

- NFI data for degradation EF
- NFI data for A/R
- Take advantage of multiple cycles

How to progress towards high-integrity data



- Sample-based area estimation
- Forest degradation
- QM in emissions inventories

- SEPAL
- Forest regrowth rates
- Peatland decomposition rates

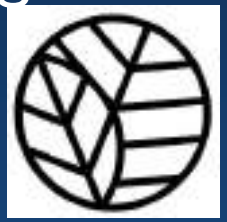
- E-learning
- GFOI Family of Resources

The landscape of carbon finance opportunities

Results-based payments

Compliance markets

Voluntary carbon markets



FAO Applications and Resources

A short overview

Open Foris initiative

www.openforis.org

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

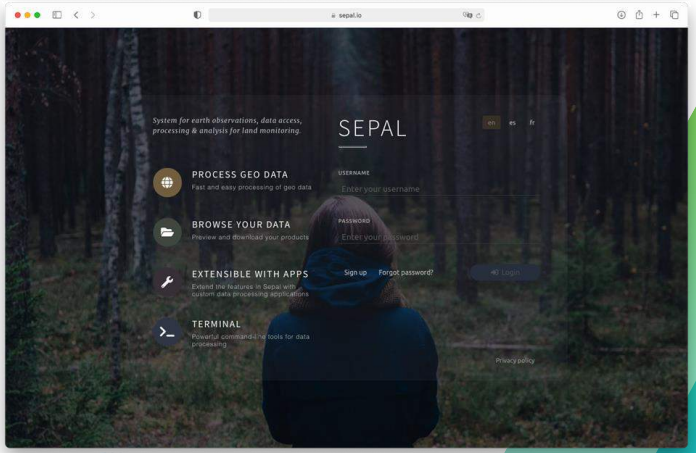
- **FAO-led** initiative
- **Free and open source:** approx. 30,000 downloads since 2016; source codes are available in GitHub.
- **Software development:** new and improved versions of the tools are released periodically.
- **Collaboration:** FAO Hand-in-Hand Initiative; private and public partners (e.g. 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.

Data vs information

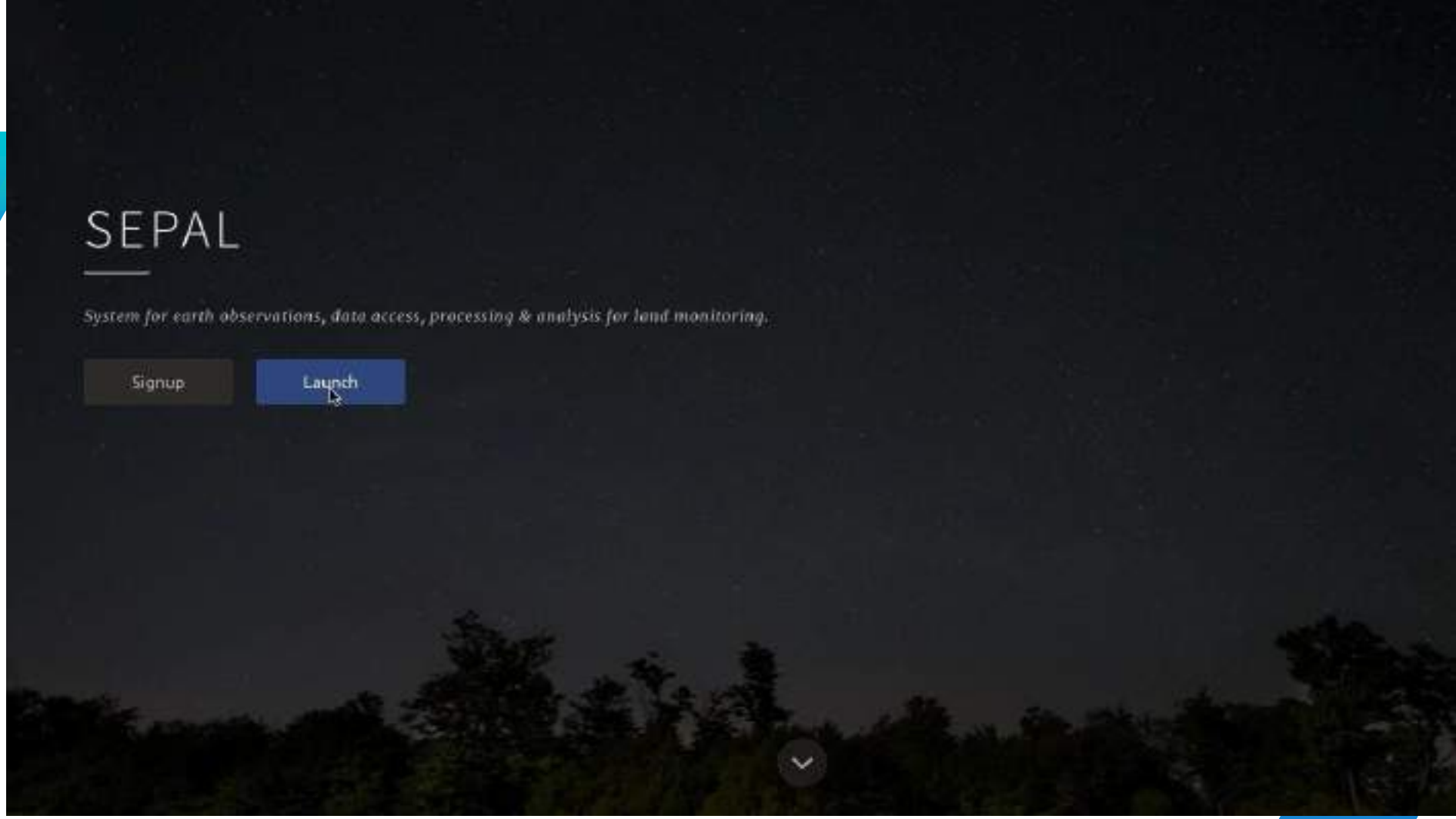
- AI: Extraction of useful relationships: use of machine learning
- Combining satellite/ Lidar data (remote sensing observations) with in-situ information
- Predictive AI: probability of extreme events or hazards e.g. pest or fire outbreaks

SEPAL: Earth Observation and cloud computing

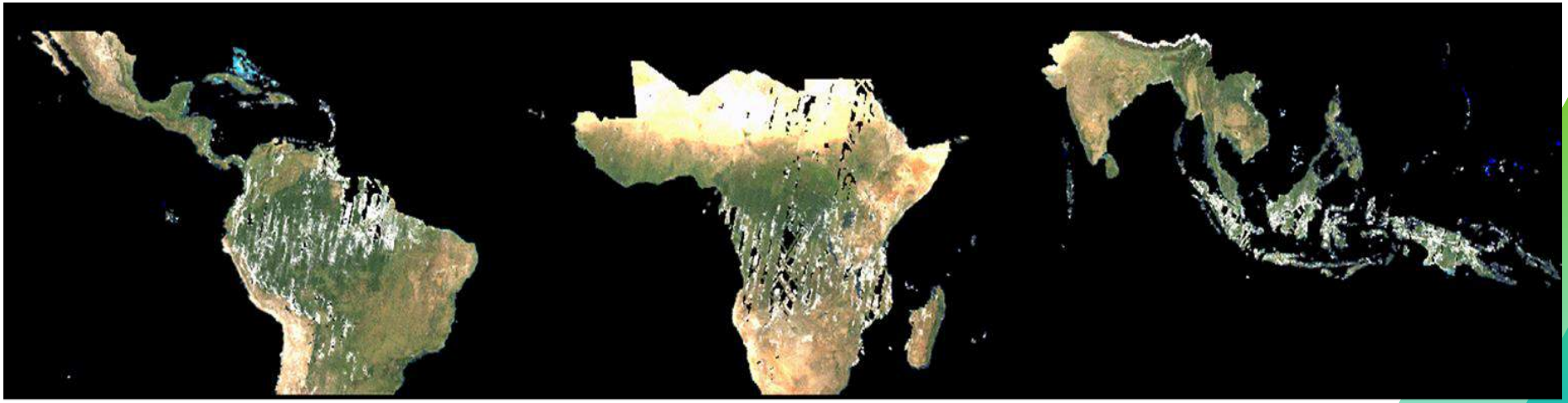
- SEPAL is a cloud based platform for accessing, processing and analysing geospatial data for land monitoring
- SEPAL is free and open: anyone can register for access to its features: https://sepal.io
- All you need is an Internet connection to access the SEPAL website



NICFI
Norway's International Climate and Forest Initiative
European Commission
esa
ETH zürich
FORMIN.FINLAND.FI
JICA
KFW
SilvaCarbon
Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit
GFOI
Global Forest Observations Initiative
Google
JAXA
NASA
SERVIR
Spatial Informatics Group
WAGENINGEN UNIVERSITY & RESEARCH
planet
See Change. Change the World.
WORLD BANK GROUP


SEPAL
System for earth observations, data access, processing & analysis for land monitoring.
Signup
Launch

Planet data



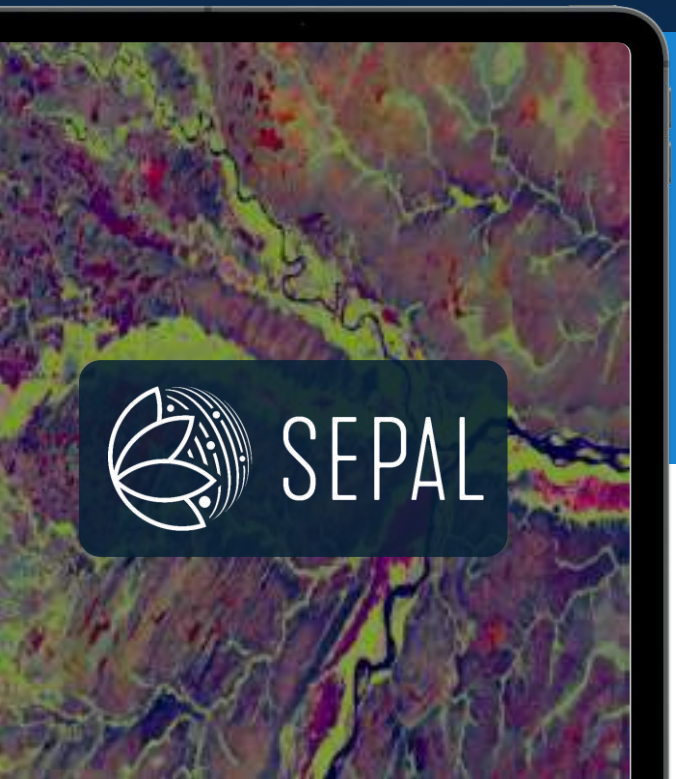
Pan-tropical, high-resolution data offer amazing opportunities

(Slides courtesy of R. D'Annunzio)

SEPAL

Forest and Land Monitoring for Climate Action

Norway's International Climate and Forest Initiative



- Expand use and application of NICFI-Planet data
- Develop the SEPAL platform to be even easier to use for critical forest and land monitoring needs and high-integrity forest data
- Apply innovative capacity development methods to reach all 64 countries included in the NICFI-Planet data program
- Develop user-friendly applications of the NICFI-planet data
- Country level engagement
- Multi-donor project; additional contributions welcomed

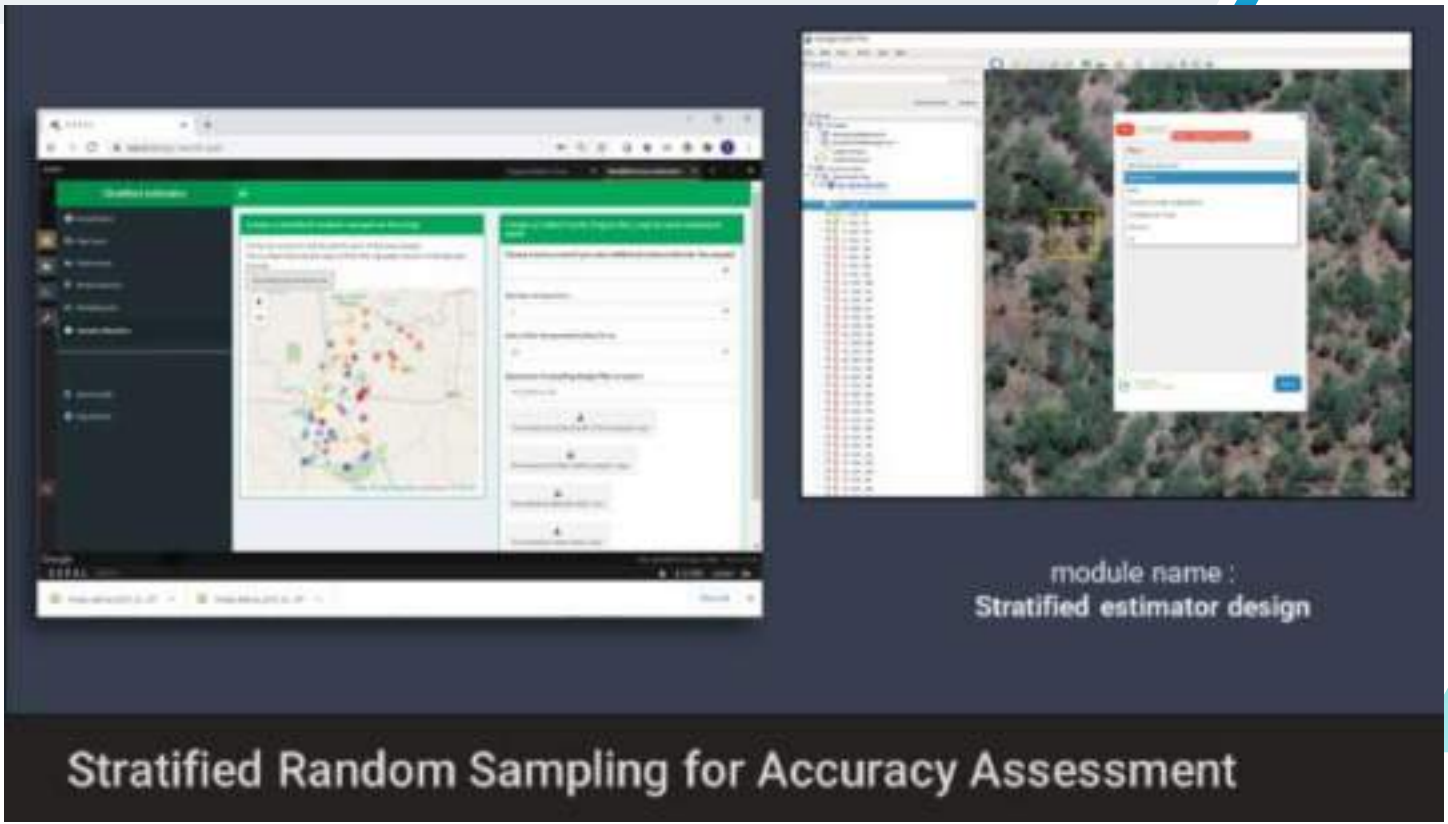
>10,000
Active users

>300
Organizations

>180
Countries

SEPAL https://sepal.io

SEPAL -module example

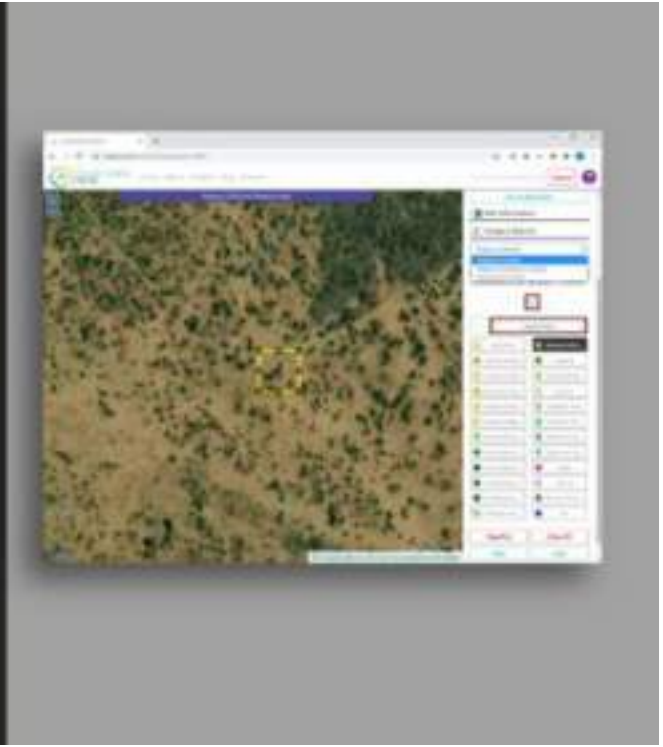


SEPAL

Link to Collect Earth and Collect Earth Online

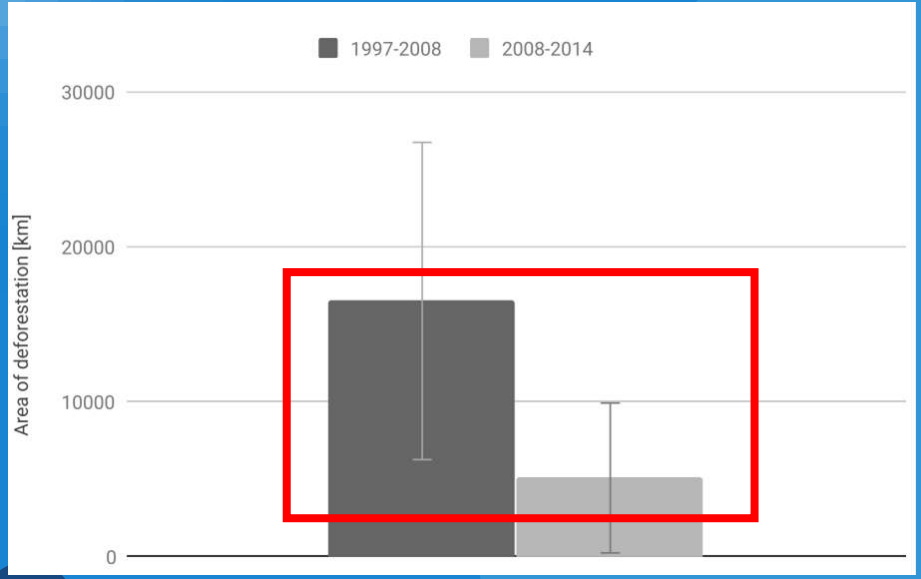
Collect Earth can be used with Sepal to produce training data.

Follow our tutorials for more information



New module:
eSBAE (Sample Based Area Estimation)

- Support countries in accessing ***Carbon Finance***
- ***Reliable*** estimates of Forest Change (High-integrity)
- ***Consistency*** over time
- Address ***Uncertainty***
- Being ***practical***
- ***Manage*** expectations



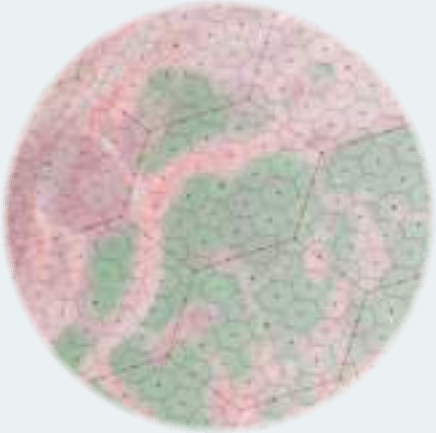
source: Olofsson et al., 2020

Overview - Ensemble

Time-Series Extraction

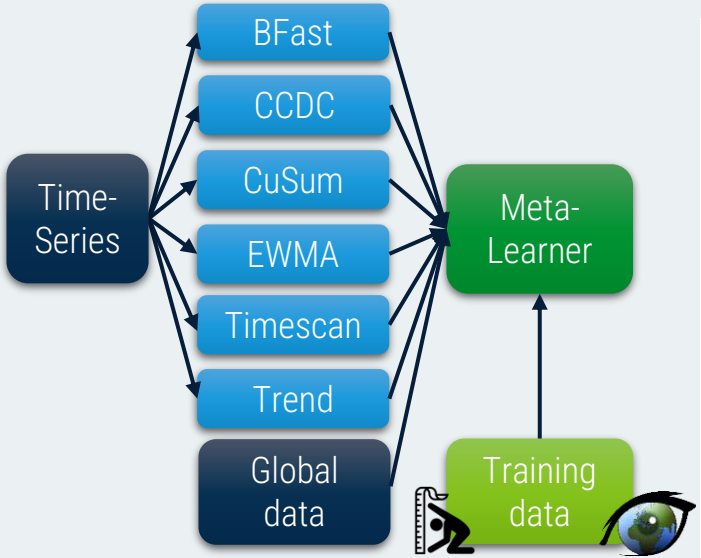
Probability of potential change as proxy for actual change

Dense systematic sampling grid: 500m to a few kms

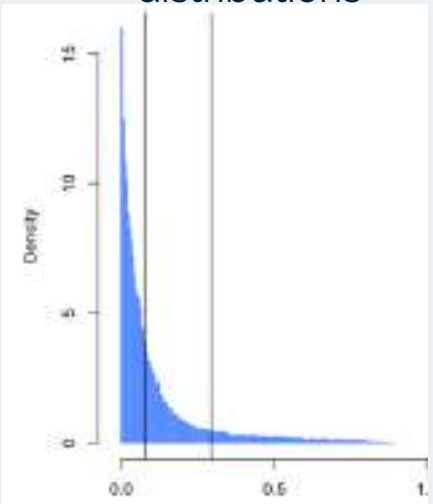


AI

Ensemble of Change



Dalenius type of stratification: optiimized for skewed stat. distributions



Potential Change Probability

On SEPAL

- eSBAE notebook series
- Streamlined & automated process
- Based on Google Earth Engine and various geo-spatial python libraries
- Use of AI for the calculations

~300k

Points

2 days

Time-series & Data Augmentation

~10 $

Processing cost

Collect Earth

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

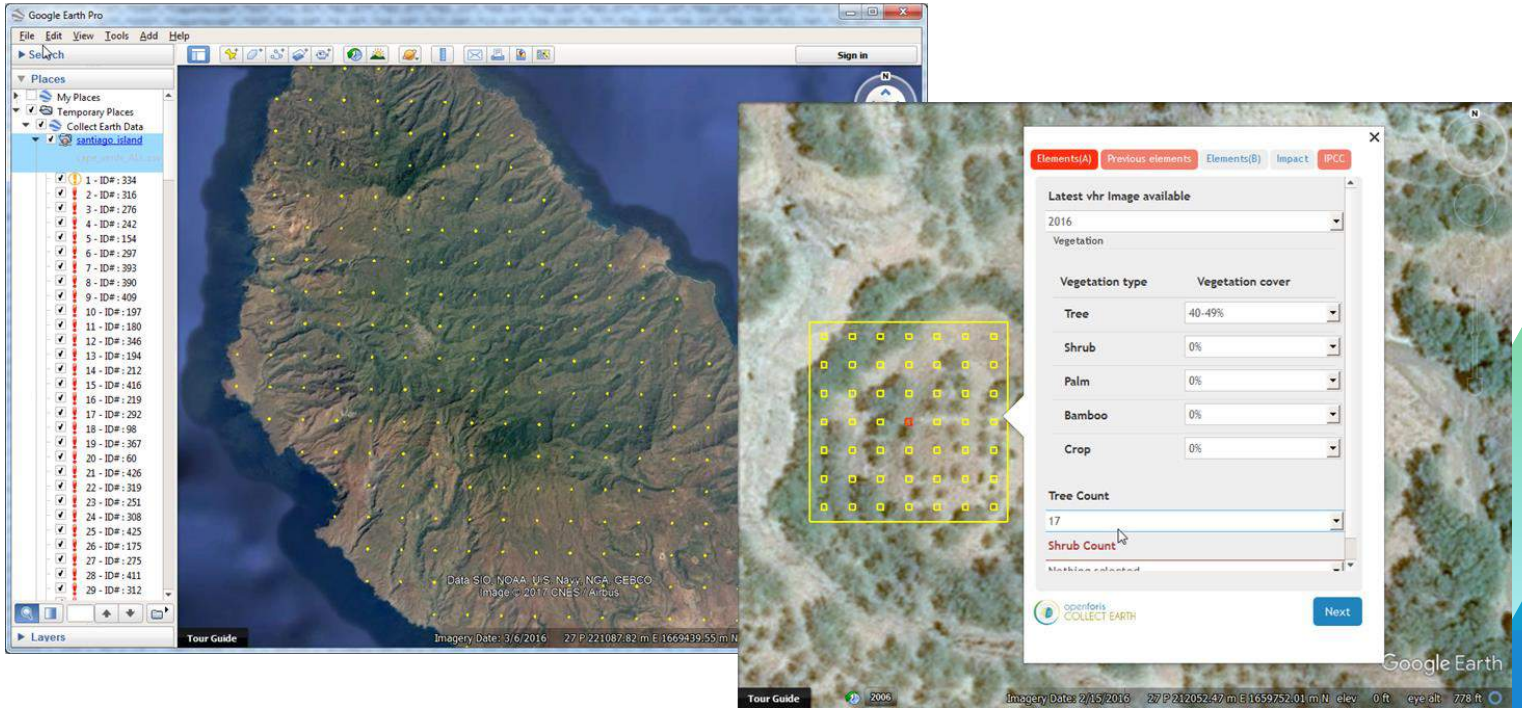
openforis

Augmented Visual Interpretation

Data Collection tool integrated in Google Earth.

Free access to Very High Resolution imagery.

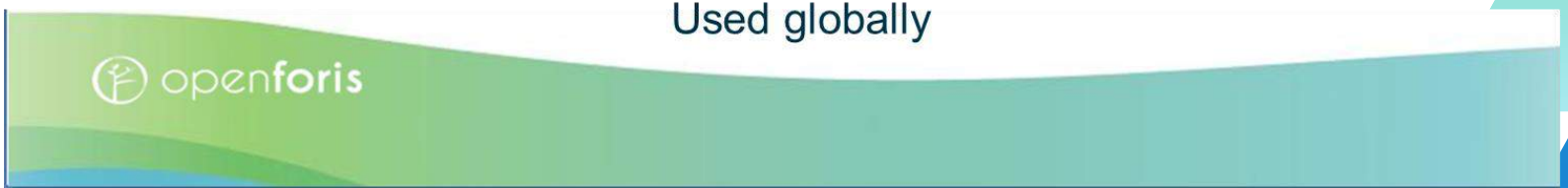
Multitemporal imagery thanks to Google Earth, Bing Maps and High Resolution



Collect Earth Online

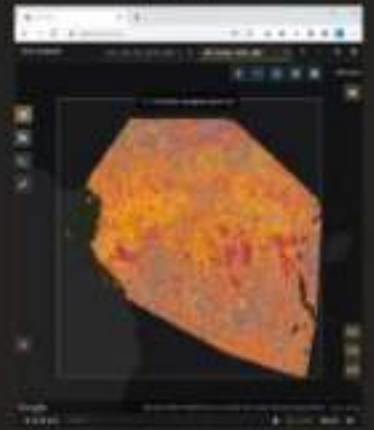
Visual interpretation tool for land use/cover classification and change detection with access to high and very high resolution satellite imagery

Used globally



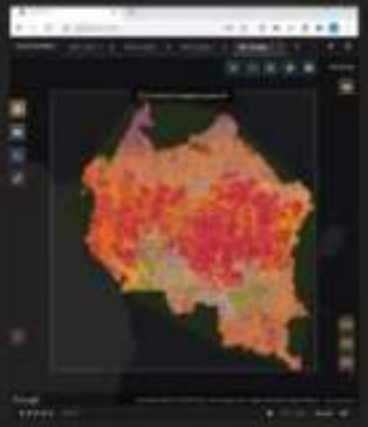
Fusion Optical and radar data

ALOS



LANDSAT 8

ALOS + LANDSAT 8

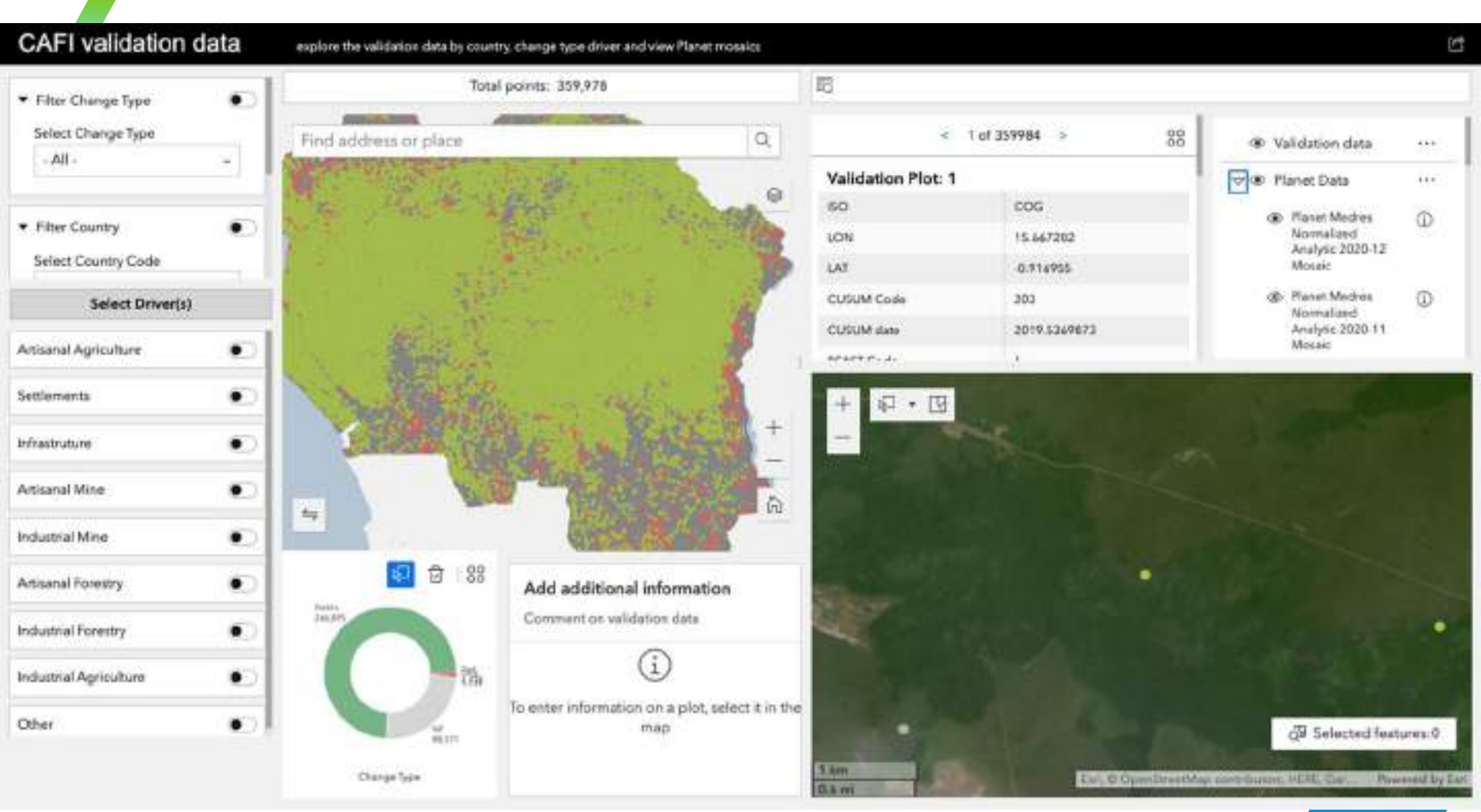


Carrasco, L., O'Neil, A.W., Morton, R.D., Rowland, C.S. Evaluating Combinations of Temporally Aggregated Sentinel-1, Sentinel-2 and Landsat 8 for Land Cover Mapping with Google Earth Engine. Remote Sens. 2019, 11, 288. https://www.mdpi.com/2072-4292/11/3/288

Hirschmugl, M., Sobe, 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., Ehammer, A., Fensholt, R., Grogan, K., Hostert, P., Jepsen, M.R., Kuemmerle, T., Meyfroidt, P., Mitchard, E.T.A., Reiche, J., Ryan, C.M., Waske, 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, Chie-Hao & Hsieh, Yi-Ta & Wu, Shiau-Tsung & Chen, Chau-Tuhn & 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.


CAFI validation data
explore the validation data by country, change type driver and view Planet mosaics
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
-0.914955
CUSUM Code
202
CUSUM date
2019.5269873
Validation data
Planet Data
Planet Medres Normalized Analytic 2020-12 Mosaic
Planet Medres Normalized Analytic 2020-11 Mosaic
Selected features: 0
1 km
0.5 mi

LandTrendr summary

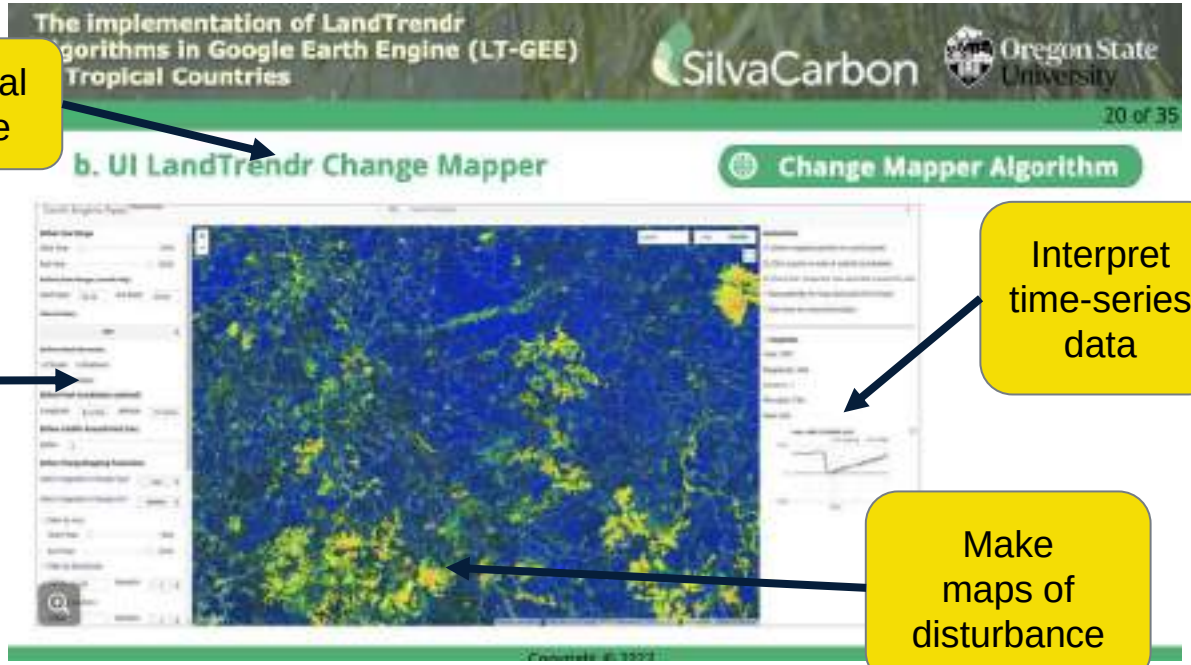
Example: What you'll learn about mapping forest disturbance

Use a graphical user interface

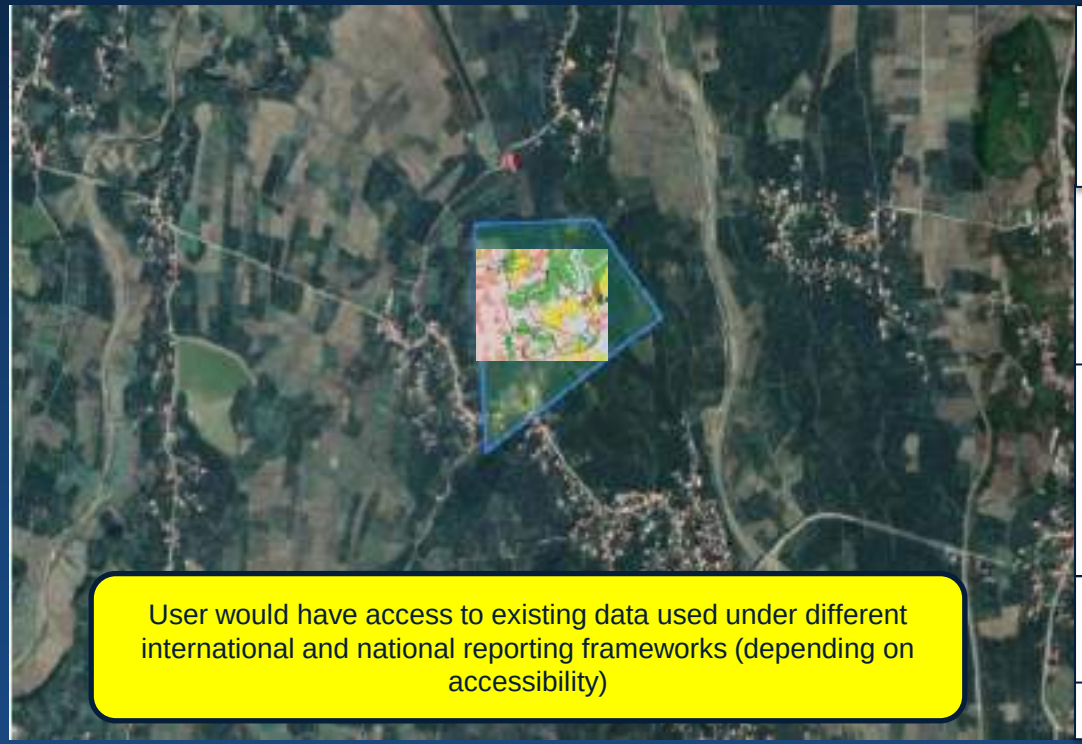
Control algorithm behavior

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

United Nations Statistics Division

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

The Forest Data Partnership

Eliminating Supply Chain Deforestation and Catalyzing Ecosystem Restoration

Work streams

Engage partners and stakeholders

Align on foundational data gaps

Innovate demand-driven approaches

Deploy data delivery mechanisms

Assess impact

Dimensions

5 years – 2022 to 2026
$ 6.2 million

USAID

WORLD RESOURCES INSTITUTE

SERVIR

NASA

Google

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

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 CO2 at scale**. 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

AI/Earth Observation 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 (monitoring)
- 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
- **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, **including impact metrics** and **distinction private and public end users**

Way forward interlinking end users and scientific community

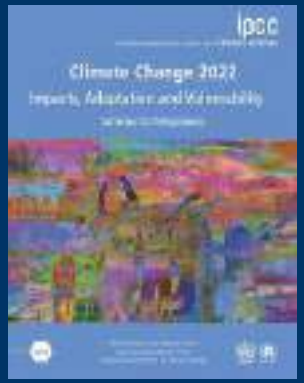
- Taking into account **user requirements** in the domains of land and forest monitoring
- **User inclusion** from the concrete (project) start
- **Data ownership** for end users
- Important **policy frameworks**, among others

UN SDGs [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).

- Upcoming: Talk in EU Pavillion (COP 28), publication white paper on SBAE

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

@FAOForestry

@FAOClimatechange

inge.Jonckheere@fao.org