Earth Engine for REDD

{{speaker}}

October 2023 | #GeoForGood23

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UN Food & Agriculture Org

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USGS

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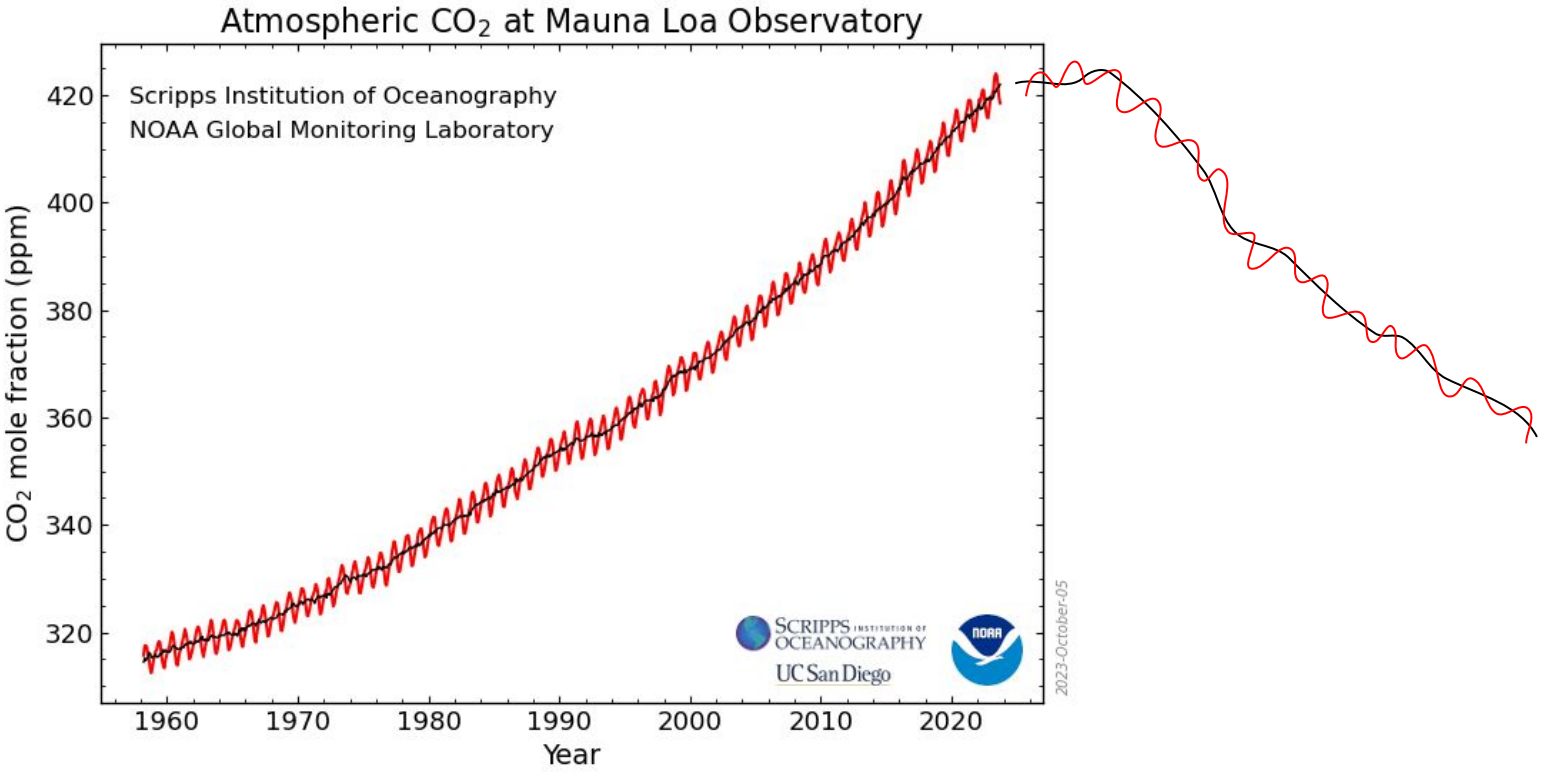
GEE for REDD
REDD-EE?

Erik Lindquist

October 2023 | #GeoForGood23


Atmospheric CO_2 at Mauna Loa Observatory
Scripps Institution of Oceanography
NOAA Global Monitoring Laboratory
CO_2 mole fraction (ppm)
420
400
380
360
340
320
1960
1970
1980
1990
2000
2010
2020
Year
SCRIPPS INSTITUTION OF OCEANOGRAPHY
UC San Diego
NOAA
2023-October-05

GEE for REDD (REDD-EE?)

Essential technology for climate change

What is REDD

Reducing CO2 Emissions from Deforestation and Degradation...more or less

The basic equation

GEE essential for REDD-like analysis and reporting

Enabling

Catalyzing

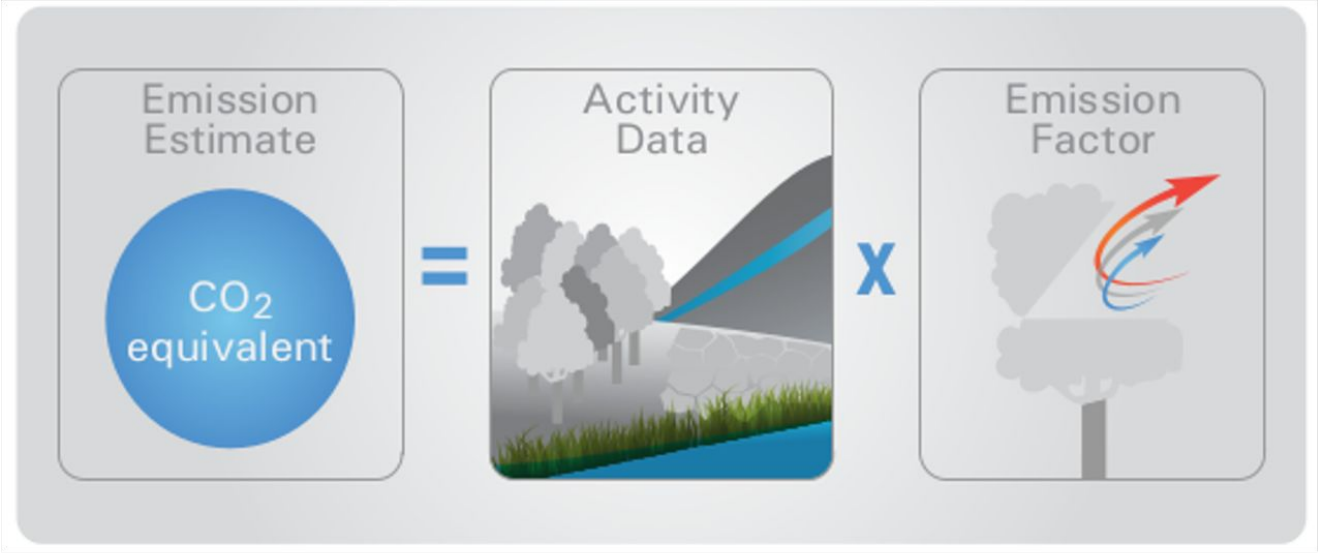
Use-cases and Impact

How FAO uses GEE in-country to facilitate analysis and reporting

Impact of using GEE

GEE for REDD

Essential technology for climate change



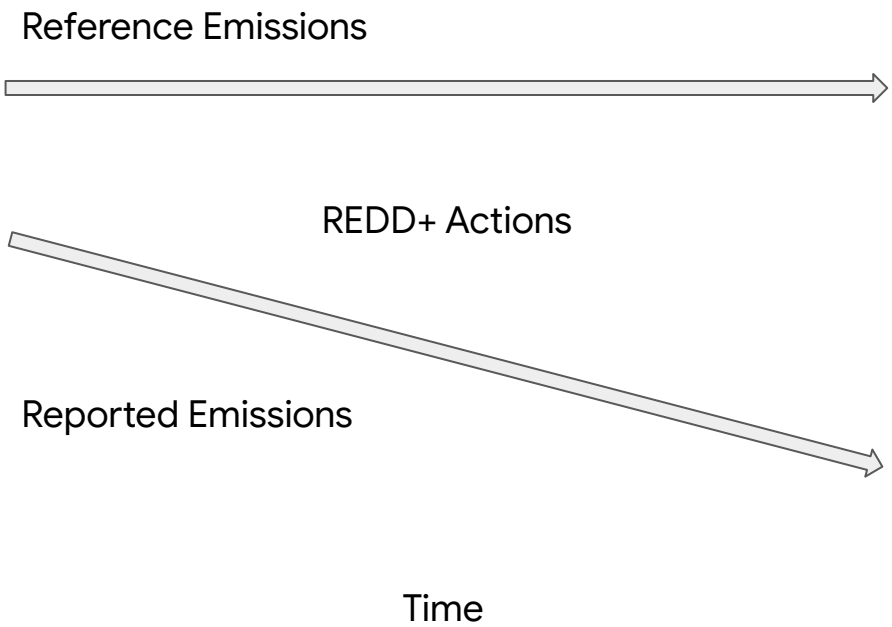
Amount of emissions tCO_2 eq / year

Area of forest change ha /year

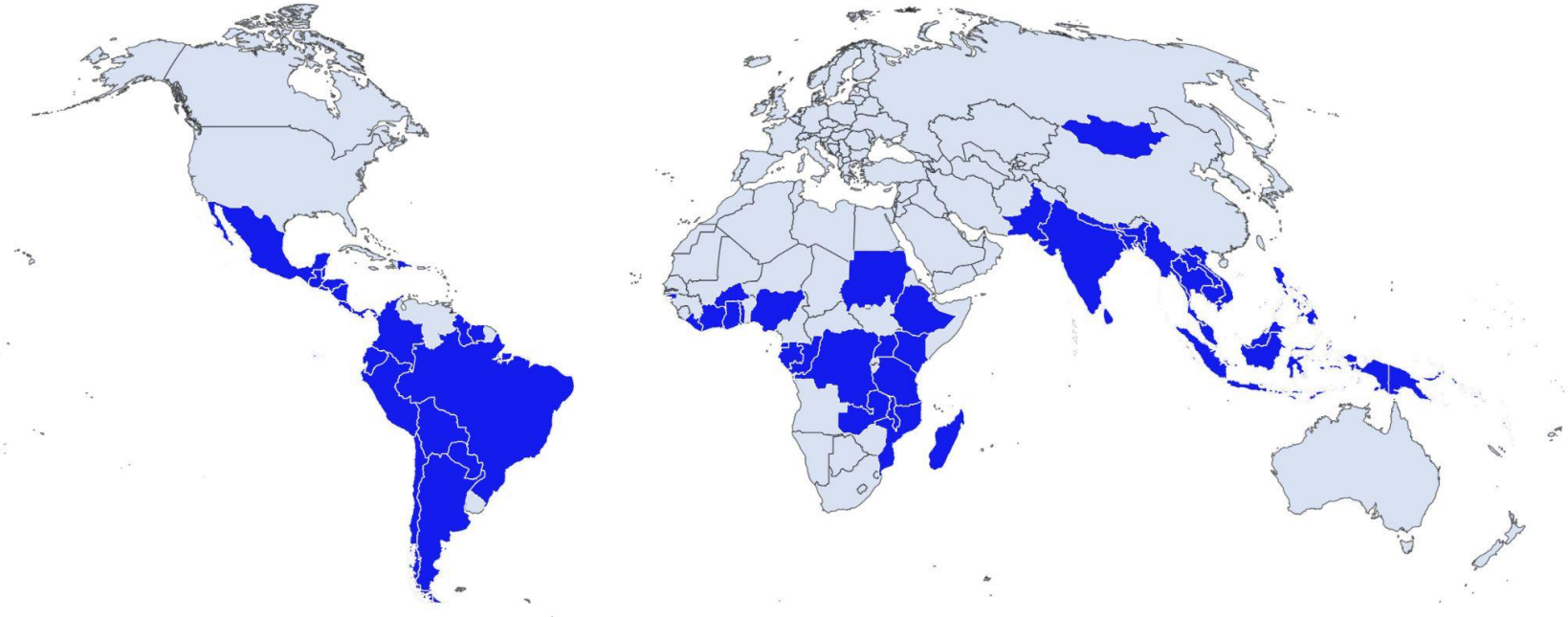
Amount of carbon per hectare deforestation tCO_2e /ha

IPCC Good Practice Guidance for LULUCF, 2003

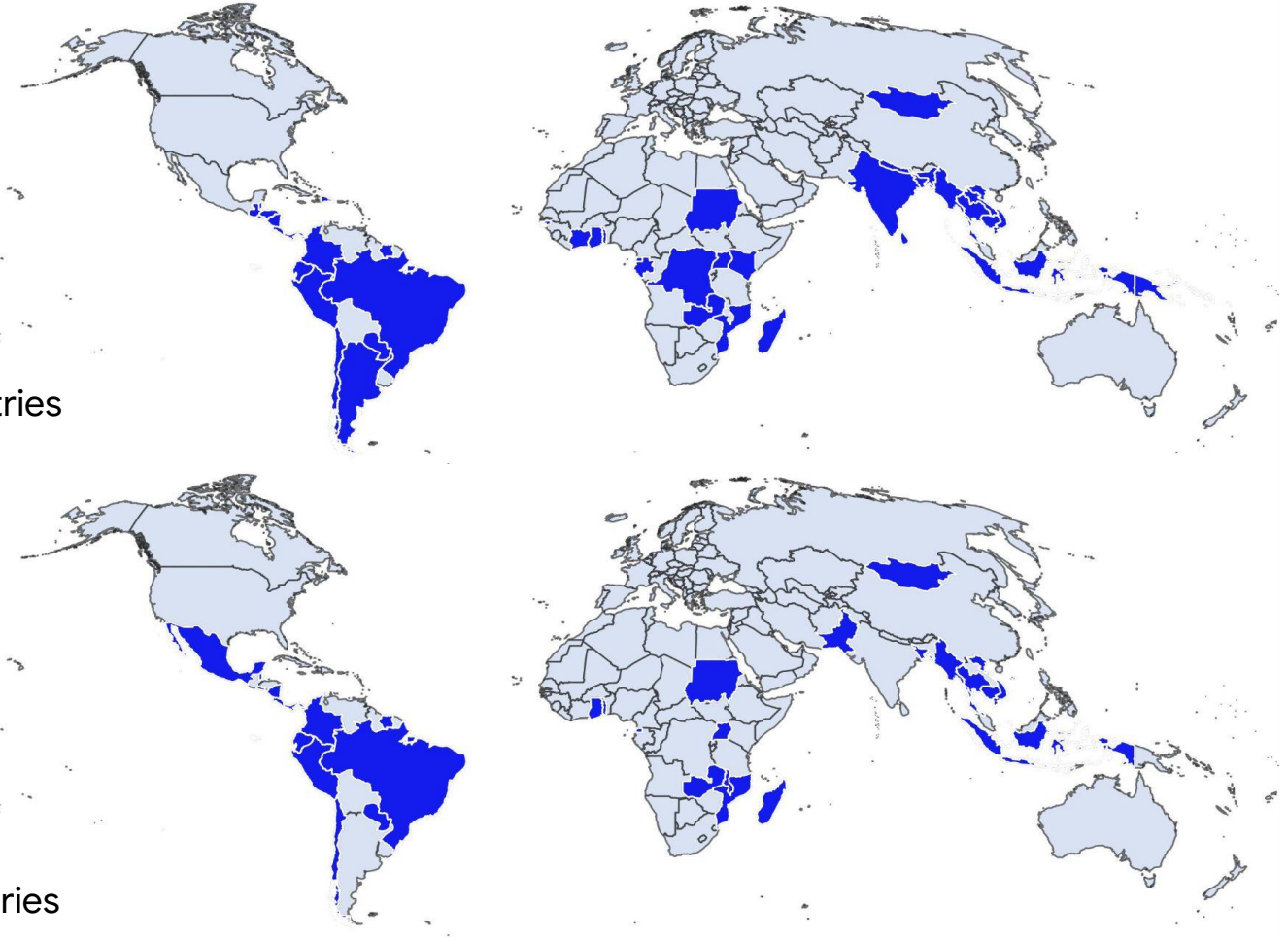
The Basic Idea Behind REDD



Forest Reference Information to UNFCCC



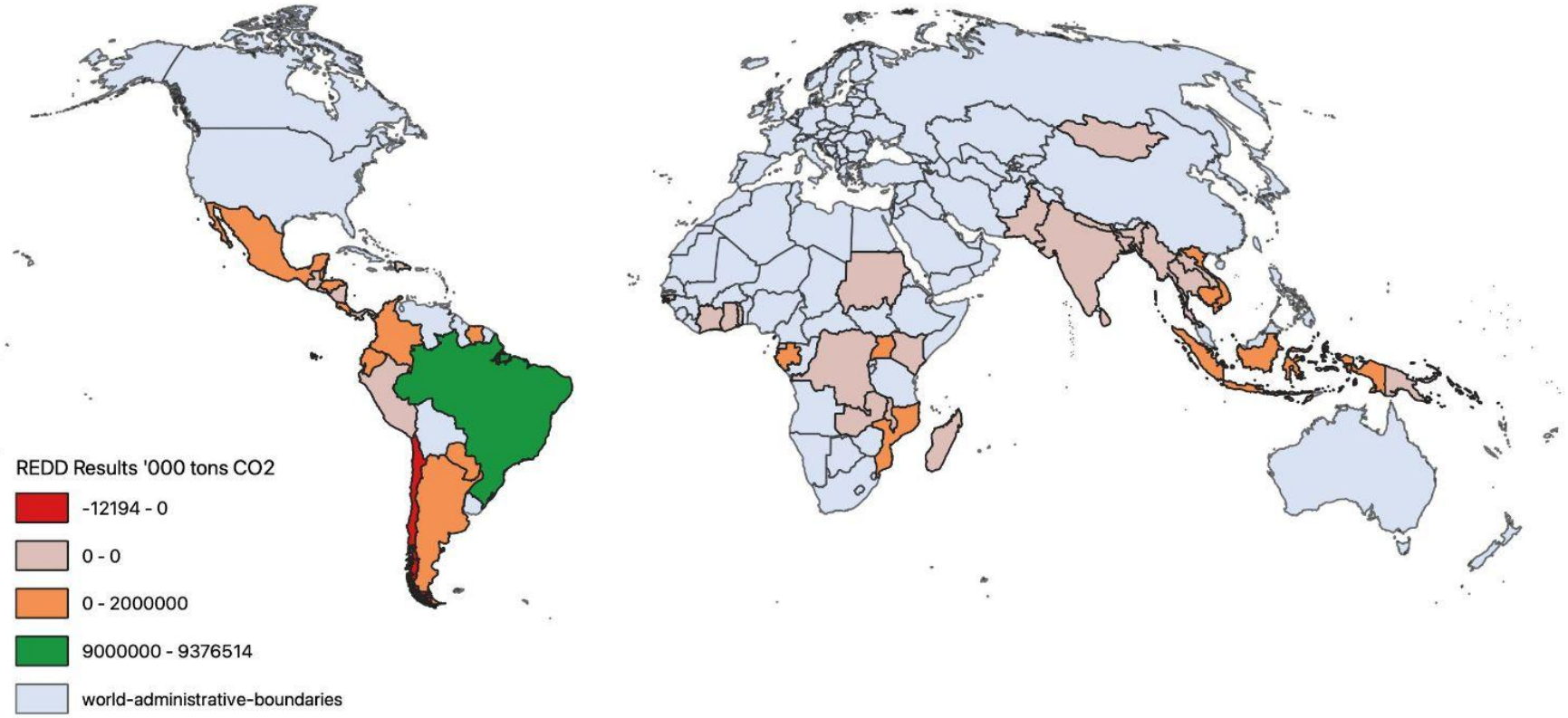
33 percent of global forest area
75 percent of global deforestation



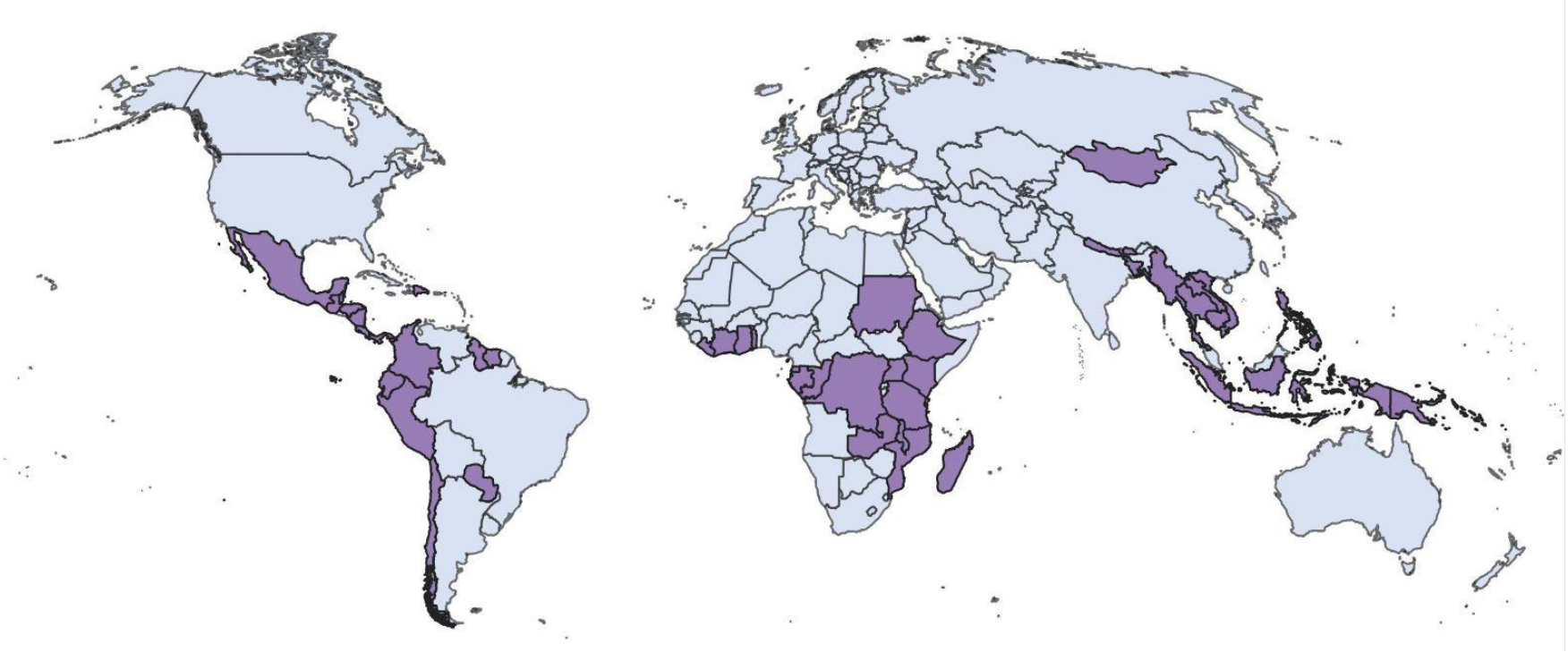
Landsat
45 Countries

Sentinel
36 Countries

REDD+ Results to UNFCCC



REDD+ Countries using GEE (in some form)



~1.6 Billion Tons of CO_2

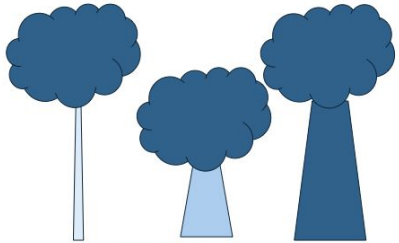
Total between 2006 - 2020

+5.9±4.1 Billion Tons CO_2eq/yr between 2010 and 2019
45% due to ‘Forestry’
Source: UNFCCC

All trees are not created equal

Activity Data + Area

Top View

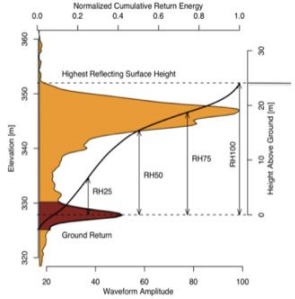


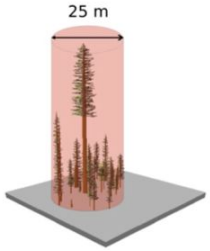
Side View

SEPAL

Laser data is very valuable

Provides information on structure





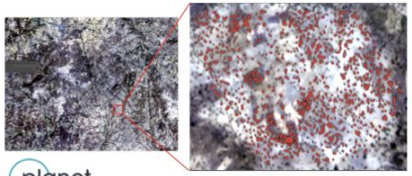
SEPAL

Combined laser + optical data

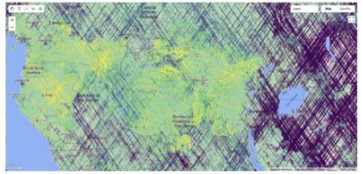
Optical data is very good for tree cover over large areas

Laser data (GEDI) is an excellent source of systematically collected laser data

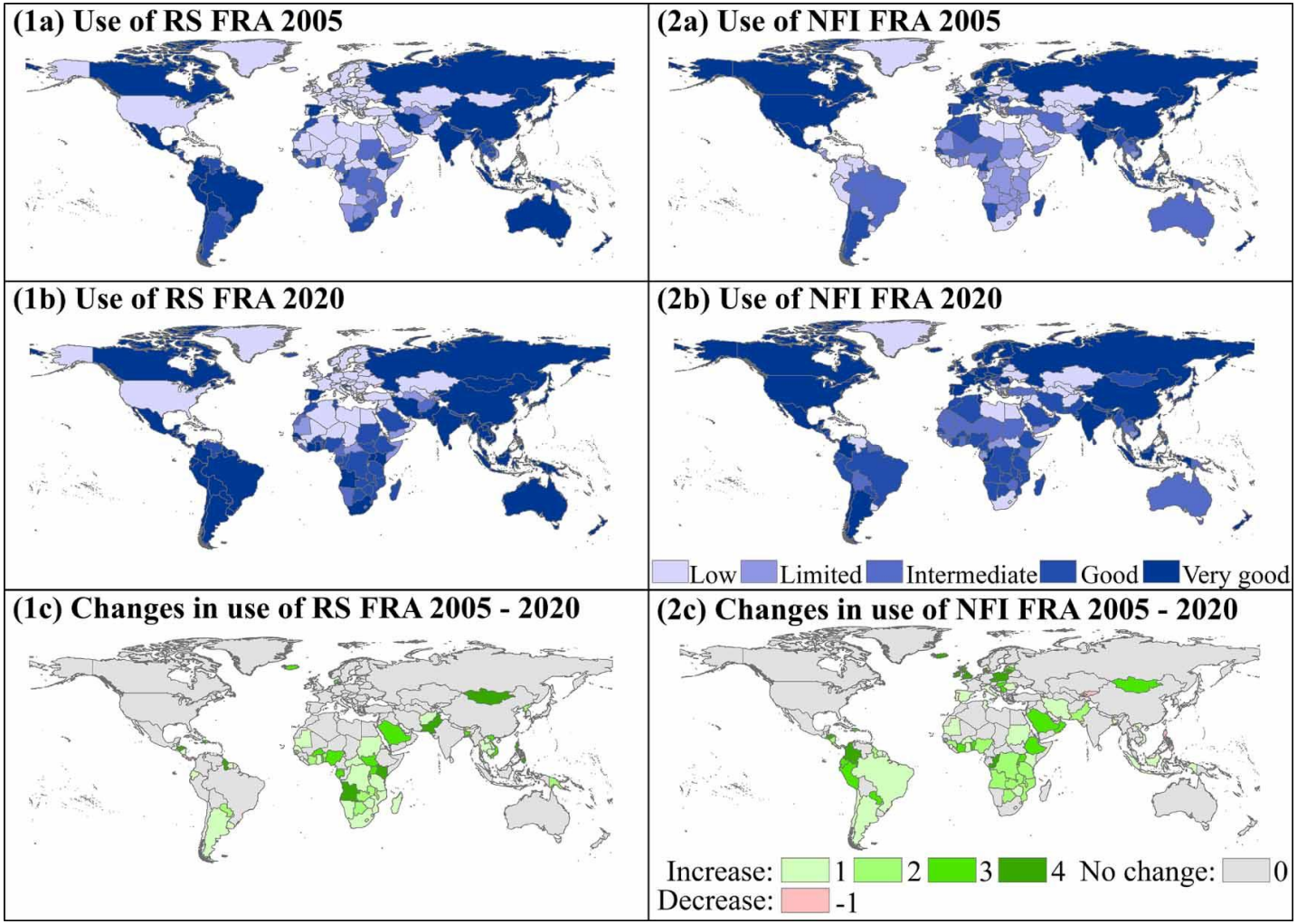
Calibrated GEDI data is a good source of data to produce estimates of biomass over large areas



planet.
See Change.
Change the World.



SEPAL


(1a) Use of RS FRA 2005
(2a) Use of NFI FRA 2005
(1b) Use of RS FRA 2020
(2b) Use of NFI FRA 2020
Low
Limited
Intermediate
Good
Very good
(1c) Changes in use of RS FRA 2005 - 2020
(2c) Changes in use of NFI FRA 2005 - 2020
Increase:
1
2
3
4
No change:
0
Decrease:
-1

OpenForis.org

Collect Earth

Augmented visual interpretation tool for land monitoring

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

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Capacity Building for forest monitoring

SilvaCarbon and GEE

Sylvia Wilson - USGS (SilvaCarbon Program)

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CEOS

- Data Interoperability
- Building National Forest Monitoring Systems and assisting setting historical baselines that inform policy
- Accessing Carbon Markets for implementing sustainable forestry activities

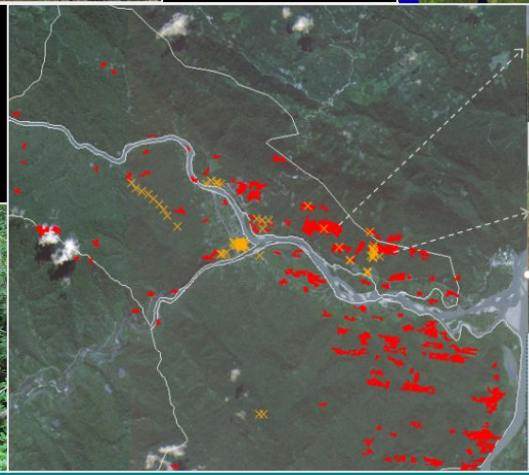
CEOS
The Committee on Earth Observation Satellites

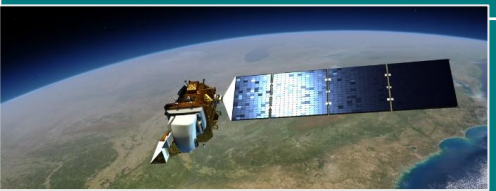
USGS
science for a changing world

SILVACARBON

- Remote Sensing
- National Forest Inventory
- National GHG Inventories
- Design of Monitoring Systems

SilvaCarbon



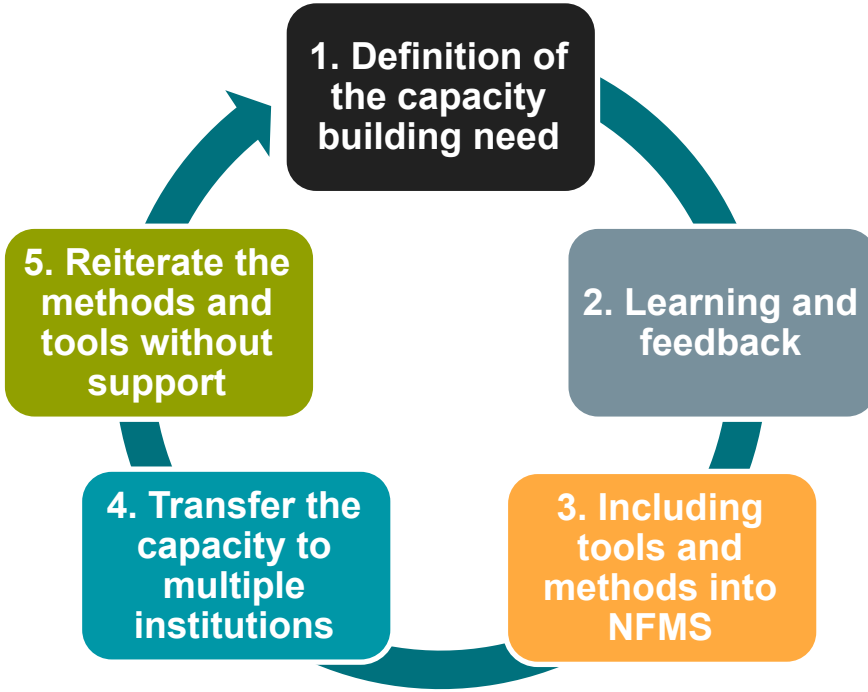


Remote Sensing Contribution to Forest Monitoring

- Google Earth Engine
- SEPAL, CEO, Global Forest Watch

Capacity Building process for SilvaCarbon and CEOS

- Capacity development is a collaborative process between the country governments and the program
- The goal is to for the countries to have ownerships of their process, tools and methods
- The country receiving the capacity building is the ones who drives the initiative



Colombia
Peru
Ecuador
Paraguay
Mexico
Costa Rica
Honduras
Guatemala
El Salvador
Belize
Panama
Argentina

Thailand
Vietnam
Nepal
Cambodia
Laos
Philippines
Bangladesh

DRC
ROC
Cameroon
Gabon
Ethiopia
Zambia
Madagascar

Solomon Islands
Vanuatu
Fiji
Indonesia

CEOS
The Committee on Earth Observation Satellites

SilvaCarbon

REDD+ WEB PLATFORM

Namibia	Nepal	Nicaragua	Nigeria
Norway	Pakistan	Panama	Papua New Guinea
Paraguay	Peru	Philippines	Saint Lucia
Solomon Islands	Sri Lanka	Sudan	Suriname
Switzerland	Thailand	Timor-Leste	Togo
Uganda	United Kingdom of Great Britain and Northern Ireland	United Republic of Tanzania	United States of America
Uruguay	Vanuatu	Viet Nam	Zambia

GEE uses stated in Forest Reference Levels Submissions

- Accessing data
- For facilitate the use of other tools such SEPAL and Collect Earth Online
- Use for accessing HR for a validation process
- To access a whole archive of Lansat and Sentinel
- For sample assessment.
- Many different applications in all these submissions.

SUCCESS OF CAPACITY DEVELOPMENT

- Assisted with NFMS development and FRL submissions
  - Technical assistance focus on the use of analysis ready data
  - Developed forest cover and forest extend national products
- Assisted with the capacity to generate accurate data for carbon markets
- Training on forest monitoring methods using open-source algorithms
- Partnerships - coordination regarding tools and approaches

METODOLOGÍA PARA EL MONITOREO DE LA COBERTURA FORESTAL Y CAMBIOS DE USO DE LA TIERRA

Elaboración de mapas – Periodo 2020-2022

Se realizaron dos mapas de cobertura forestal y cambios de uso de la tierra para los períodos 2020-2021 y 2021-2022, siguiendo la metodología del Sistema Satelital de Monitoreo Terrestre (PNC ONU-REDD+2016[1]). Esta metodología consta de los siguientes pasos: (1) creación de mosaicos libres de nube y clasificación supervisada en la plataforma geoespacial Google Earth Engine; (2) segmentación de imágenes multitemporales; (3) cálculo de estadísticas zonales utilizando el criterio de mayoría; (4) reclasificación de categorías del mapa; (5) depuración de resultados mediante fotointerpretación; y (6) Evaluación de Exactitud Temática (EET).

La Evaluación de Exactitud Temática (EET) es un proceso independiente que se realiza una vez finalizado el mapa. Consiste en una evaluación objetiva de la calidad del mapa y la estimación de su incertidumbre. La EET de ambos mapas fue realizada por el Laboratorio de Geomática de la Dirección de Posgrado de la Facultad de Ciencias Agrarias de la Universidad Nacional de Asunción (Anexo 1).

Generación de mosaicos

Para la generación de los mosaicos, se utilizaron imágenes satelitales Landsat 8 y 9 de las colecciones SR (Reflectancia de Superficie) en sus niveles Tier 1 y Tier 2, así como TOA (Reflectancia calibrada al tope de la atmósfera), disponibles en la plataforma web GEE. Los mosaicos de imágenes satelitales se generaron por región del país, considerando parámetros de fechas y porcentaje de nubes.

La generación de los mosaicos se implementó mediante un script que incluye los siguientes pasos:

Selección colección de imágenes y fechas

Se emplearon varias colecciones de imágenes de Landsat con el objetivo de mejorar la disponibilidad y calidad de las imágenes satelitales dentro de cada periodo de análisis. Se utilizaron las siguientes:

- Colección SR_Tier 1: "LANDSAT/LC08/C02/T1_L2" y "LANDSAT/LC09/C02/T1_L2"
- Colección SR_Tier 2: "LANDSAT/LC08/C02/T2_L2" y "LANDSAT/LC09/C02/T2_L2"
- Colección TOA: "LANDSAT/LC08/C02/T1_TOA" y "LANDSAT/LC09/C02/T1_TOA"

Estas colecciones proporcionaron una variedad de datos satelitales con diferentes niveles de procesamiento, como la Reflectancia de Superficie (SR) que elimina los efectos atmosféricos y proporciona valores de reflectancia de superficie corregidos, mientras que la Reflectancia

PERIODO	AÑO	RANGO DE FECHA
2020-2021	2020	01/08/2020 al 01/01/2021
	2021	01/06/2021 al 01/01/2022
2021-2022	2022	01/09/2022 al 01/01/2023

Cuadro 1. Rango de fechas empleados para los mapas de cobertura forestal y cambios de uso de la tierra

Paraguay:

- 44% of Paraguay is forest cover. Mostly native forest, but also palm and forest plantations.
- 83% of forest cover in the west región and 17% in the east región.
- 88% of native forest loss between 2020 y 2022 happen in the west región, and inside management plans.
- 12% of native forest loss happen in the east región and 80% of this change in áreas of less of 20 Ha.
- The trend of land use change in the 2005 to 2022 historical period showed a decrease of deforestation at a national level.

PERIODO DE CAMBIO DE USO DE LA TIERRA	SUPERFICIE (HA)	%
2005-2011	261.638,6	41,4
2011-2013	98.760	15,6
2013-2015	73.844,7	11,7
2015-2017	57.965,2	9,2
2017-2018	25.558,5	4,0
2018-2019	24.372,2	3,9
2019-2020	39.960,1	6,3
2020-2021	21.517,2	3,4
2021-2022	28.982,5	4,6
Total	**632.599,0**	**100,0**

Cuadro 26. Cambios de uso de bosques nativos en la Región Oriental registrados según periodos de monitoreo

PERIODO DE CAMBIO DE USO DE LA TIERRA	SUPERFICIE (HA)	%
2005-2011	2.000.336,4	42,2
2011-2013	583.428,5	12,3
2013-2015	637.055,4	13,4
2015-2017	490.918,2	10,4
2017-2018	328.662,7	6,9
2018-2019	159.836,8	3,4
2019-2020	178.577,0	3,8
2020-2021	165.674,7	3,5
2021-2022	196.470,0	4,1
Total	**4.740.959,7**	**100,0**

Cuadro 27. Cambios de uso de la tierra en la Región Occidental registrados según periodos de monitoreo

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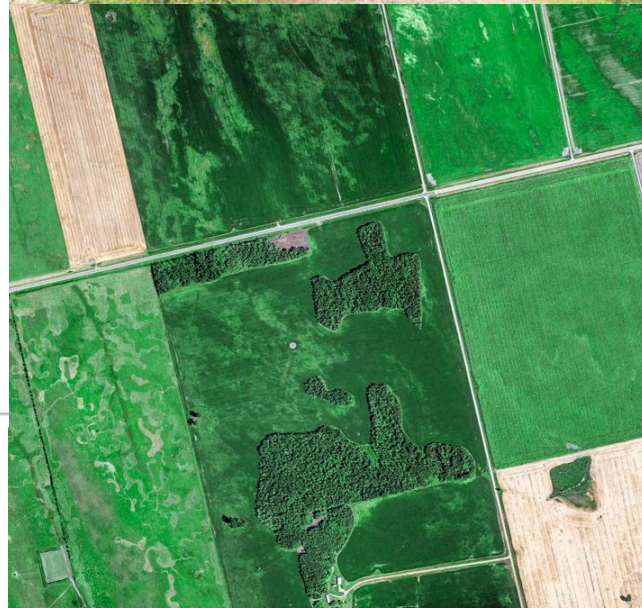
Forest Reference Levels Results

	2006-2016	2017-2021	2006-2016	2017-2021
Nacional	Originales	Corregidos	Originales	Corregidos
Tipo de Cambio/Actividad	**Ha/año**	**Ha/año**	**$TonCO_2$/año**	**$TonCO_2$/año**
Tierras Forestales-tierras agrícolas	4,884.63	4,405.75	1,850,824.39	1,673,164.55
Tierras Forestales-tierras agrícolas café	383.11	383.11	137,094.72	147,419.49
Tierras Forestales a tierras agrícolas-palma africana	1,436.66	1,245.10	494,244.06	464,512.93
Tierras Forestales a tierras agrícolas-hule	670.44	766.22	225,624.38	285,743.36
Tierras Forestales a sistemas agroforestales	1,628.21	1,340.88	480,154.61	443,705.36
Tierras Forestales a pastizales y matorrales	27,583.81	22,699.18	10,722,473.22	8,681,107.60
Tierras Forestales a asentamientos	287.33	383.11	122,555.76	165,421.12
Tierras Forestales a otras tierras	766.22	574.66	307,801.14	228,110.75
Tierras Forestales a humedales y cuerpos de agua	191.55	191.55	78,591.19	78,591.19
Deforestación total	**37,831.96**	**31,989.56**	**14,419,363.48**	**12,167,776.36**
Tierras forestales (>70%) a Tierras forestales degradadas (70-30%)	16,952.55	21,549.85	3,335,668.95	4,243,453.53
Degradación total	**16,952.55**	**21,549.85**	**3,335,668.95**	**4,243,453.53**
Incremento en tierras forestales degradadas que se recuperan	10,631.26	12,929.91	-2,147,649.32	-2,617,888.29
Incremento de Tierras Forestales por Plantaciones Coníferas	1,532.43	1,245.10	-182,615.03	-148,374.71
Incremento de Tierras Forestales por Plantaciones Latifoliados	1,436.66	1,628.21	-94,819.34	-107,461.92
Incremento de reservas de carbono plantaciones total	**2,969.09**	**2,873.31**	**-277,434.37**	-255,836.63
Balance			**15,329,948.74**	**13,793,341.60**



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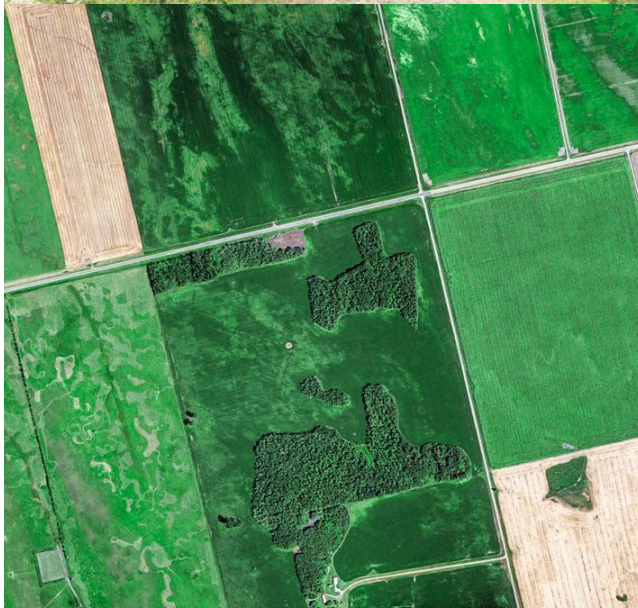

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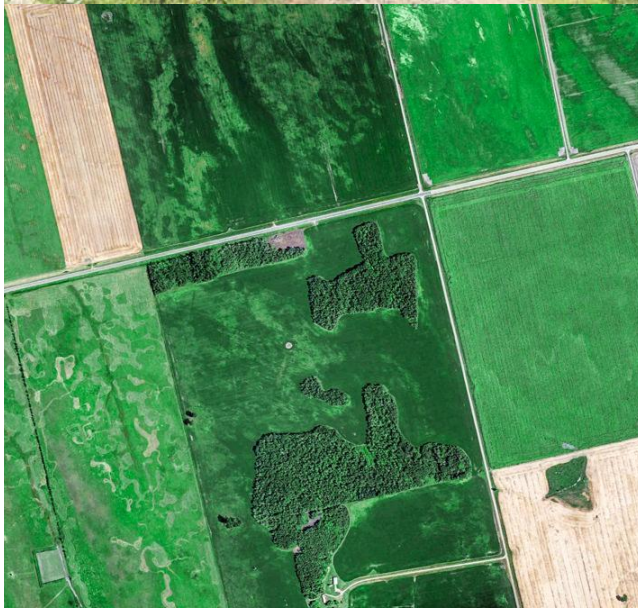

GOBIERNO de GUATEMALA
DR. ALEJANDRO GIAMMATTEI
MINISTERIO DE AMBIENTE Y RECURSOS NATURALES

GUATEMALA

Forest Reference Levels Results

	2006-2016	2017-2021	2006-2016	2017-2021
Nacional	Originales	Corregidos	Originales	Corregidos
Tipo de Cambio/Actividad	**Ha/año**	**Ha/año**	**TonCO₂/año**	**TonCO₂/año**
Tierras Forestales-tierras agrícolas	4,884.63	4,405.75	1,850,824.39	1,673,164.55
Tierras Forestales-tierras agrícolas café	383.11	383.11	137,094.72	147,419.49
Tierras Forestales a tierras agrícolas-palma africana	1,436.66	1,245.10	494,244.06	464,512.93
Tierras Forestales a tierras agrícolas-hule	670.44	766.22	225,624.38	285,743.36
Tierras Forestales a sistemas agroforestales	1,628.21	1,340.88	480,154.61	443,705.36
Tierras Forestales a pastizales y matorrales	27,583.81	22,699.18	10,722,473.22	8,681,107.60
Tierras Forestales a asentamientos	287.33	383.11	122,555.76	165,421.12
Tierras Forestales a otras tierras	766.22	574.66	307,801.14	228,110.75
Tierras Forestales a humedales y cuerpos de agua	191.55	191.55	78,591.19	78,591.19
Deforestación total	**37,831.96**	**31,989.56**	**14,419,363.48**	**12,167,776.36**
Tierras forestales (>70%) a Tierras forestales degradadas (70-30%)	16,952.55	21,549.85	3,335,668.95	4,243,453.53
Degradación total	**16,952.55**	**21,549.85**	**3,335,668.95**	**4,243,453.53**
Incremento en tierras forestales degradadas que se recuperan	10,631.26	12,929.91	-2,147,649.32	-2,617,888.29
Incremento de Tierras Forestales por Plantaciones Coníferas	1,532.43	1,245.10	-182,615.03	-148,374.71
Incremento de Tierras Forestales por Plantaciones Latifoliados	1,436.66	1,628.21	-94,819.34	-107,461.92
Incremento de reservas de carbono plantaciones total	**2,969.09**	**2,873.31**	**-277,434.37**	**-255,836.63**
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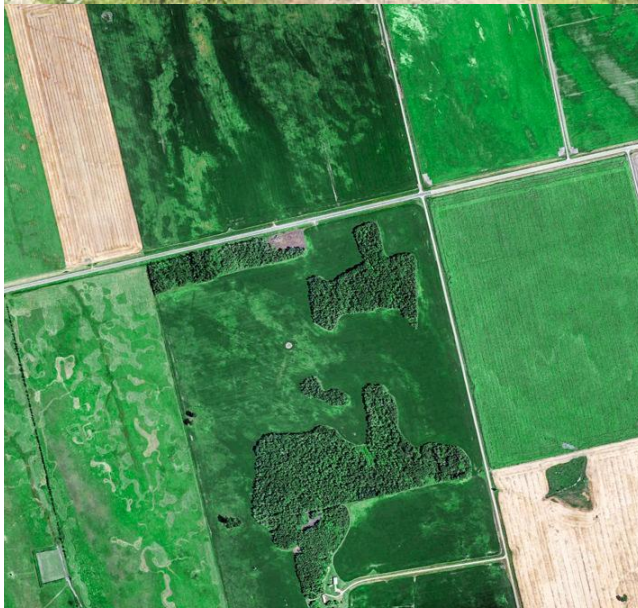

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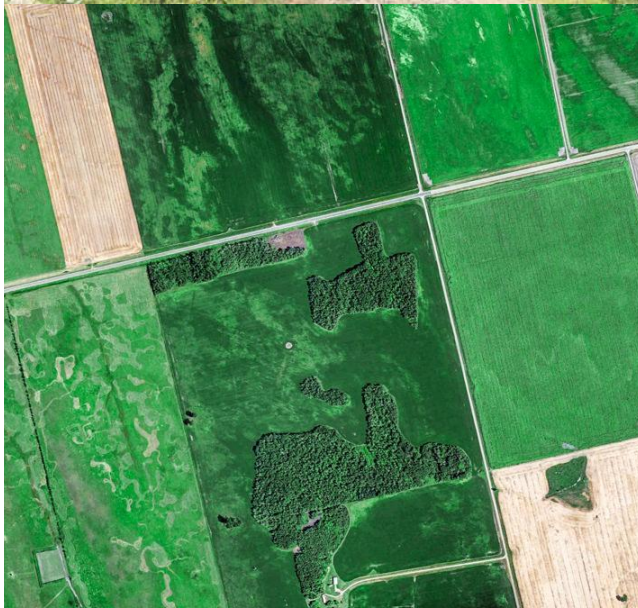


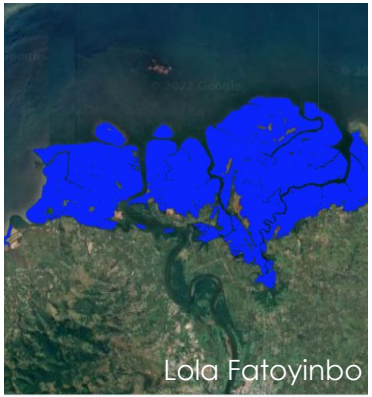
PRIORITY AREAS FOR 2024 ONWARDS

- Mangroves mapping and monitoring
- Deforestation alerts
- REDD+ Standards
- Emission Factors assisted with satellite data
- RS Data Interoperability

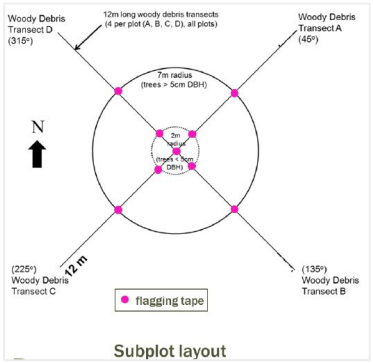
Mangroves included in REDD+

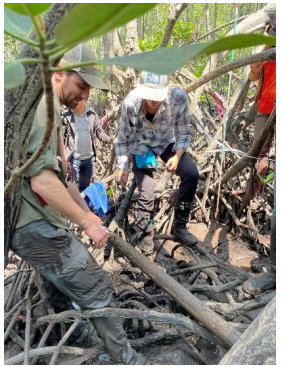
1. **Background**: Role of mangroves in carbon storage, sequestration, emissions. Disproportionate impact. Unique characteristics. REDD+ vs. Blue Carbon.

2. **Remote sensing component**: EE scripts and GUIs to map extent, canopy height, and estimate AGB (calibrated with field data).



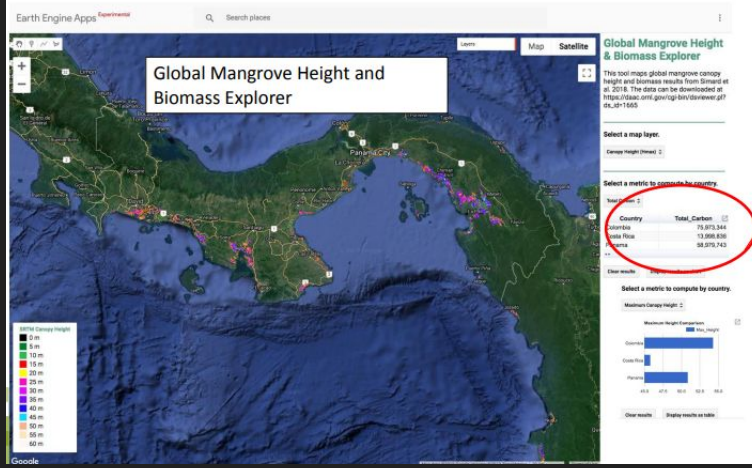
3. **Field surveys**: Use SWAMP protocol to measure C stocks in 4 pools – AGB, BGB, soils, downed woody debris. Cross-plot design. Data processing to compute Mg C/ha.





4. **Integration**: How to combine RS and field data into emissions estimates (REDD+). Unbiased map areas. Approaches and tiers.

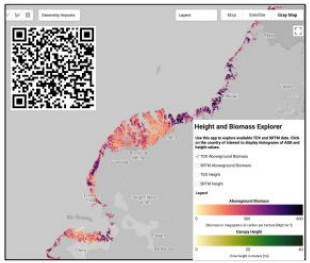
https://mangrovescience.earthengine.app/view/mangroveheightandbiomass



Here we can provide relevant results as table or bar chart.

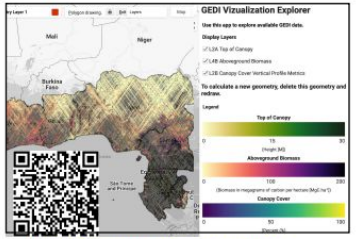
Example Apps in GEE

Explore Datasets:
Height and Biomass



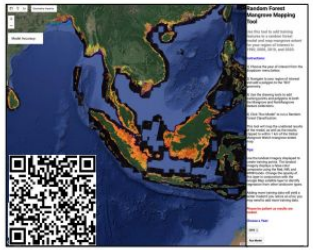
https://mangrovescience.earthengine.app/view/heightbiomassexplorer

Visualize and Collect:
GEDI



https://mangrovescience.earthengine.app/view/gediexplorer

Test Classifications:
Random Forest



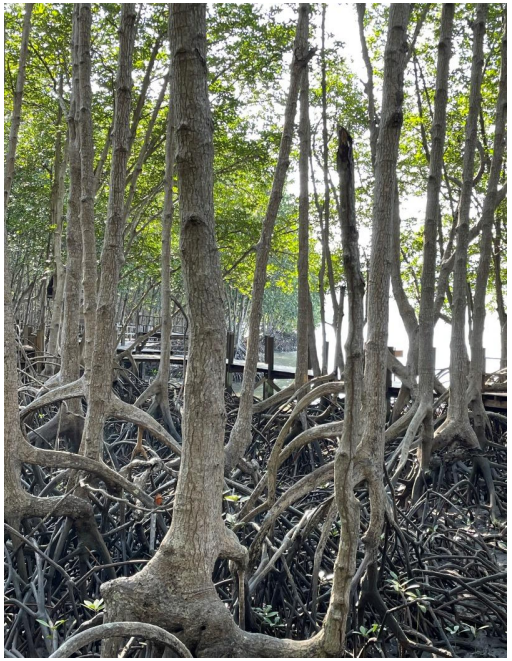
https://mangrovescience.earthengine.app/view/randomforest

Geo for Good Summit 2023;/

MANGROVE MAPPING AND MONITORING

Recent workshops:

Suva, Fiji: October 5–11, 2022



Chanthaburi, Thailand:
February 26 – March 1, 2023

Manchon Guamuchal, Guatemala:
August 15 - 30, 2023


Thank you!

Earth Engine: Monitoring of Forest for ISFL Emission Reduction Result-Based Payment in Oromia, Ethiopia

Dereje Likissa Beyene

October 2023 | #GeoForGood23

Agenda

01 Introduction

02 Interventions and Emission Reductions monitoring strategy

03 Area Based Regional & Zonal Emission and removal baseline

04 Role of Google Earth Engine (GEE) for REDD?
.

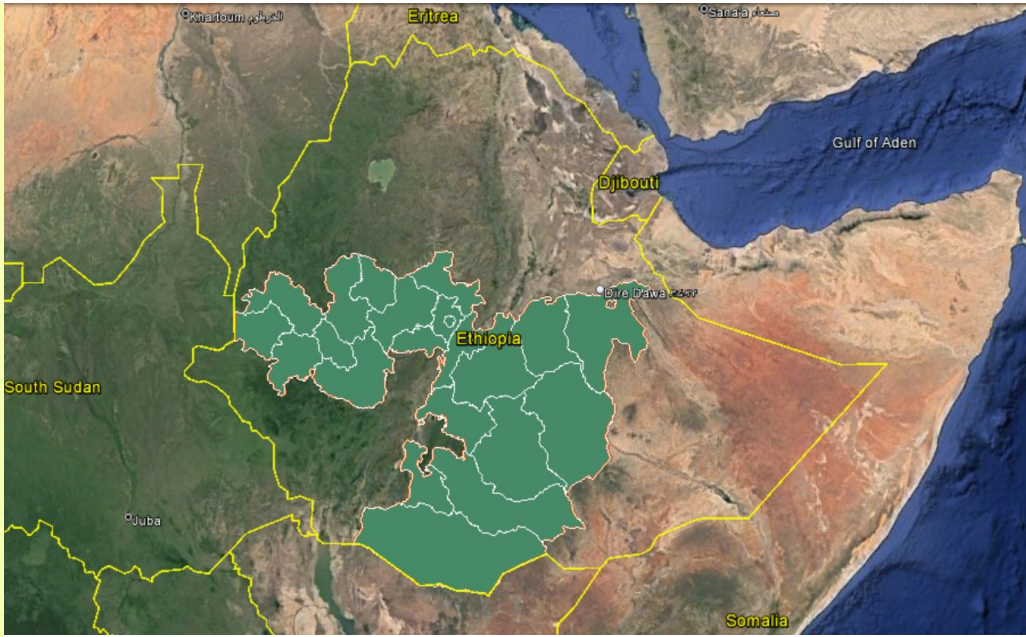
05 Estimate Deforestation baseline, integrated with GEE, CEO and SEPAL platforms

06 Estimate Forest Height and Canopy Cover

1. Introduction

Program and Area Information of Oromia Forested Landscape Program (OFLP)

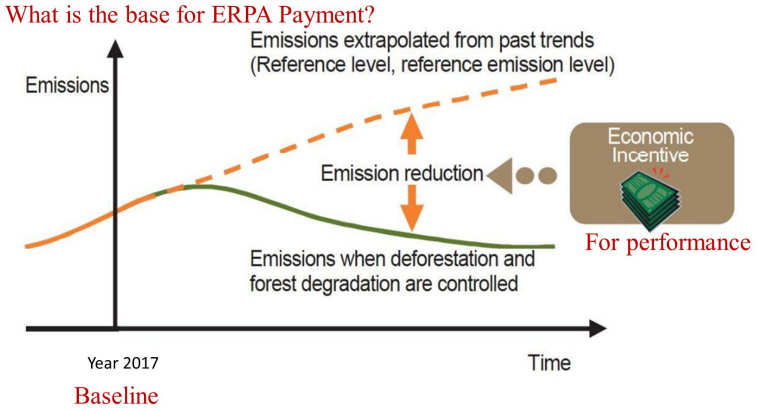
- ER Program Name & Country:
  - **Oromia Forested Landscape Program (OFLP), Ethiopia**
- Name of the Program Area
  - Oromia National Regional State
- Geographic area of the Program Area
  - > 32 Mha of which > 9.9m forest
- Drivers of land use change
  - Conversions for agricultural expansion
  - Extraction of fuel wood for charcoal



- Large National contribution of Forest (9.9 /17.2 mil. ha)
- Home for the most productive rural landscapes,
- Unsustainable management of land resources

ISFL Emission Reduction Requirements

- Result based payment is for net emission reduction generated from the two sectors; (AFOLU and Livestock) in two phases during ERPA periods;;



Mandatory ISFL requirement:

1. Grassland → forest land (A/R)
2. Crop land → forest land (A/R)
3. Forest land → grass land (Def^n)
4. Forest land → crop land (Def^n)
5. Forest land = forest land (Deg^n)
6. Enteric fermentation (cattle)

Phase I & II

Phase II

OFLP aims to foster low carbon development → reducing GHG emissions stemming from AFOLU activities, and sustainably managing Forests.

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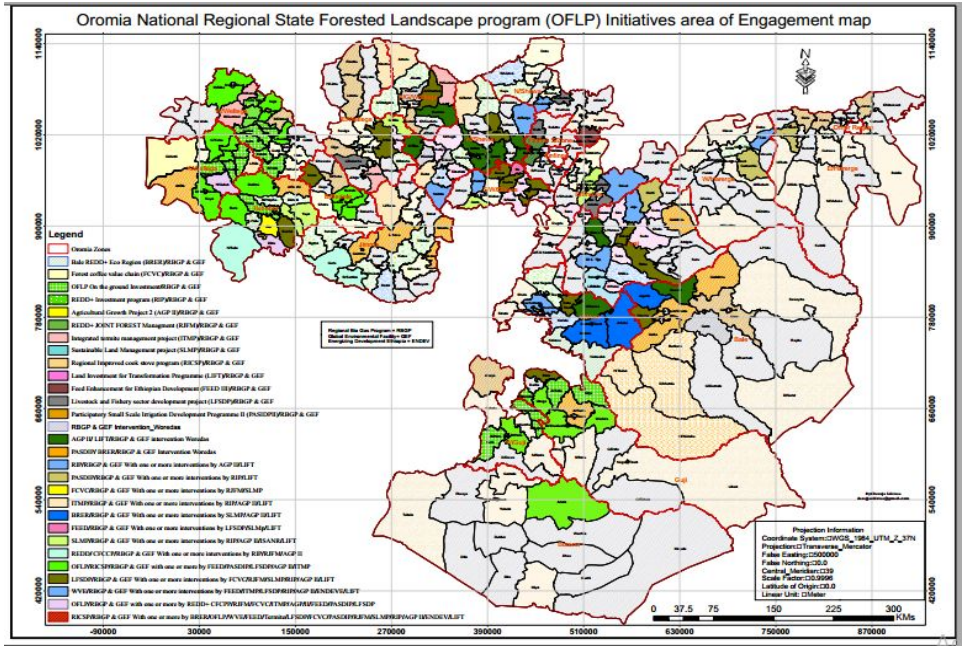
2. Interventions and Emission Reductions monitoring strategy

- Estimation of Emission Reductions



Process	SLMP	AGP	PASIDPII	ITMP	LIFT	ILUP	EWNRA	GFCVCDP	OFWE	OEFCCA	Oromia L & FDA	ISAIA & BWDP	GIZ-PFM Oromia	BER REDD+ Pilot Project	OFWP- JICA	FEED III	LFSDP	OBLA	RICSP2	RBGP	GEF Phase II	WVE	ENDEV Ethiopia	RIP
Termite management and control	I	I	I	R	I	I		I	I	I	I		I											
Increased soil and water conservation area coverage.	R	R		R						I														
Increased soil fertility				R																				
Second level land certification (SLLC)	I	I			R				I	I														
Development of rural land administration information system,					R																			
Implement sustainable REDD+ PFM models									A															R
Identifying, delineating, and mapping of the current land use of the area	I	I	I	I		R			I	A														
Conducting land suitability classification						R																		
Recommend Land use management options						R																		
Development of a dedicated forest coffee value chain								R			A													
promote old coffee rejuvenations and rehabilitation of degraded lands								R			A													
Improving the conservation practice and resilience of high value biodiversity											A	R												
Promotion of sustainable agricultural practices and soil and water conservation											A	R												
Develop a proven model of PFM-REDD+ in Bale Eco-region											A			R										
Develop and design a fair and transparent carbon benefit sharing mechanism											A			R										
Exploring and piloting sustainable timber harvesting Mechanisms											A			R										
Provide knowledge hub for REDD+ initiatives in Ethiopia and mostly for OFLP											A			R										
Promotion of Forest Management through REDD+ activities											A				R									
Certification on forest coffee production and promotion											A				R									
enabling growth of feed, forage, fattening, poultry, and dairy enterprises																R								
Exp and trade of agricultural products in the livestock and poultry sector																R								
Promote Improved On-farm Feeding Practices																A								
Feed enhancement for livestock production																	R							
promotion/demonstration of Improved Cook stove (ICS) technologies																		A	R			R		
Increase the use and utilization of ICS technologies in rural and urban areas																		A	R					
Reduce pressure on forests and emission associated with fuel wood use																		A	R	R	R	R	R	
Disseminate domestic biogas																		A		R				
Construct 3000 biogas plants at house hold level across oromia region																		A		R				
Maximize the benefits of all biogas plants installed																		A		R				
Disseminate innovations on development and usage of solar and cook stove																		A			R			
Maximize the benefits of all solar energy and cook stove installed																		A			R	R		

The ex-ante emission reduction calculation considered activities and projects that are/will be implemented in Oromia

The assessment identified

1. concerned initiatives for regional GHG emission reduction
2. Roles and responsibility of each initiatives (RACI)
3. Key processes/ activities to be done

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Monitoring intervention activities

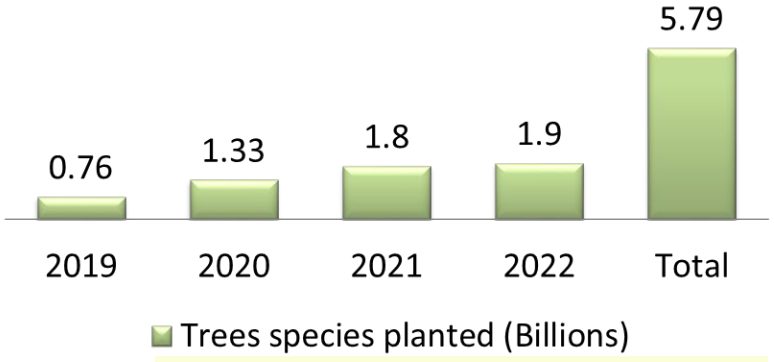
- In support of CRGE, Oromia region is envisioned to reach 30% forest cover in 2030

What OFLP has done on the ground

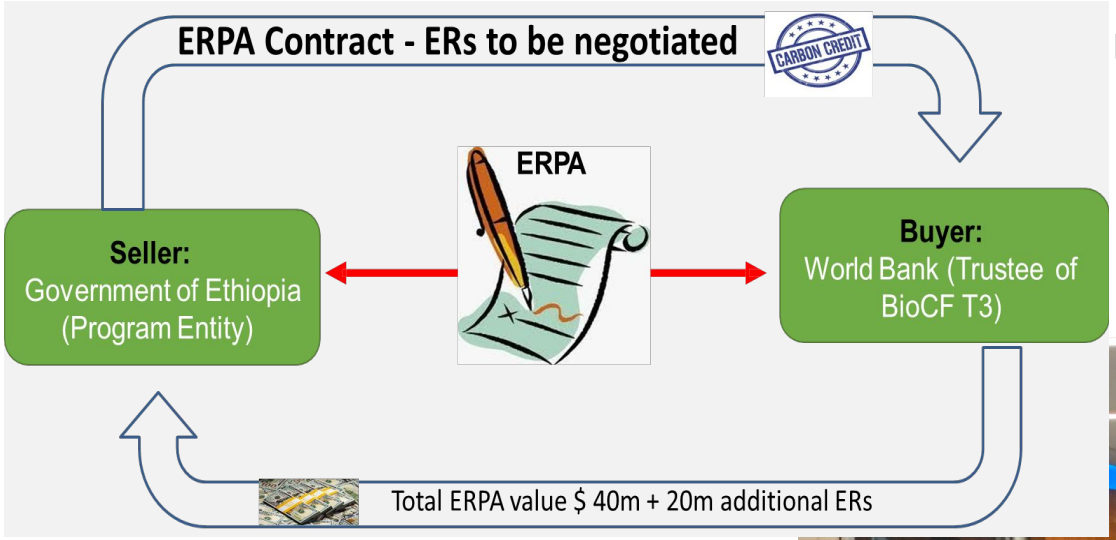
- Nearly **38 mil.** Tree Seedlings Produced and Planted
- Participatory Forest Management plan developed for forest area of over = **190,000 Ha**
- About **10,600 Ha** of Land demarcated for plantation
- Over **100 coops** established and engaged in Participatory Forest Management Activities
- Over **10,000 Ha** of Land Reforested
- Over **300 Coops** Established and engaged in A/R activities
- Over 60,000 people directly benefitted from the project **(30% F)**
- Over **210,000 Ha** Area demarcated for sustainable forest management
- Over **70M ETB** transferred to about **300 Coops** engaged in A/R

Afforestation Reforestation Activities

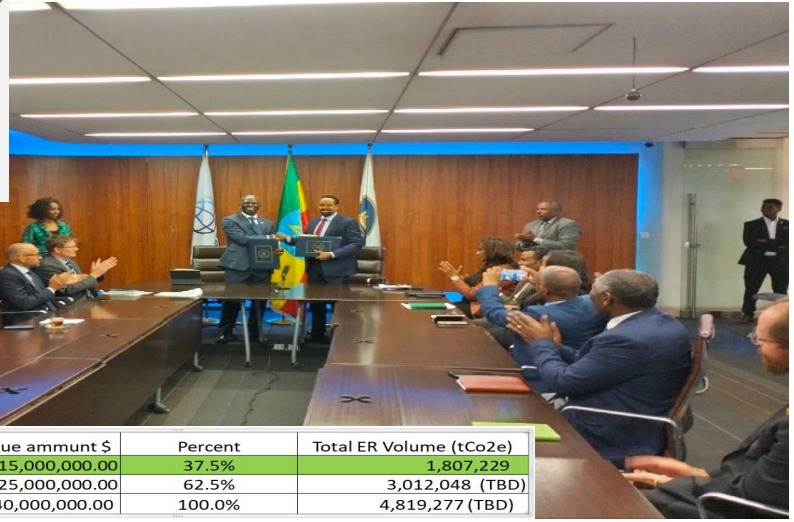
Green Legacy Initiative 2019-2022



OFLP ERPA Success stories



- Ex-ante ER Estimated from 2020-2029 = 45 $mtCO_2e$,
  - ✔ 23.8 m tCO_2e potential after risk and buffer is removed



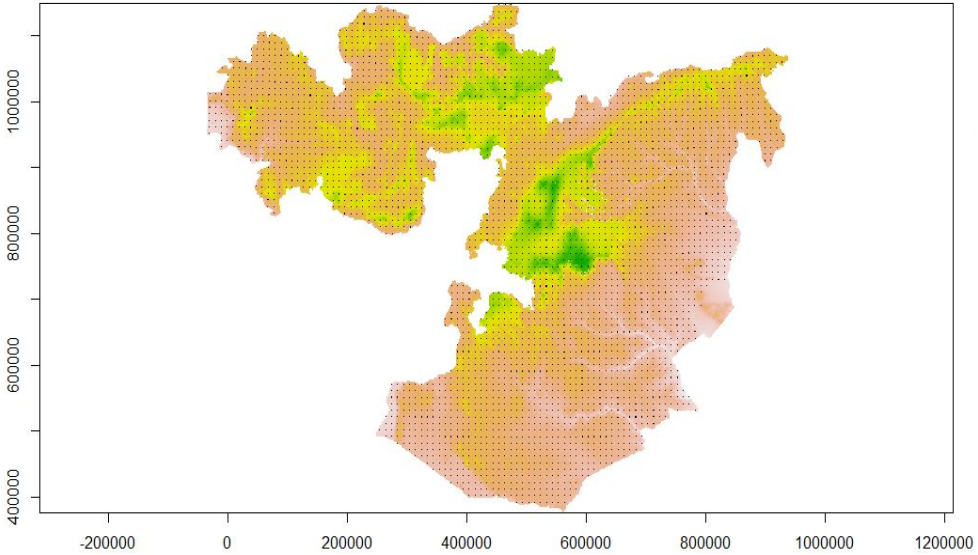
- From 2022 – 2029:
  - ~4.87 $mtCO_2e$ ER purchase agreement
  - with 40m$ Contract ER +
  - ~ 20m$ Additional ER

Phase	Value ammunt $	Percent	Total ER Volume (tCo2e)
1	15,000,000.00	37.5%	1,807,229
2	25,000,000.00	62.5%	3,012,048 (TBD)
Total	40,000,000.00	100.0%	4,819,277 (TBD)

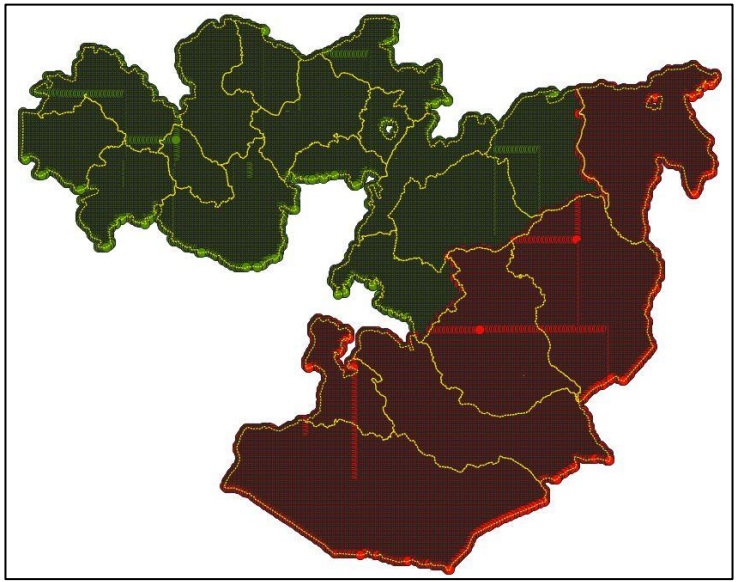
3. Monitoring Approaches

Area Based Regional & Zonal Emission and removal baseline

Regional Scale



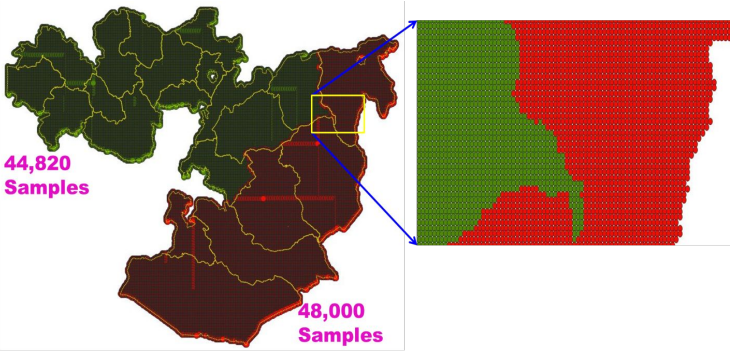
Zonal Scale



- **Used 3758** training samples (with 10X10 km grid interval and 0.5 ha) for 2007 - 2017
- Six IPCC LULC Classes were considered for Above grand carbon pool ER baseline Estimation

- Used 2x2 km grid sample point with total of 92,820
- Main focus is set deforestation and related ER baseline for each 21 for next ER payment X BSP

Area Based Regional & Zonal Emission and removal baseline (2007-2017)



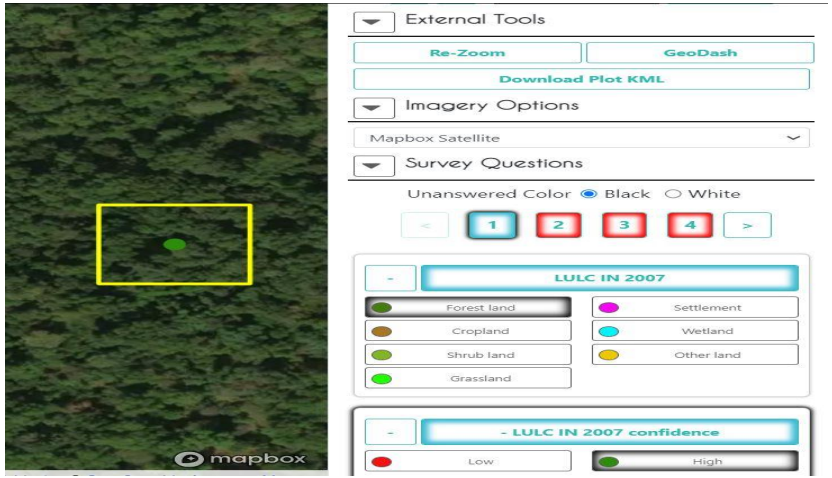
Imageries: Landsat, Sentinel 2, & NICFI

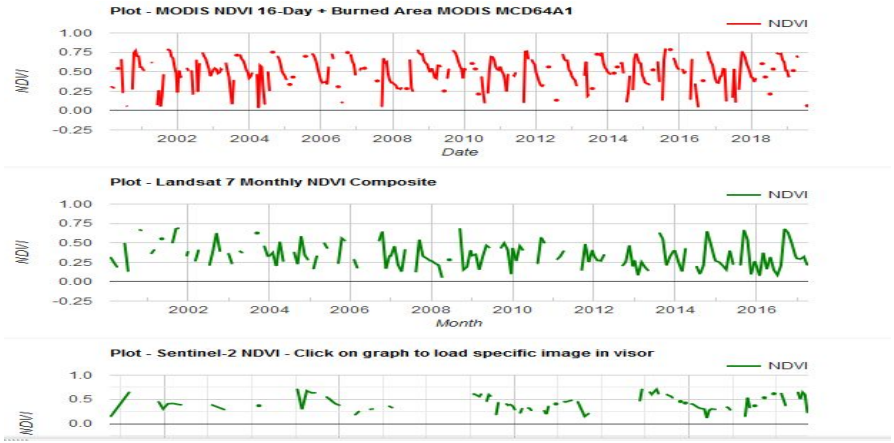
Analysis: Sample Baed area Estimation + Wall to wall

Platform:

Collect Earth Online

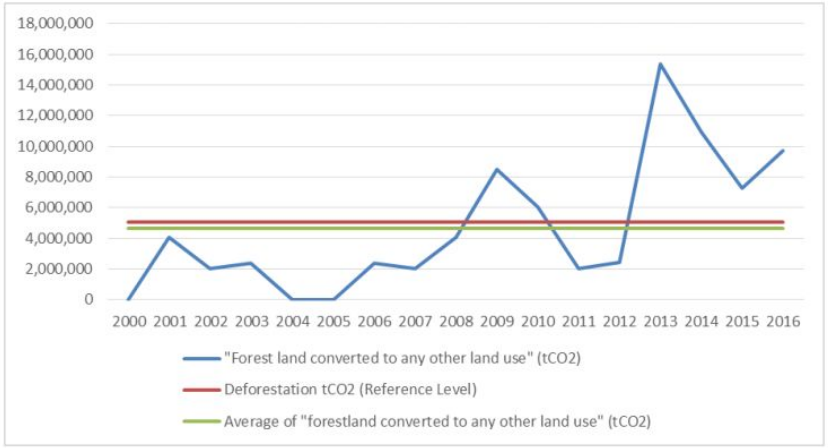
SEPAL

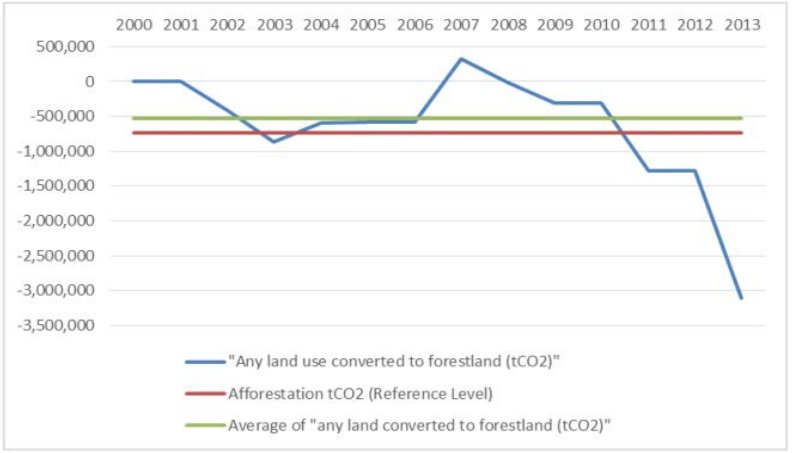


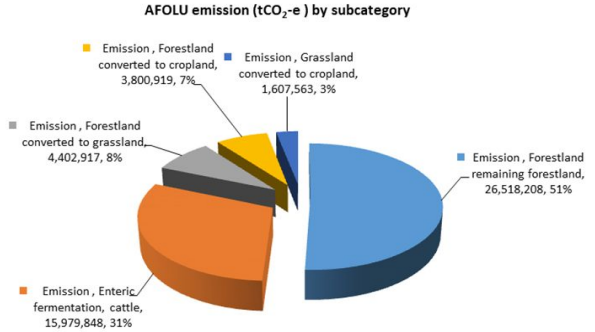


Regional Emission and Removal baseline for ISFL Accounting

Emissions of “Forest land converted to other land uses (left) and, Removals of “land converted to forestland (B) during GHG Inventory baseline assessment with its average



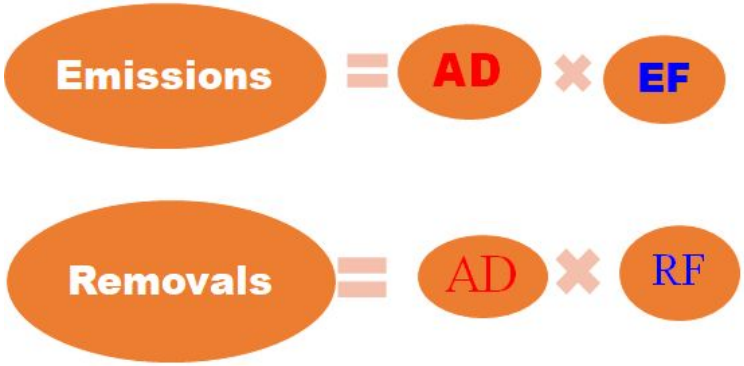




- The total sum of absolute emissions by category and subcategory for AFOLU from 2008 to 2017 is estimated **772 MtCO2-eq**
- yearly average absolute emission for the same period is **85 MtCO2-eq.**

Area Based Regional Emission and removal baseline updated - LULUCF

Row Labels		2007 LULC							
		Cropland	Forest land	Grassland	Other land	Settlement	Shrub land	Wetland	**G/Total**
2017 LULC	Cropland	10,860,157	245,994	109,598	400	7,200	137,597	4,400	**11,365,346**
	Forest land	49,199	10,290,570	15,200	400	800	9,599	400	**10,396,167**
	Grassland	20,800	52,399	6,375,857	-	400	37,199	400	**6,487,055**
	Other land	800	400	2,000	109,598	400	2,400	400	**115,997**
	Settlement	81,998	11,200	16,400	400	748,383	7,200	2,000	**867,581**
	Shrub land	16,800	33,199	26,399	1,200	400	6,887,046	400	**6,965,444**
	Wetland	3,200	1,200	800	400	8,400	800	914,780	**929,579**
	G/Total	**11,032,953**	**10,634,962**	**6,546,253**	**112,397**	**765,983**	**7,111,841**	**922,779**	**37,127,169**



- About **345,525 ha forest cover** (34,553 ha/yr) loss between 2008 -2017,
- Equivalent to about 127m tCo2e (12.7 mtCo2/yr)
- Six zones are responsible for about 55% of emission
- Removal estimated is about 1.6 mtCo2e

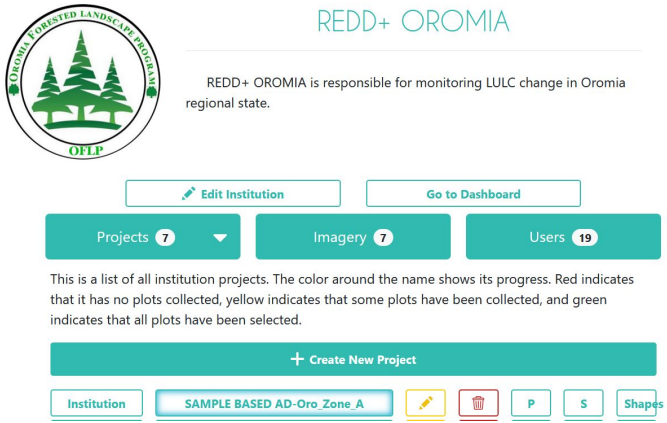
Current ERPA payment at Bale Eco-region – OFLP REDD+ Pilot program

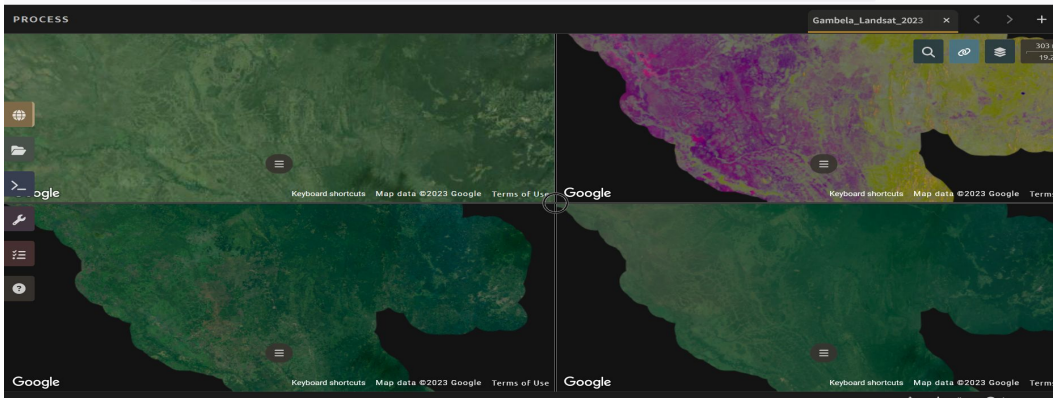
- More than 9.8 million Euro was received as Emission Reduction Result Based Payment due avoided deforestation (2012-2019).
- Current estimated (2020-2021) about 6,335 ha avoided deforestation from Pilot area

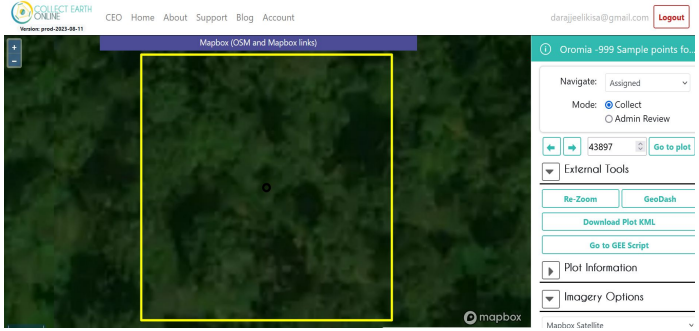
#Geo

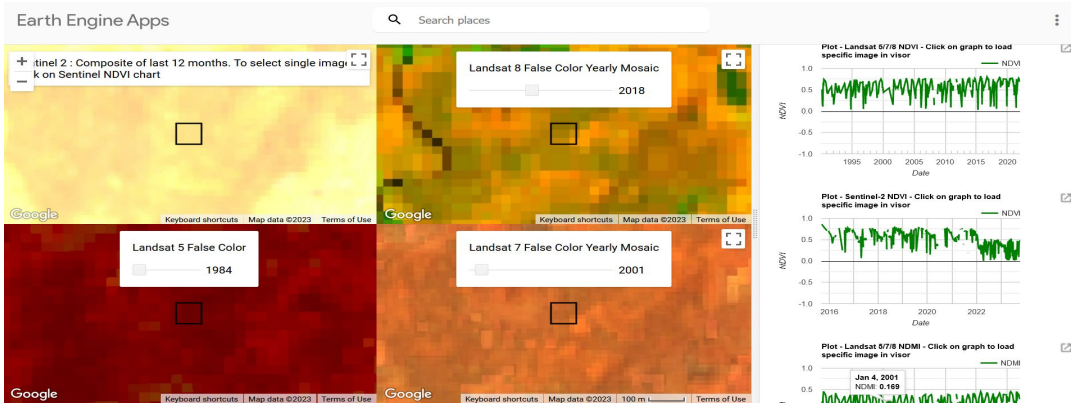
Role of Google Earth Engine (GEE) for REDD+

I. Assess Deforestation and LULC change baseline. CEO+SEPAL+GEE





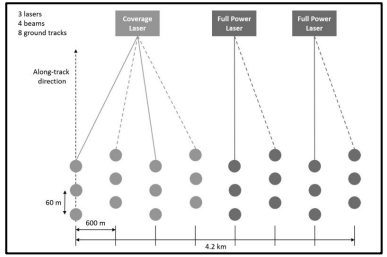


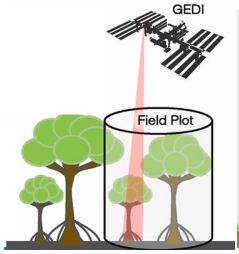


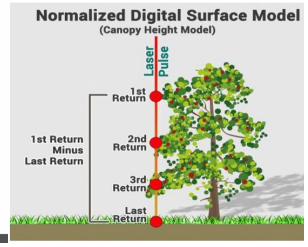
#GeoForGood23

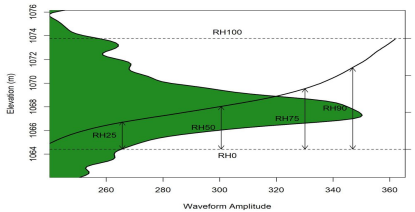
II. Estimate Forest Height, Canopy cover and AGBM using GEDI data

- Important for Degradation baseline Assessment,
  - fusing Global Ecosystem Dynamics Investigation (GEDI) data with other EO and ancillary geographic datasets.
- *Forest degradation monitoring followed Mixed Approach: Direct and Indirect Approach (NFI and Remote Sensing)*

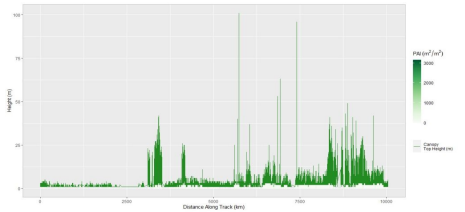








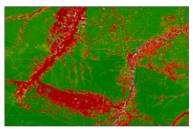
L1A at RH100



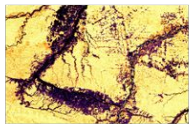
L2B Plant Area Density

NFI Planned

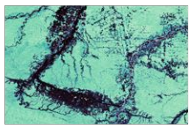
Remote Sensing Based



Canopy Height

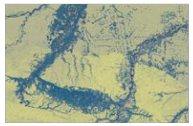


+ Canopy cover +

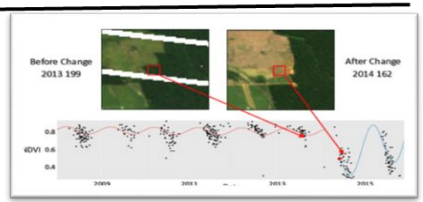


Canopy desity

=

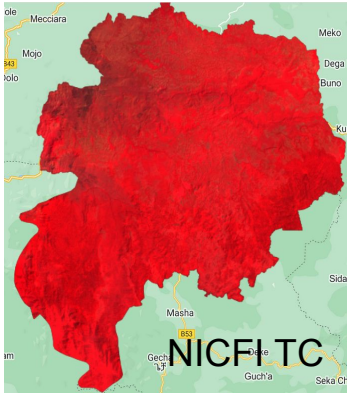


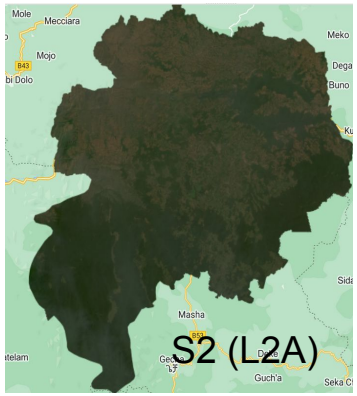
AGB

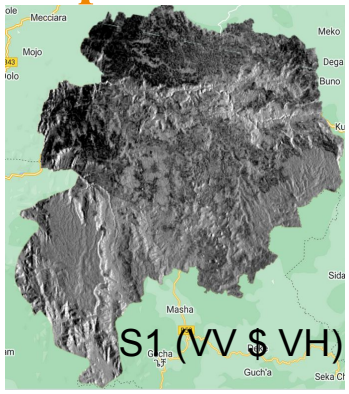


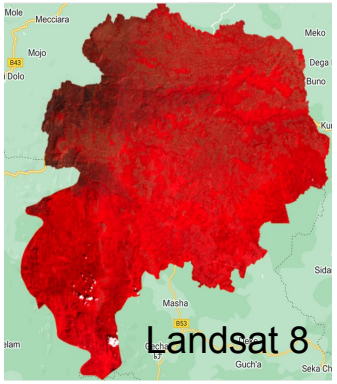
LandTrender
CODED/ CCDC

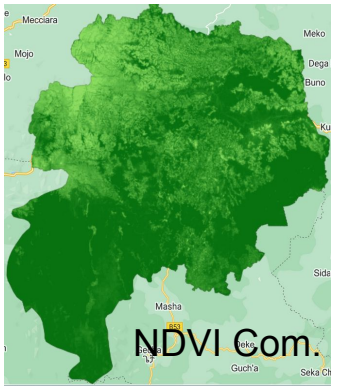
Data Fusion and selection of Important Variables

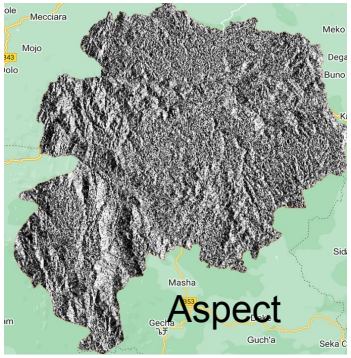


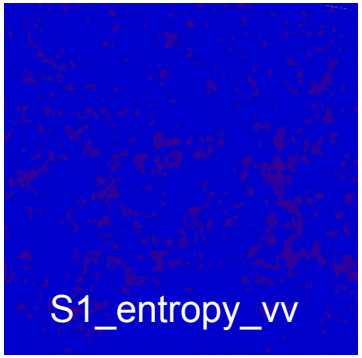


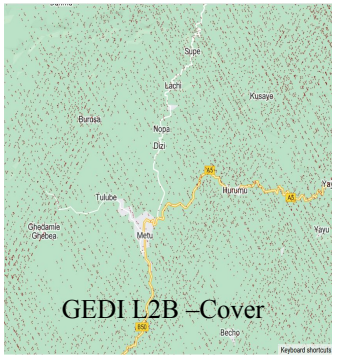


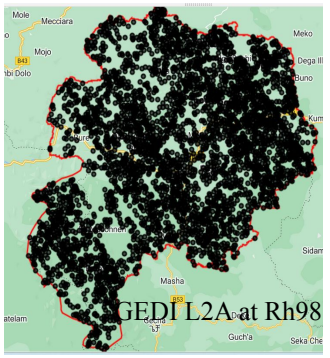












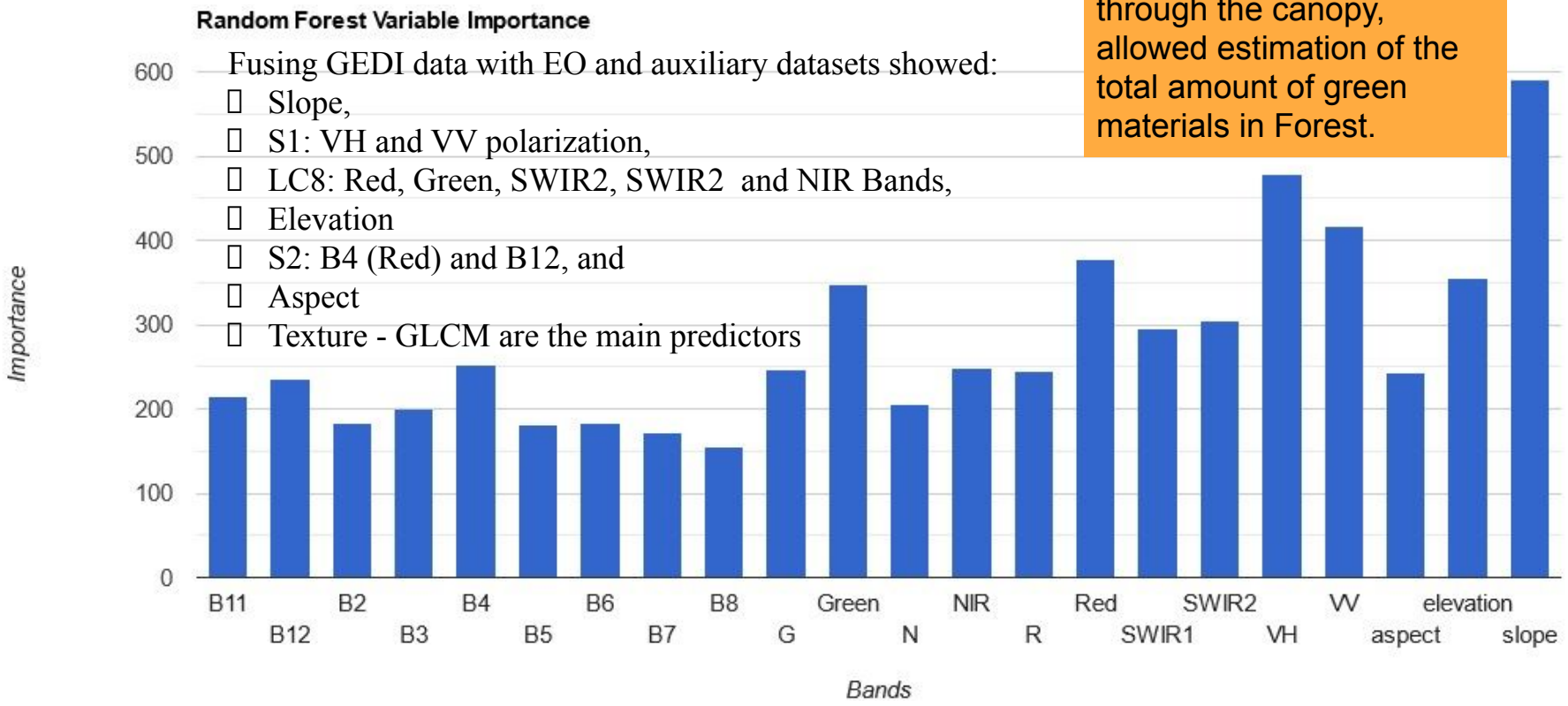
var VariableCollection = S2_composite.addBands(elevation) .addBands(slope) .addBands(aspect) .addBands(NICFI) .addBands(GLCM).addBands(LC8_composite);

Importance of Variables/predictors using RF Regression Model on GEE

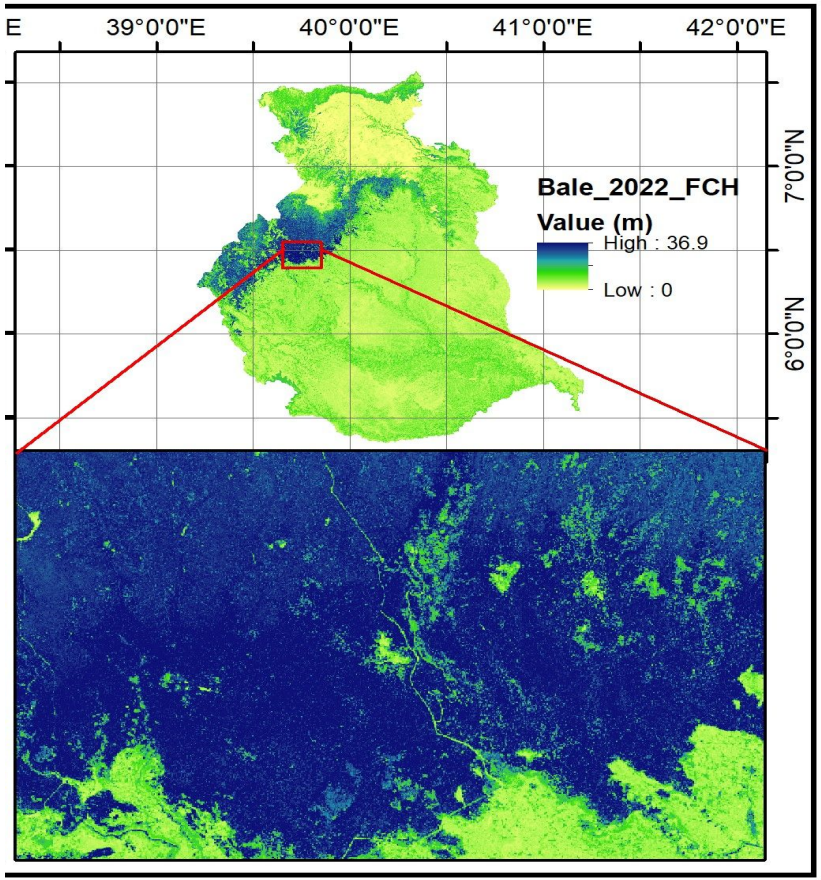
Fusing GEDI data with EO and auxiliary datasets showed:

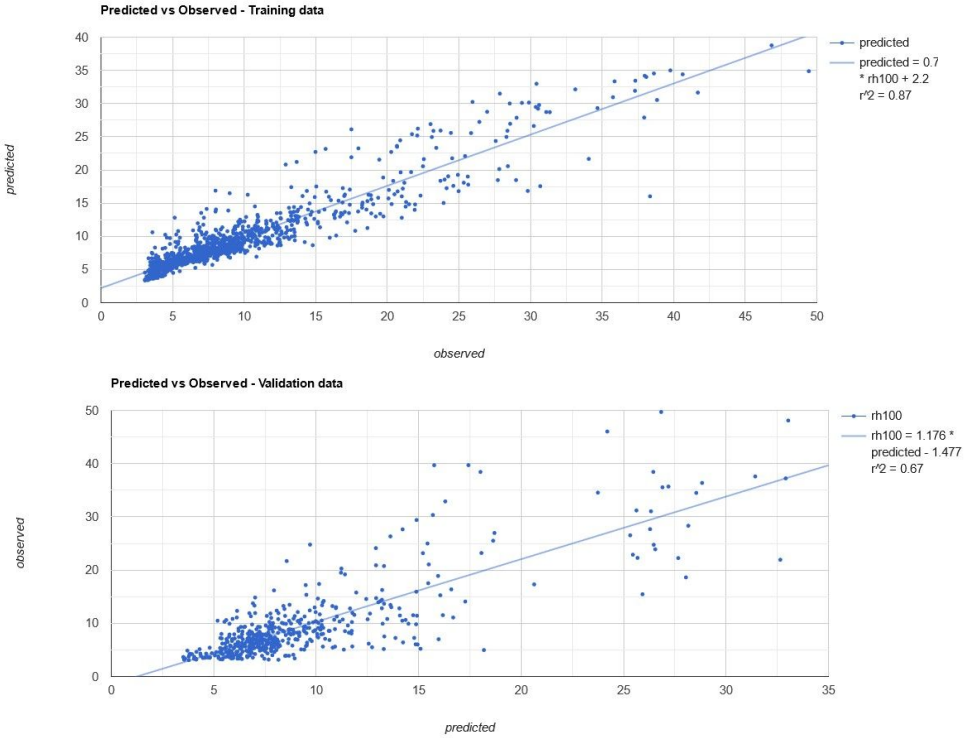
- Slope,
- S1: VH and VV polarization,
- LC8: Red, Green, SWIR2, SWIR2 and NIR Bands,
- Elevation
- S2: B4 (Red) and B12, and
- Aspect
- Texture - GLCM are the main predictors

Greater penetration depth through the canopy, allowed estimation of the total amount of green materials in Forest.



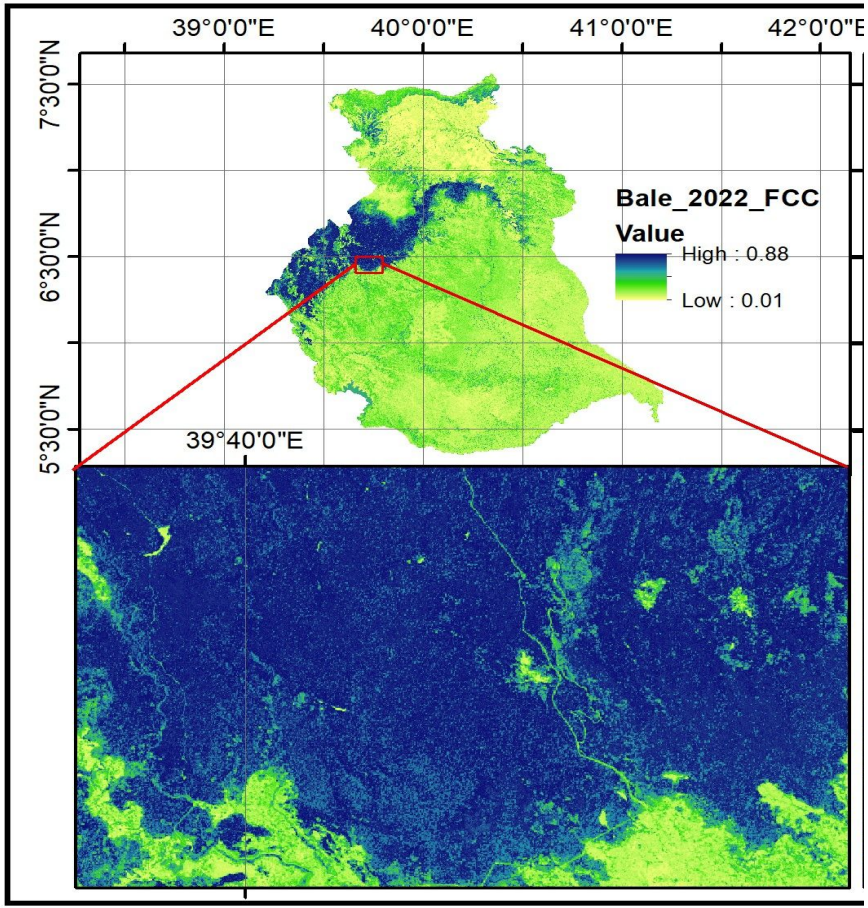
Bale Zone Forest Canopy Height Baseline

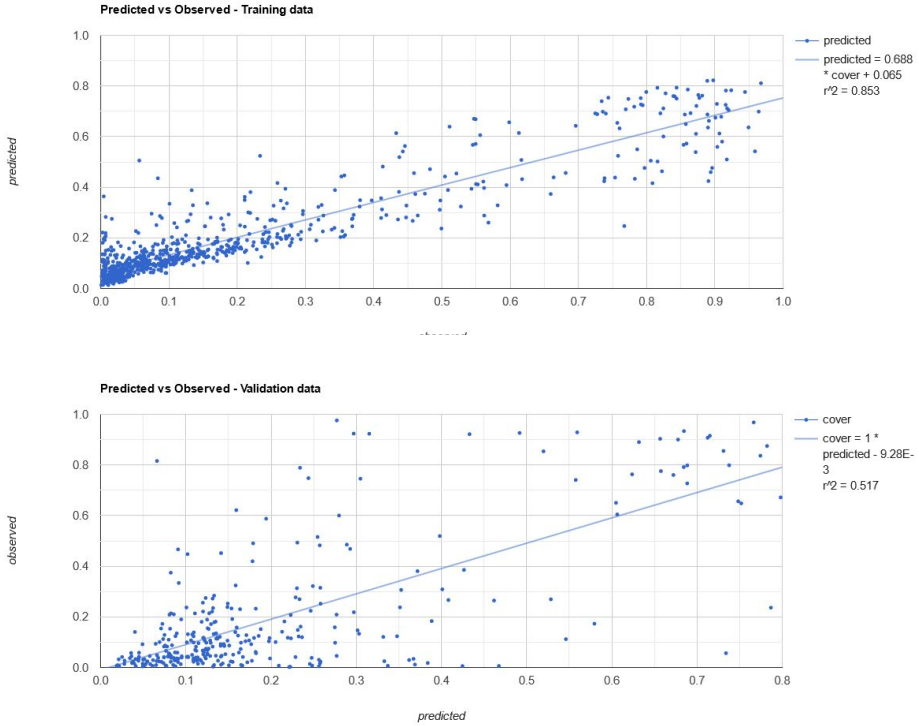




- Validation using 2428 independent Ground Collected tree height data showed R2 of 0.89 with RMSE of +3.4 m

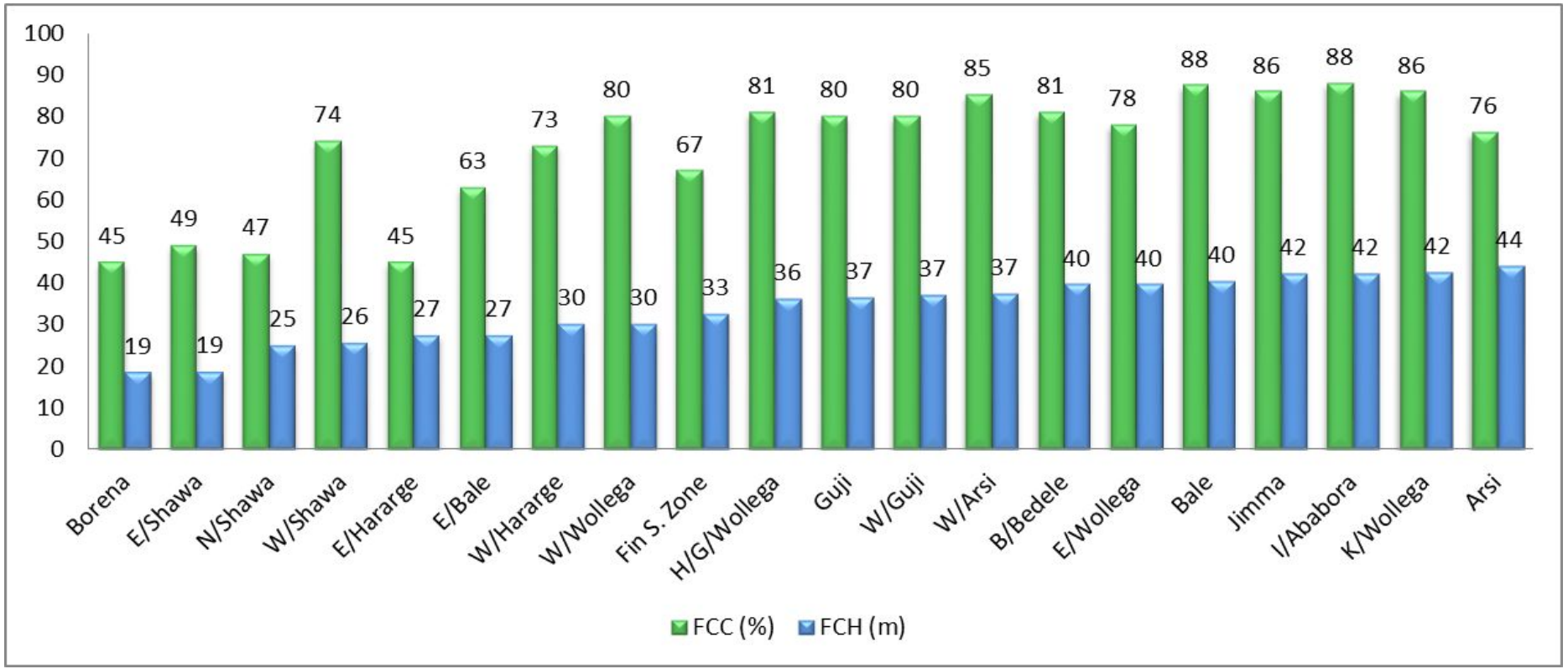
Bale Zone Forest Canopy Cover Baseline





Will be Validated using NFI data

Maximum Forest Canopy Cover/Density and FCH Observed Per Zones



So, what is GEE for REDD+?

- Provide integrated functionalities for data and analysis platform
- Sophisticated way of analysis: LULC extent and change, tree structure, density and AGB at each specific location
- Mapping Carbon potential hotspots and linking with conservation activities
- It minimized workload and time to preprocess and analysis bunch of imageries,
- Regularly monitor and determine what forest Management option is needed.

Technology is transforming


Thank you!

Baselines, remote sensing, and JREDD+

Luke Sanford, Yale School of the Environment

October 2023 | #GeoForGood23

Agenda

01 **Carbon markets and offsets**

02 **What are baselines?**
(and why are they so important?)

03 **New approaches to project baseline quantification**
Using Google Earth Engine

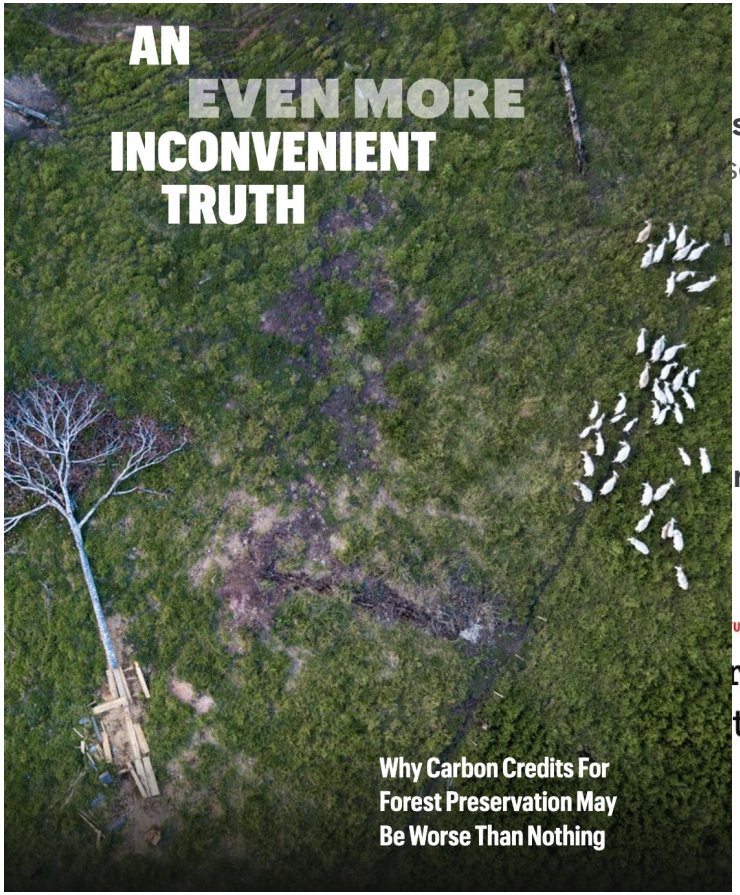
04 **JREDD+ and baselines**
What can baselines tell us about how well JREDD+ programs will work?

05 **Wrap up**

06 **Questions**
You gotta think like a tree.

Carbon Markets

What are they?



Carbon offsets are a scam

Chris Greenberg
10 November 2021 • 4 min read

Rainforest carbon credit schemes misleading and ineffective, finds report

System not fit for carbon offsetting, puts Indigenous communities at risk and should be replaced with new approach, say researchers

Revealed: more than 90% of rainforest carbon offsets by biggest certifier are worthless, analysis shows

Investigation into Verra carbon standard finds most are 'phantom credits' and may worsen global heating

- 'Nowhere else to go': Alto Mayo, Peru, at centre of conservation row
- Greenwashing or a net zero necessity? Scientists on carbon offsetting
- Carbon offsets flawed but we are in a climate emergency

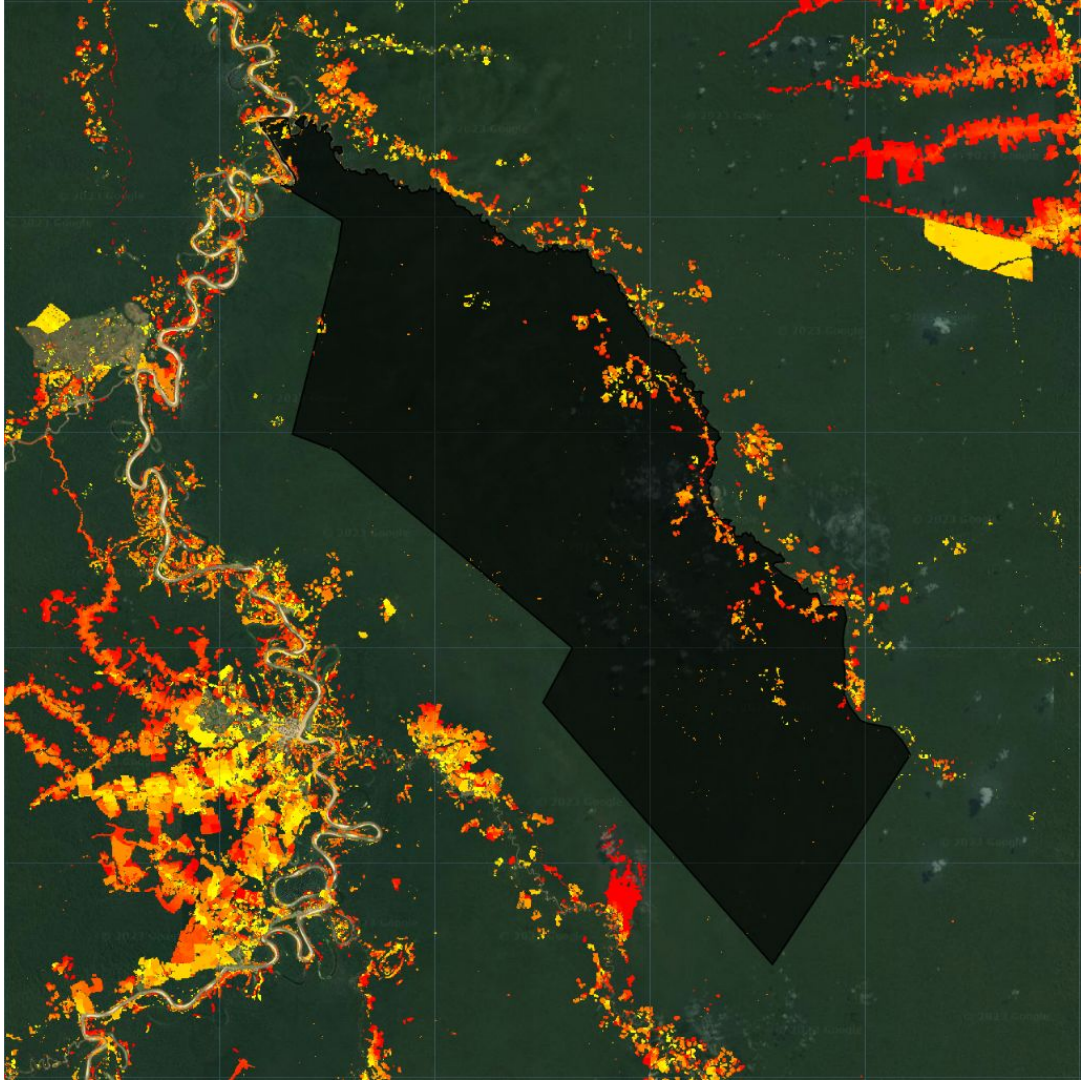
“In 2021, the voluntary carbon market grew at a record pace, reaching $2 billion—four times its value in 2020—and the pace of purchases is still accelerating in 2022. By 2030, the market is expected to reach between $10 billion and $40 billion.”

-Boston Consulting Group

Why the disagreement?

It is mostly about baselines

- Baseline: what would have happened without the carbon credit project
- Methodology: how to create a baseline
- Developer: sets a baseline
    - How much carbon will be/would have been emitted/sequestered here?
- Additionality is the difference between the project scenario and the baseline (non-project) scenario



How much carbon did this project sequester?

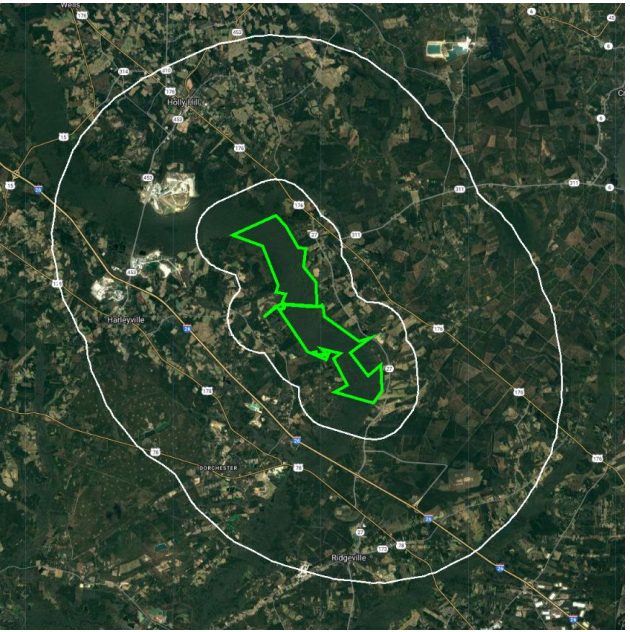
Depends on what the baseline looked like:

Optional eyebrow

Challenge: the (true) baseline is unknowable

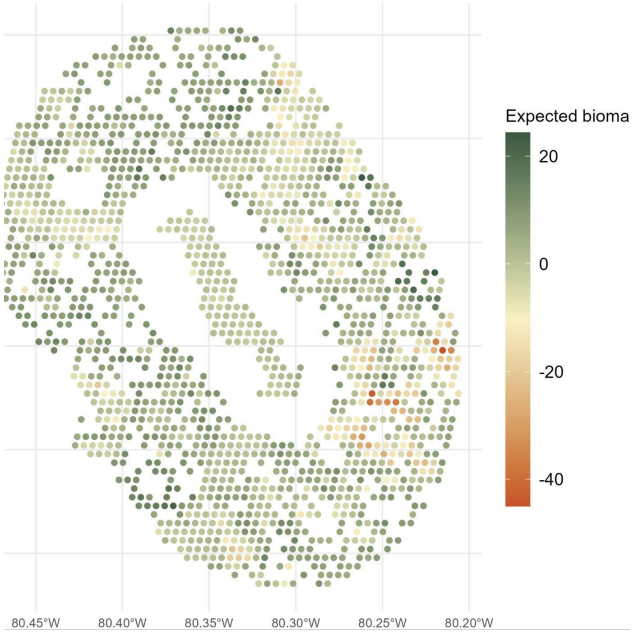
Our solution: use GEE + ML + Statistics: Satellite Double Machine Learning

With Seung Min Kim



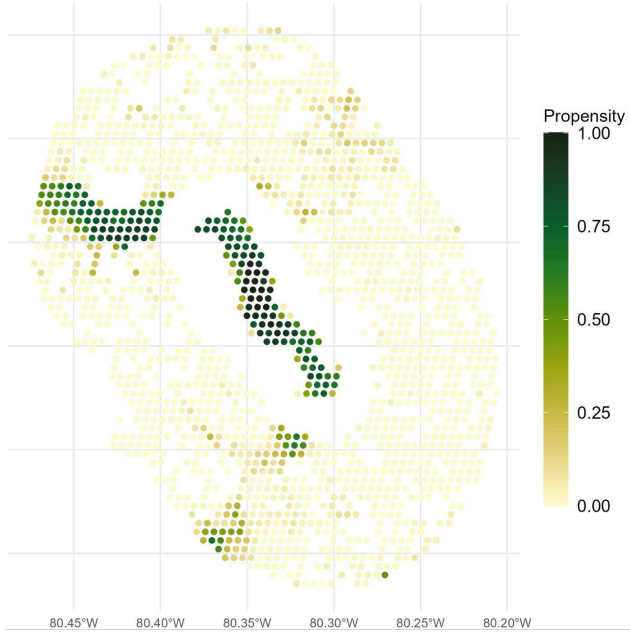
Carbon Project

Green is project, 2km leakage buffer, 8 km “donor pool” around that



Outcome model

What do we think will happen on this point based on years of remote sensing and geographic data

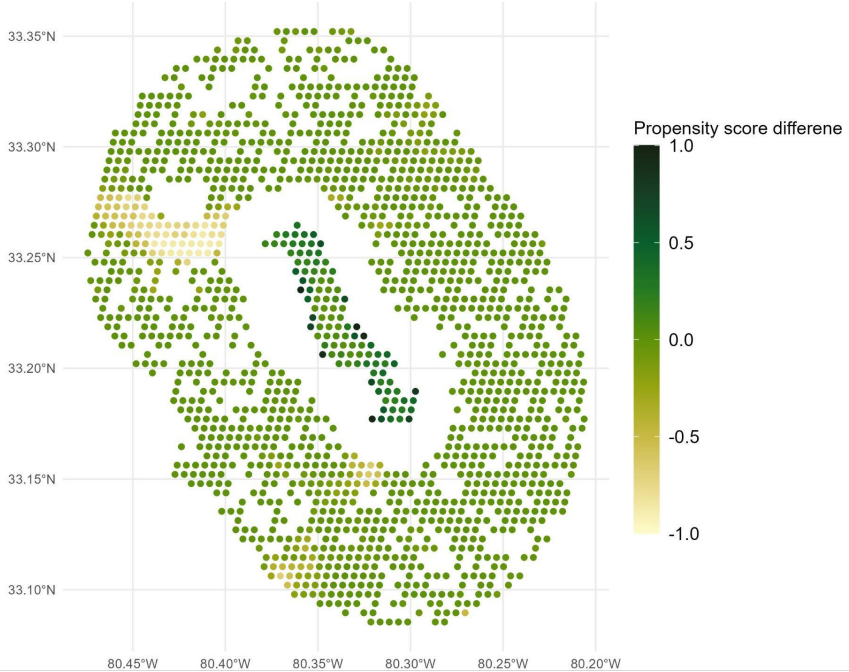


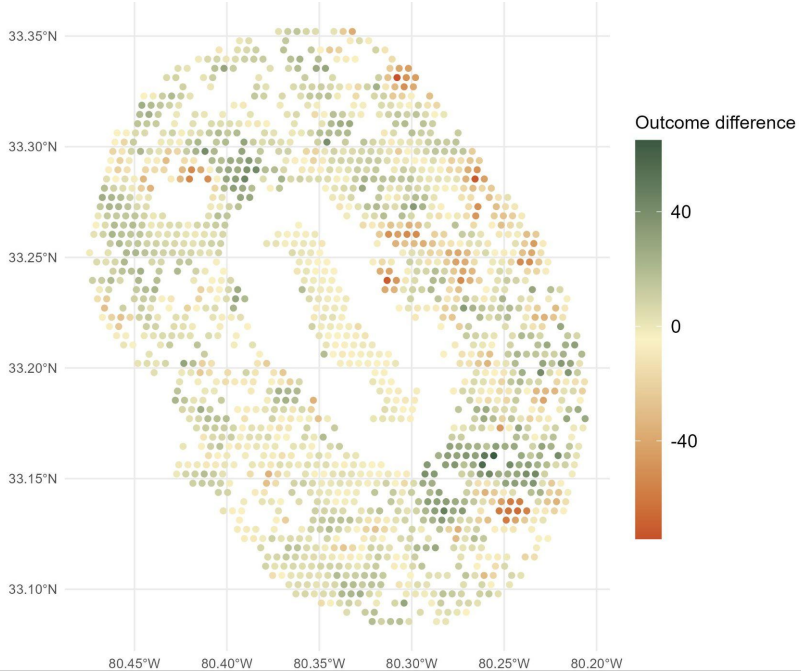
Propensity model

Does the point “look like” it is inside or outside of the project

Our solution: use GEE + ML + Statistics: Satellite Double Machine Learning

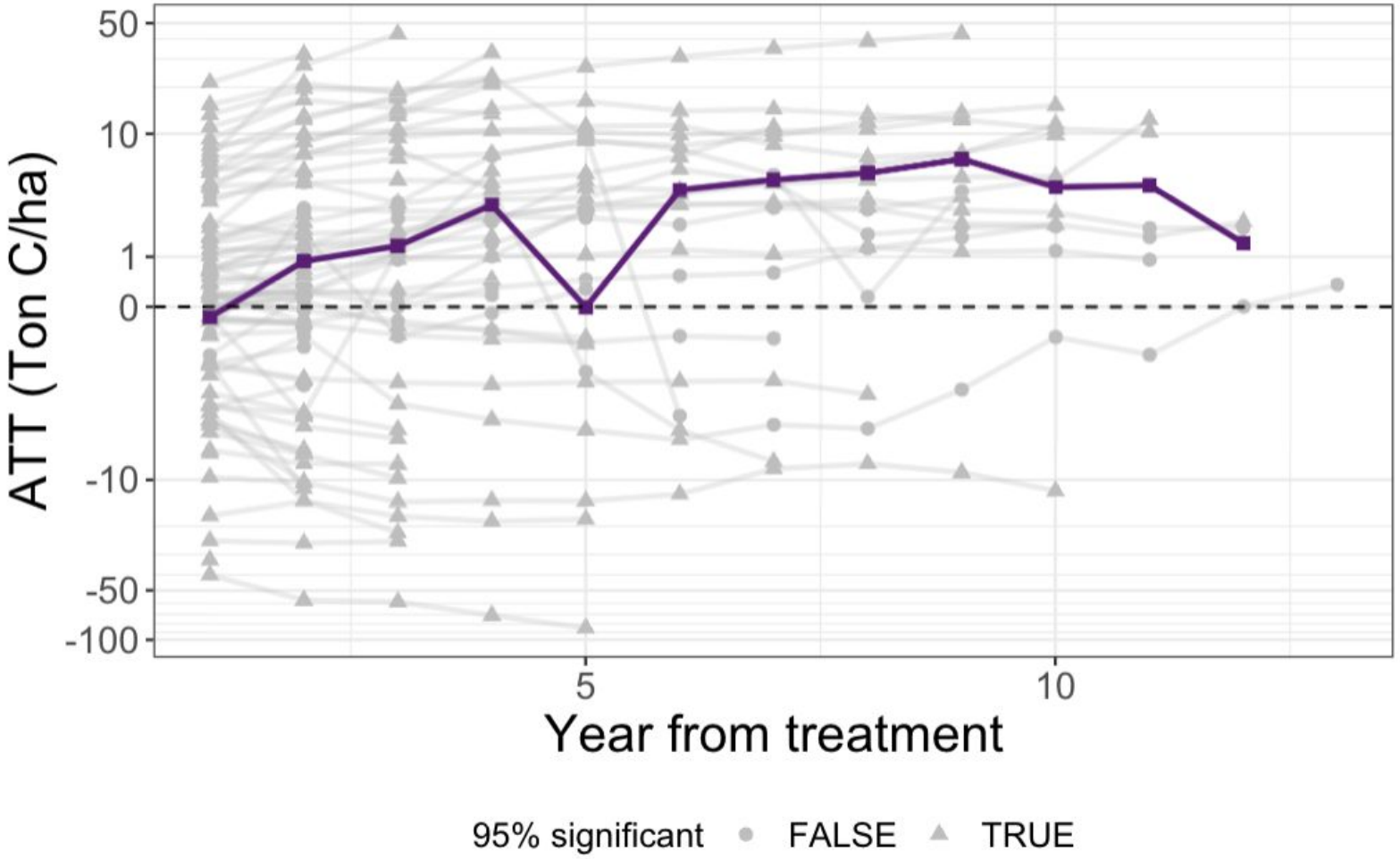
With Seung Min Kim





Use “unexpected” treatment status

To predict “unexpected” outcomes


ATT (Ton C/ha)
50
10
1
0
-10
-50
-100
5
10
Year from treatment
95% significant
FALSE
TRUE

Results

20-25% additionality for IFM projects which generate offsets in the California Carbon Market

~0% additionality for Avoided Conversion projects

Landowner type matters–tribal projects generate the highest quality offsets!

Lots of additional work in using remote sensing to improve project-based offsets

Go see Megan Ayers in the next session to see joint work on leakage detection

JREDD baselines with GEE data

What is Jursidictional REDD+?

ART
Architecture for
REDD+ Transactions

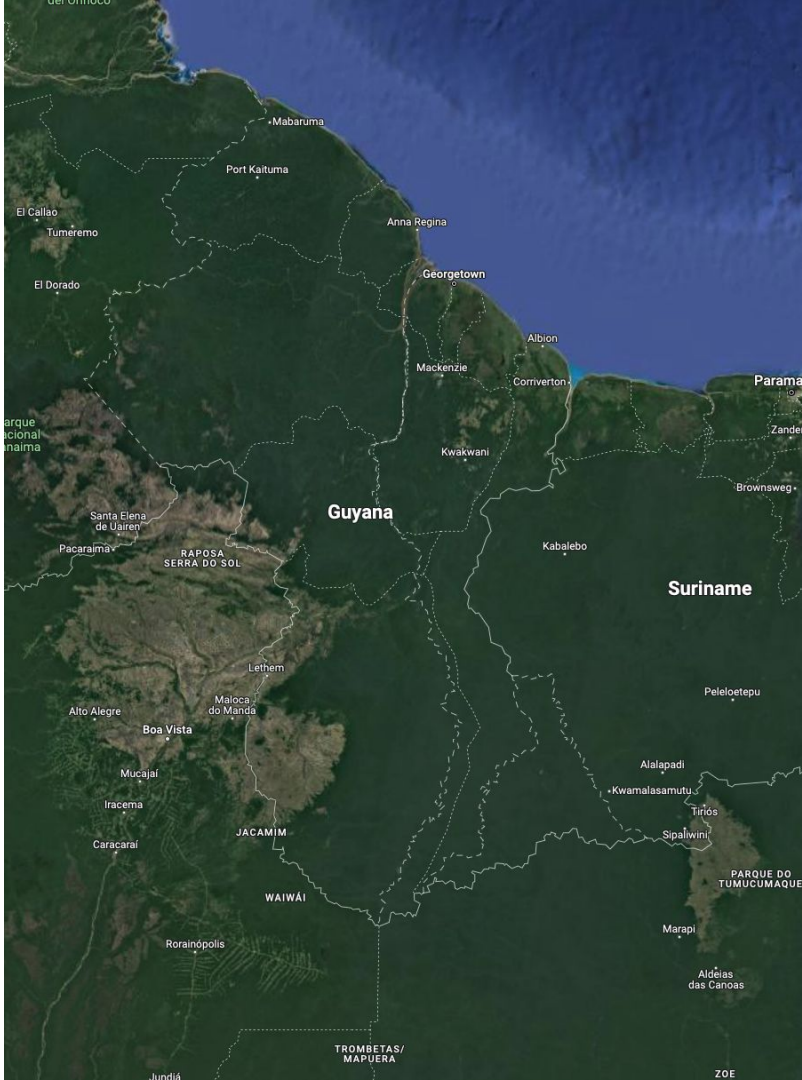
“The fundamental difference to project-level REDD+ is that all the forest in a national (i.e. whole country) or subnational (e.g. state or province) jurisdiction must be considered when setting a baseline and monitoring deforestation.”

-Sylvera

Advantages:

- Reduced risk of inflated baselines
- Reduced Leakage
- Scale
- Changes to policy and regulation

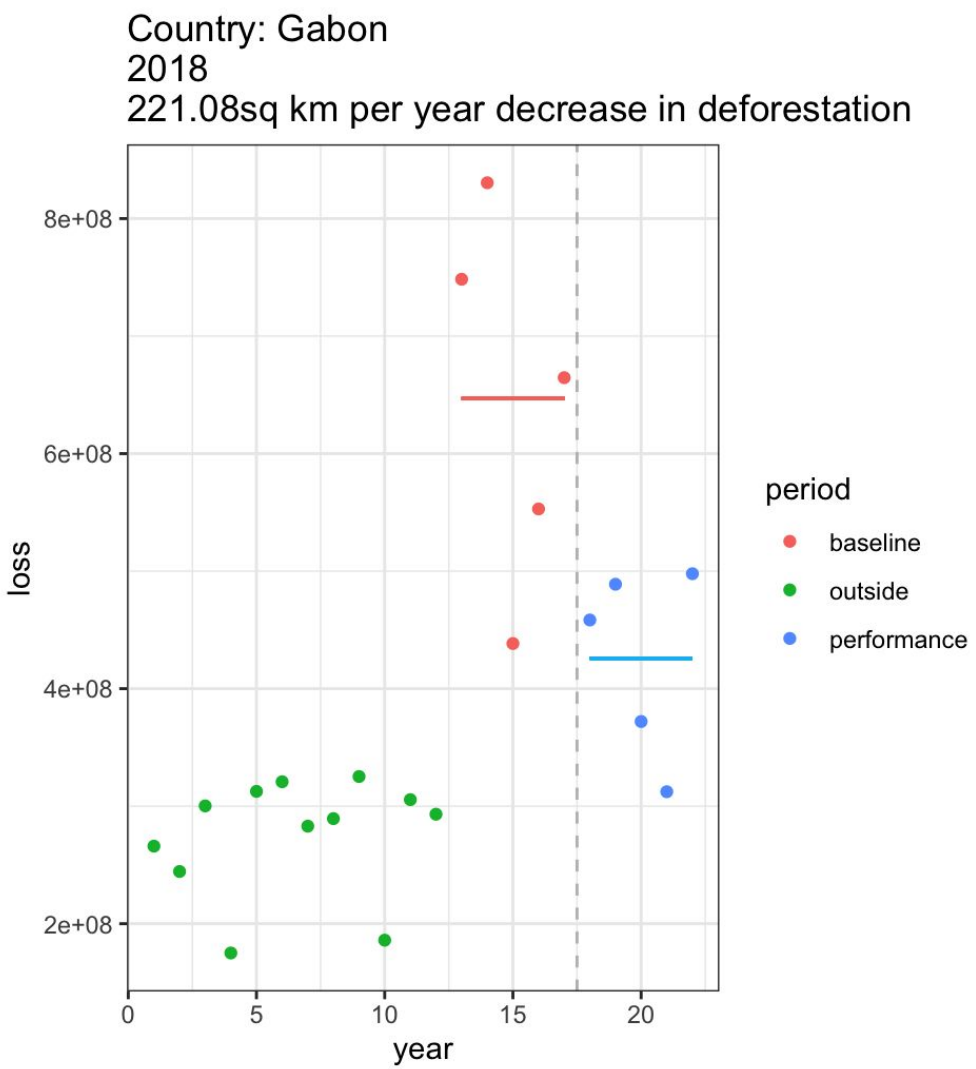
Guyana issued the first JREDD+ credits in late 2022



#GeoForGood23

How “baselines” are calculated

- Reference period (baseline)
- Performance period
- Credits = baseline - performance



Baseline:

What a jurisdiction would have done absent JREDD

We have a lot of data on this!

We have it for every jurisdiction in every year since 2000 (Hansen et al.) or 1990 (Vancutsem et al.)

Processing is fast thanks to GEE

Approach:

Calculate a baseline for every eligible jurisdiction-year

See how well protocol baselines correspond to actual emissions

Only in years before JREDD carbon credits existed

How this works:

Calculate baseline + endline for Matto Grosso for each year:

How often would we have awarded credits for behavior which was not a result of JREDD?

Can we predict when this might happen?

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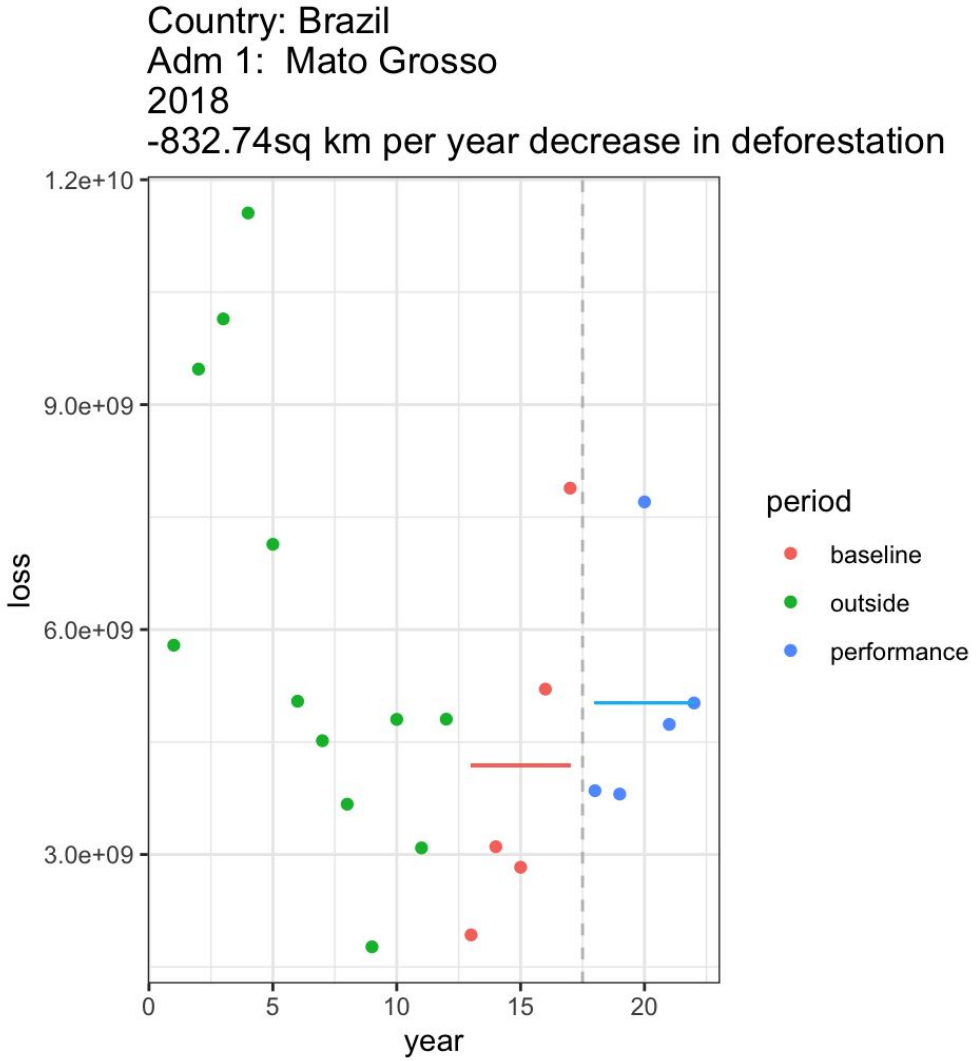
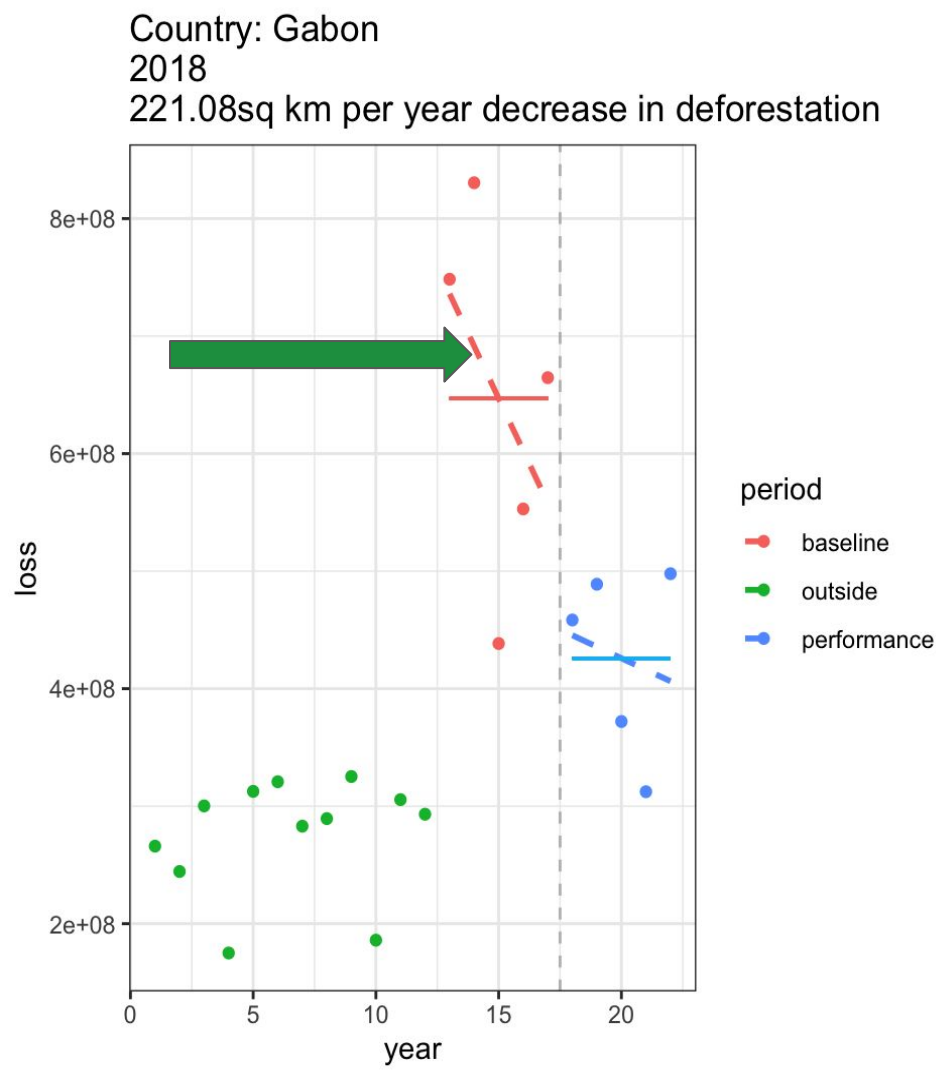
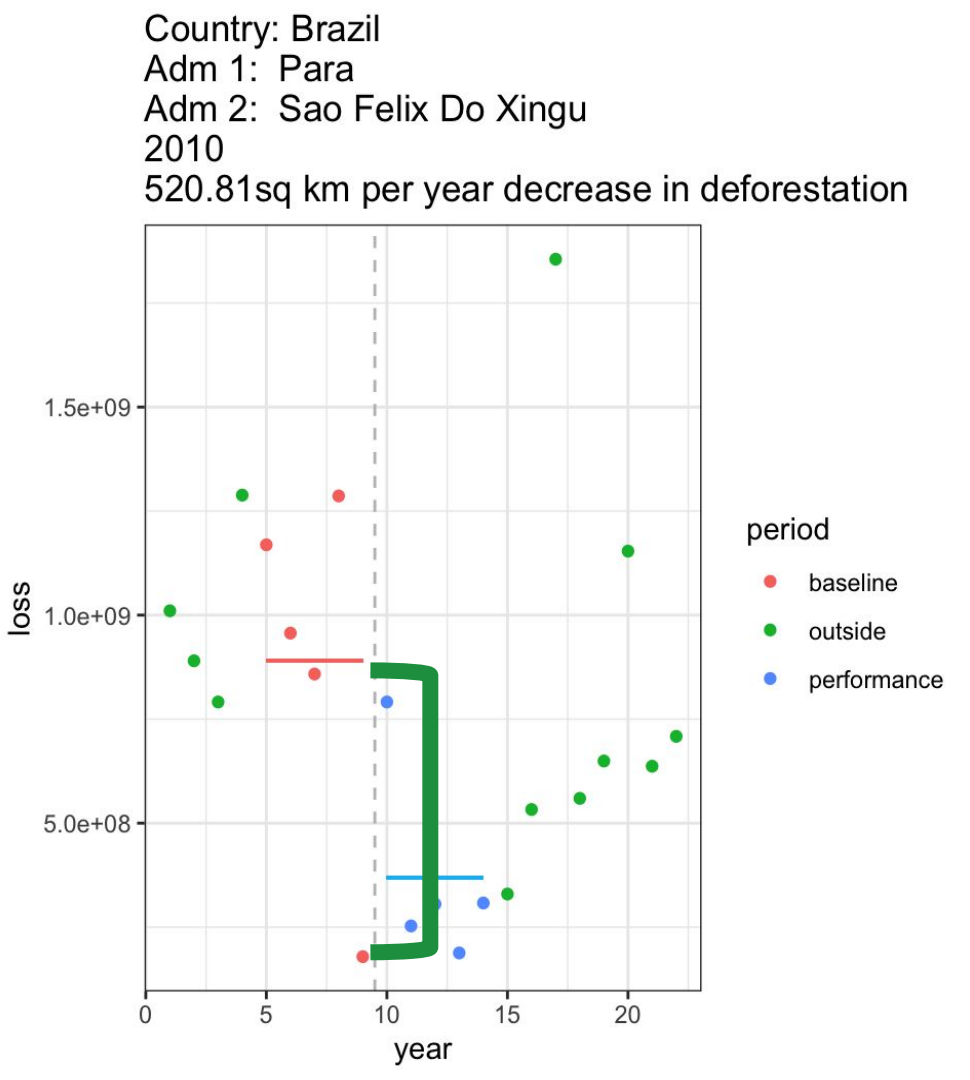



Country: Gabon
2018
221.08sq km per year decrease in deforestation
8e+08
6e+08
4e+08
2e+08
loss
0
5
10
15
20
year
period
baseline
outside
performance


Country: Brazil
Adm 1: Para
Adm 2: Sao Felix Do Xingu
2010
520.81sq km per year decrease in deforestation
1.5e+09
1.0e+09
5.0e+08
loss
0
5
10
15
20
year
period
baseline
outside
performance

Results

Baseline slopes and final year differences both predict performance period emissions

There is the possibility for adverse selection leading to non-additional credits

No evidence of adverse selection in jurisdictions which register for JREDD

Further projects ongoing on JREDD+ offsets:
HFLD methodologies, policy changes in JREDD+ jurisdictions


Thank you!