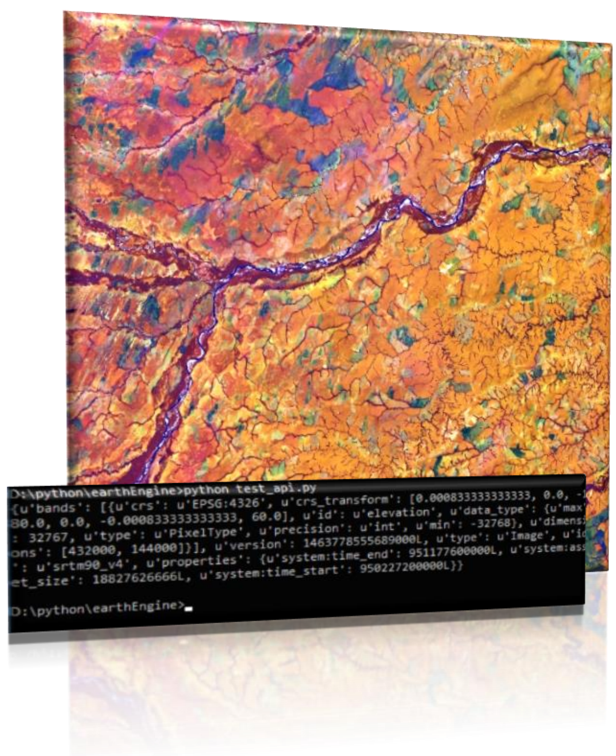
BioCarbon Fund
Initiative for Sustainable Forest Landscapes

MINUTES and ACTIONS

SilvaCarbon and the Initiative for Sustainable Forest Landscapes Workshop on Exchange of Experiences on Land Use Change Mapping

March 25 – 27, 2019

Washington, DC



THE WORLD BANK SilvaCarbon BOSTON UNIVERSITY Google Earth Engine

Objectives:

- To provide the participants with an opportunity to exchange experiences, challenges and benefits of land-use change mapping approaches used and identify points for collaboration and needs for further capacity building activities.
- To revise, evaluate, and suggest improvements for existing mapping land use methodologies.
- To present alternative methodologies and open source algorithms that run in the Google Earth Engine (GEE) platform.
- Look into solutions according to the needs of the countries for mapping forest degradation and the conversion among the six land use classes defined by the Intergovernmental Panel on Climate Change (IPCC) as required to inform greenhouse gases (GHG) Inventories in the Land Use, Land-Use Change and Forestry (LULUCF) and agricultural sectors.

Expected Outcomes:

- Understand the countries' mapping priorities and link to their respective desire outcomes.
- Sharing of experiences, expertise, practices and knowledge gaps.
- Introduce and further deepen the participants' knowledge of land-use change and degradation mapping and monitoring.
- Facilitate future work through workshops and training classes based on direct needs of the participating countries.

The flow of the week:

- Understand the Initiative for Sustainable Forest Landscapes (ISFL) requirements, and the best practices for producing activity data.
- List new potential methodologies to integrate into the process of producing activity data, including degradation.
- Learn the experiences from the countries, including constrains, technical needs, institutional and technical challenges, areas where there is room for improvements.
- Match country needs with potential capacity building activities. Work planning

Day # 1
Monday, 25 March 2019

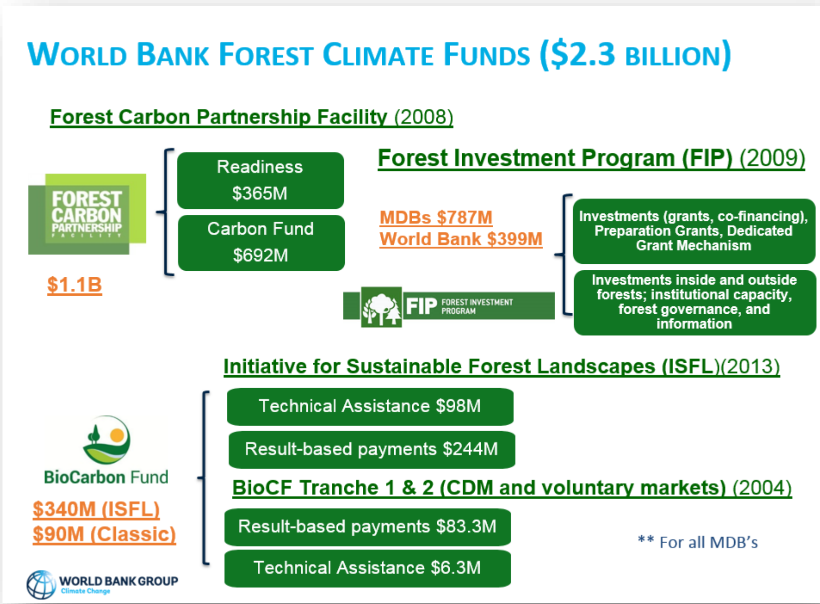
The workshop was opened by Andres Espejo from the World Bank. He introduced Christine Dragisic from the Department of State who welcomed everyone to the workshop and provided a brief summary of the SilvaCarbon and the ISFL programs both of which have been supported by the State Department. The SilvaCarbon program coordinates a collaborative effort among government agencies involving USGS, USFS, NASA, NOAA, and USDA on ground breaking technical efforts.

The ISFL is a pioneering international effort demonstrating what can be done in a diverse set of countries to take actions in an entire set of diverse landscape to reduce emissions, improve livelihoods, and build resilience. Even though there might be challenges, it is essential to find a way to bring SilvaCarbon and ISFL together to help programs in the countries move forward by improving capacity in forest and land use change mapping. The focus of this workshop is on land use change mapping and some of the best approaches that can help countries identify ways forward on this challenging topic.

PRESENTATIONS

1. Andres Espejo, World Bank
Welcome and Introduction: Initiative for Sustainable Forest Landscapes

Andres Espejo started with providing a brief introduction into the World Bank (WB) Climate Land Use Programs. The WB has a $2.3 billion forest climate funds of which $340 million are set for the Initiative for Sustainable Forest Landscapes (ISFL), established in 2013.



The WB promotes and rewards reduction in greenhouse gas (GHG) emissions and increased sequestration through better land management, climate-smart agriculture, and smarter land use planning and policies. The WB has a 3-phase business model which includes:

1) Enabling Environment (policy and strategy; capacity building; social inclusion; consultations)

2) Development Action (investment in low carbon development; sustainable management of forests; climate-smart agriculture)

3) Low-Carbon Development Benefits (poverty alleviation; shared prosperity; climate change mitigation and adaptation).

Under the BioCarbon Fund, the WB ISFL program works with 5 countries, on jurisdictional level:

- **Mexico:** Nuevo León, Coahuila, Chihuahua, Durango, 58 million ha

- **Ethiopia:** Oromia Regional State, 32 million ha
- **Colombia:** Orinoquia Region, 25 million ha
- **Zambia:** Eastern Province, 5.1 million ha
- **Indonesia:** Jambi Province, Sumatra, 5 million ha

The difference between REED+ and ISFL: Even though forests are important, countries need to be moving towards mapping the six top-level land categories for GHG inventory reporting: forest land, cropland, grassland, wetlands, settlement and other land. It is important to understand the land cover change not only in forests' landscape and forest cover changes and degradation but beyond, moving to other land use and land use change classes.

2. Sylvia Wilson, USGS

Building Capacity Worldwide for Measuring, Monitoring, and Reporting Forest and Terrestrial Carbon

The SilvaCarbon program provides capacity building worldwide for measuring, monitoring and reporting forest and terrestrial carbon. SilvaCarbon is currently working in 23 countries. The program has coordinators in every region, organized by the USFS intern program. On this map, the countries where SilvaCarbon works, colored in blue, are funded by intergraded money from the USAID mission.

The SilvaCarbon program develops guidance and supports other organizations and universities to develop tools needed by the countries for their forest and land use change mapping and monitoring.

Evan Notman, a consultant to the Global Forest Observations Initiative (GFOI), provided a summary of the initiative's goals and objectives. The GFOI is an informal partnership of multiple actors to assists developing countries on forest monitoring and GHG accounting for REDD+ and other related activities. The GFOI actors are: SilvaCarbon, USA, Norway, Australia, Germany, United Kingdom, as well as the World Bank, FAO, and CEOSS. GFOI helps coordinate the work of the actors to ensure that there are no overlapping efforts and to ensure symbiotic relationships among all partners and countries. Evan Notman mentioned the upcoming GFOI meeting in Mozambique in April that will present opportunities for greater coordination on technologies such as those that will be presented during this workshop.

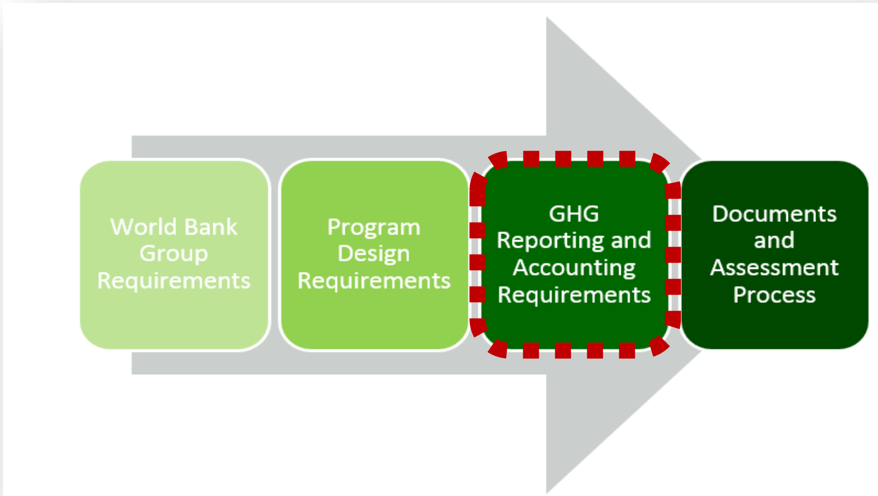
Sylvia Wilson explained that scientists from Guatemala were invited to this workshop even though they are not ISFL country but have valuable experience in using various land use change methodologies. SilvaCarbon has experience with providing Remote Sensing training for land use change mapping. The SilvaCarbon program brings to the table lessons learned since 2011.

One example Sylvia Wilson provided is how at the beginning of the SilvaCarbon capacity building work, the program was delivering Landsat imagery to the countries on external discs in comparison to the current stage where SilvaCarbon is providing capacity building in doing the remote sensing analysis using Google Earth Engine. Even though the main expertise of the SilvaCarbon program are in the forestry, the knowledge can be advanced and applied to the other IPCC classes and work with the ISFL countries.

Institutional challenges exist, such as non-functioning systems in place, countries have different maps, methodologies, and uncertainties in the use of new platforms. Some countries express the need to have all the images in place (downloaded), while other countries like the idea about the cloud. It is usually the technical personnel that is onboard with working on the cloud but not the higher-level management.

3. Rama Reddy, World Bank
ISFL Overview and Emission Reductions (ER) Program Carbon Accounting Requirements

Rama Reddy started his presentation by summarizing a document with the requirements that ISFL emission reductions (ER) programs must comply with to be eligible to receive results-based finance from BioCarbon Fund. The four major categories of requirements of ISFL are shown below:



The third requirement is the focus of this workshop, analysis of emissions and removals to inform program design.

The program design is informed by 1) contributions of key sources and sinks to the total GHG emissions and removals in the Program GHG Inventory, 2) Analysis of emission trend of key drivers, and 3) assessing the risk of displacement.

Rama provided example of how terms are used in requirements, see in the table below.

	Categories	Subcategories
Livestock	A. Enteric fermentation	Cattle
		Sheep
		Swine
		Other livestock
Other	C. Rice cultivation	Irrigated
		Rain-fed
		Deep water
		Other
LULUCF	A. Forest Land	Forest Land remaining forest land
		Land converted to forest land
	B. Cropland	Cropland remaining cropland
		Land converted to cropland

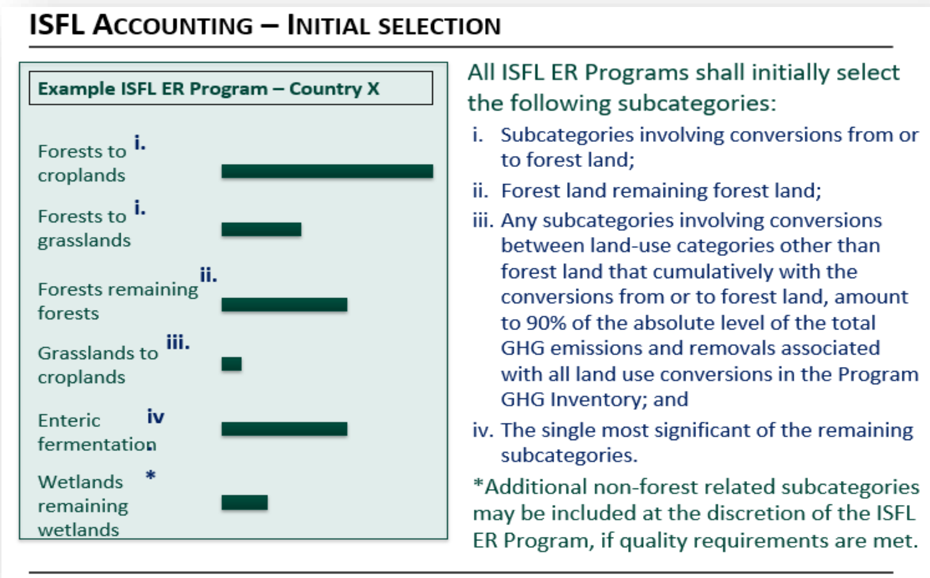
For example, Colombia's Program which has rice as part of their land use is required to estimate and report the emissions from that category.

ISFL Reporting: 1) reporting of all AFOLU related emissions and removal for the Program Area, 2) supports the program design, 3) basis for identifying important subcategories, 4) uses existing data from the National GHG inventory or similar processes.

The ISFL ER program will compile GHG inventory for all AFOLU categories, sub categories, gases and pools in the Program Area. ISFL requires time series data.

ISFL Accounting: 1) identification of subcategories that are eligible to receive result-based payments, 2) accounting of emission reductions by comparing monitored emissions and removals with a baseline, based on minimum quality requirements.

The figure below summarizes the initial selection.



Under the ISFL accounting quality requirements, the activity data needs to be IPCC Tier 3 for emission factors, but the country could start with minimum of IPCC Tier 2 and move to Tier 3 asap. For land use change-related subcategories, Approach 3, if not possible Approach 2 may be used. The table below summarized the requirements for determining eligibility:

Subcategory	Emissions Baseline setting	Methods and data	Spatial information
Any subcategories involving conversions from or to forest land	Historical Baseline Period of 10 years	Tier 2 methods and data	Approach 2 or 3
Forest Land remaining Forest Land	Historical Baseline Period of 10 years	Tier 2 methods and data, **using jurisdiction-specific proxies as necessary**	Approach 2 or 3
Any subcategories involving conversions between land-use categories other than forest land	Historical Baseline Period of 10 years	Tier 2 methods and data	Approach 2 or 3
Most significant of the remaining non-forest subcategories	Historical Baseline Period of 10 years as default. **Where not possible and convincing justification is provided, at least 5 years**	Tier 2 methods and data	
Additional non-forest related subcategories	Historical Baseline Period of 10 years	Tier 2 methods and data	

ISFL Accounting Phasing Approach: 1) ERPA signature (qualitative or quantitate analysis of emissions or removals), 2) End of Phase 1you will be evaluated. For example, phase 1 – we can include forest, phase 2 – life stock, phase 3 you continue to expand to include other traditional activities.

Important part of the accounting is monitoring. It is important how well the monitoring of the categories and subcategories of activities is done. It is important to include good quality data at the first phase if possible. Once the program gets more experienced (data requirement and people knowledge increase), the ISFL has a 10 year of implementation. There are different phases – 5 years, after that you could improve and include other subcategories, and renegotiate some of the terms that were established in phase.

ISFL is set up till 2030 (there might be extensions but for now, it is that). The countries need to start preparing the national and provincial data in phase 1 to submit in phase 2. If there are differences between the national level data and jurisdictional level, it is possible that the jurisdictional level can help the national and vice versa. In ISFL countries, the national level is responsible for the juridical level – so they are the umbrella and making the decision and submitting GHG numbers. Jurisdictional levels sometimes are advancing faster than the national level however, the ISFL is working only in specific jurisdictions in these 5 countries for accounting purpose.

Rama emphasized the needs to assess, quantify and try to reduce uncertainties. Uncertainties are high if a program had used some proxies for the estimates. Uncertainties includes all possible errors and so, all errors need to be quantified and assessed.

- **ISFL Accounting Uncertainties:** 1) Identity and assess (Systematically identify and assess sources of uncertainty in the determination of the Emissions Baseline and the monitoring of emissions and removals), 2) Manage and reduce (Systematically identify and assess sources of uncertainty in the determination of the Emissions Baseline and the monitoring of emissions and removals), 3) Quantify (Quantify the uncertainty of the emission reductions using a Monte Carlo method)

- **ISFL Accounting Reversals:** 1) Assess (Assess the anthropogenic and natural risk of reversals that might affect emission reductions during and after the emission reductions program area (ERPA) Term (inclusive of all Phases), 2) Set aside (Set aside a portion of emission reductions in a buffer reserve. The portion to be set aside shall be determined using an ISFL approved risk assessment and buffer tool), 3) Monitor (Monitor and report major emissions that could lead to Reversals of emission reductions).

4. Pontus Olofsson, Boston University

~~Best~~ Good practices for sampling-based estimation of area and map accuracy

Rationale why do we need a sampling-based approach to area estimation:

People say why don't we just use the map we have already produced? We know how many pixels are deforested but we should not do pixel-counting. We cannot use it because maps have errors and we do not know where the errors are and how many.

Remote sensing has not utilized the full potential to contribute to policy and decision making because the analyses were not based on a sample-based approach. We have not been good in the remote sensing community historically. Forestry has done a better job using sample-based data and analyses. We need to achieve unbiasedness. We must quantify the uncertainties to be able to reduce them. To achieve unbiasedness, we need to use to unbiased estimator. An estimator is a formula that yields estimate of a population parameter.

Pontus Olofsson mentioned the GFOI methods and guidance document which takes the IPCC guidance and it explains what it means in a practical context.

Maps need to be delivered with statistics, defensible estimates, and with tools sufficient to move a map from a pretty picture to a basis for scientific inference. Parameter is unknown, so we need to select a random number of pixels and for each unit we will collect reference observations which can be done in the field or using high-resolution satellite data. Then we apply an estimator that gives us estimate.

Pontus went over various old statistics textbooks and organized them to be applicable to the remote sensing world.

Good Practices: these are not requirements, just good practices.

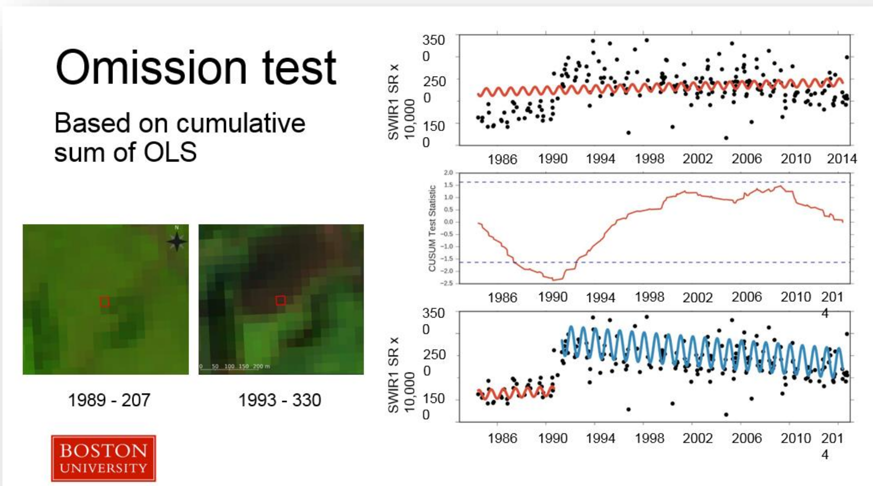
- Create a probability-based sampling design (typically STR – stratified random sampling, usually done using maps).
- Determine sample size by setting an error target. If you do not stratify, you might miss important areas such as areas with deforestation. For example, if 2% of the land cover is forest change, then to be within $\pm$ 0.5% accuracy, you can estimate how many sample units one would need.
- Observe reference conditions in high resolution, Landsat, and field data if possible.
- Use an estimator that corresponds to the design and then apply the estimator to estimate area and map accuracy with uncertainty.

This process is not that complicated, and one does not need a degree in mathematics to be able to do it.

Pontus talked the Google Earth Engine Application *Area Estimation and Accuracy Assessment* AREA^2 at https://area2.readthedocs.io Using the application, one can select any of the following sampling designs: simple random, stratified random, simple systematic, stratified systematic, and two-stage sampling. One can also choose from the following estimators: SRS, STR, GREG, ratio for two-stage for analysis.

Pontus emphasized that if the country has a new map, they can use the old stratification, but they must use certain type of estimator. The GFOI is providing more detailed information on how to do it and it is on the AREA^2 web site. The documentation and the Time series viewer on the AREA^2 site are not completed yet.

Using the GEE and Time Series, one can use the CCDC methodology which is now on GEE to look at all observations. In Collect Earth Online, you can look at different types of data. Pontus talked about omission error and provided an example for clarification. Omission error of sample units that were classified in a stratum of stable forest, but it turns out to be actually deforestation thus we conclude that the map omitted to put them in the deforestation strata.



One approach to mitigating the impact of omissions is to buffer around the mapped deforestation strata, which is a small area but in close proximity to the correctly mapped strata with the hope that the error is contained in the buffer area thus one would expect the error to “stay” in that small area.

Example: If the red line on the top graphic looks like an uninterrupted line while it should look like the bottom graphic (red and blue lines), then we can say that we are observing an omission error when the model did not pick up the change in the forest (deforestation).

The stratification you will apply for the other IPCC classes will be different. In general, we might need different approaches for IPCC classes beyond mapping forests.

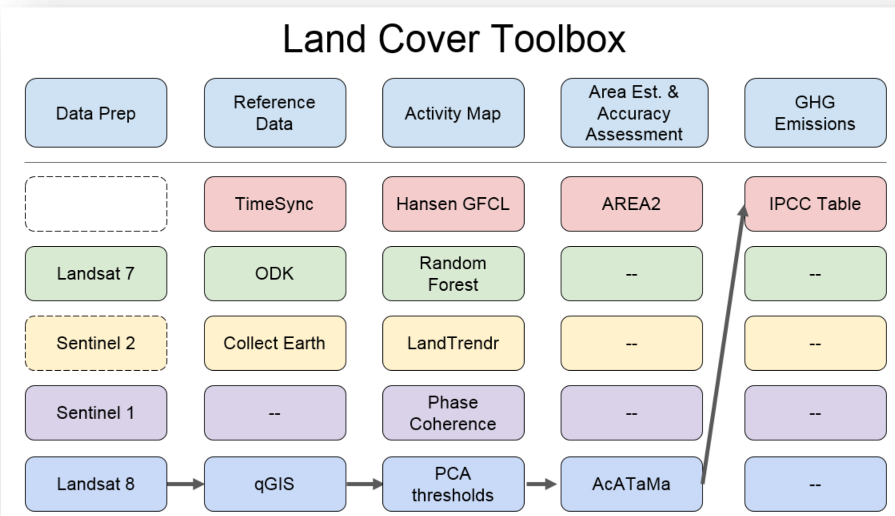
In conclusion, Pontus said that all maps have errors, therefore areas obtained by pixel counting are biased and are not IPCC-compliant.

5. Noel Gorelick, Google

Google Earth Engine: Land Cover Toolkit

Noel Gorelick works at Google and is responsible, among other duties, to build cloud-based tools that are not currently available but are needed. He emphasized that the data is on the cloud, so you do not have to download them. The Google Earth Engine data analyses and visualization is built upon Google powerful base and the scientists' analyses. The goal of GEE is to make it easy to use any data and to be sharable. You should be able to build the tool you want/need and provide them to the communities that might need such tools. Their focus is on society's biggest challenges such as deforestation, disaster, climate change, drought, disease, and sustainability.

Google has a 25 PB data catalog with imagery collected from the Landsat, MODIS, Sentinel 1 and 2, as well as digital elevation, land cover, and surface temperature.
When working on the GEE, one can upload their own commercial imagery.
GEE uses all available data to do data compositing to get a full dataset to work with. They work globally, and create animations using all available satellite images. This is all visualization.
Noel gave credit to the work by Matthew Hansen and his team for the Global Forest Cover and Loss Map (Hansen, Science 2013) where 654,178 Landsat images were used. Their product is used in the World Resources International's Global Forest Watch Mapping, https://www.globalforestwatch.org/ where GEE is the engine behind it.

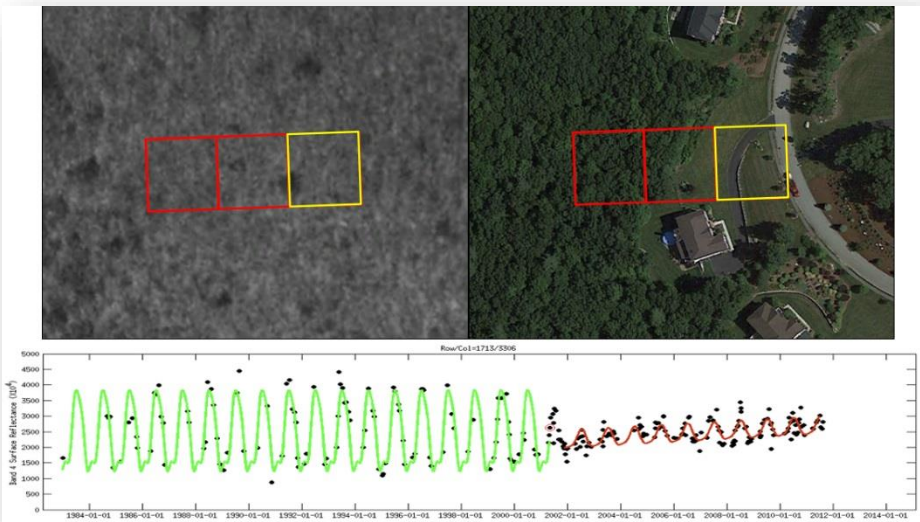


GEE is free for academia and for programs like ISFL and SilvaCarbon. In GEE, the customer owns all intellectual property rights in customer data, code, and application.
To use the GEE, you need Internet and codes in JavaScript. Noel emphasized that Google has created tutorials to bring anyone up to speed with short lectures.

GEE has a tool (without using a code editor) that can produce quick maps (cannot be used for publications or reporting) but good for introduction for land cover classification and real monitoring on the ground. Using a code editor, you can do more, this could be used for monitoring, with only few lines of coding. There is a lot you can do but at first it is overwhelming so GEE builds tools to help you do two PCI analysis and other analysis identified as needed. The training data and land cover expertise is still more dependent on the users. There are plans to utilize the Land Cover Toolbox so one can have multiple options to choose from. Landsat 8 path is the Colombia module.

6. Noel Gorelick, Google
Continuous Change Detection and Classification (CCDC)

This presentation was prepared together by Noel Gorelick and Eric Bullock from Boston University. CCDC allows you to take all available data and use it. With using all observations, we can fit a harmonic model, CCDC finds sections in the harmonic model and applies the coefficients.



Noel shared that the work with CCDC is going forward and that for near real-time on-line monitoring, GEE will work Boston University.

CCDC is a pixel-based analysis using all observations while other methods such as the LandTrendr produces annual composites. CCDC focus is more on using transitions classes. You can introduce classes and start studying gradual change on a larger scale.

Noel is explaining the vision behind developing tools using java script, but FAO is proposing to create a GUI thus it is getting more user friendly.

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Discussion about the CCDC on the GEE:

- Pontus Olofsson and Eric Bullock from Boston University are providing the background about the CCDC. Gustavo Galindo from Colombia expressed a concern about the linear regression, to which Noel responded that there is a lasso regression that might be more suitable.

- Andrew Lister, USFS expressed a concern about the sustainability of the GEE and that eventually it "goes away" and leaves the users without an adequate platform. Noel addressed his concern by explaining that now GEE is commercial, and its future looks good.

- A question was raised by Karis Tenneson, if there is a methodology to validate all years in a time series analysis. The answer from Eric Bullock and Pontus Olofsson was that even though such validation does not really exist at this point if you have continuous reference labels on the time series basis and you can keep track when the change occurred.

- Noel answered Evan Notman's question if the CCDC framework in GEE could work in other interfaces such as SEPAL, that it should be easy to plug into SEPAL and other interfaces.

- Andres Espejo from the World Bank asked if the changes of sensors would have impact on the data quality. Eric Bullock commented that there might be some effects, but they are minimal and will not affect land cover change mapping results. Cloud cover was mentioned as a factor limiting the amount of data over certain areas but hopefully soon CCDC should be able to be done with radar-based analyses.
- Brian Mutasha from Zambia asked how one can deal with strips of missing data in the Landsat data archive. Noel Gorelick explained that there are modules in GEE that could help with this issue.

7. Sean Healey, USFS
Case Study: CCDC, Land Cover Change Maps, and Forest Emission Factors

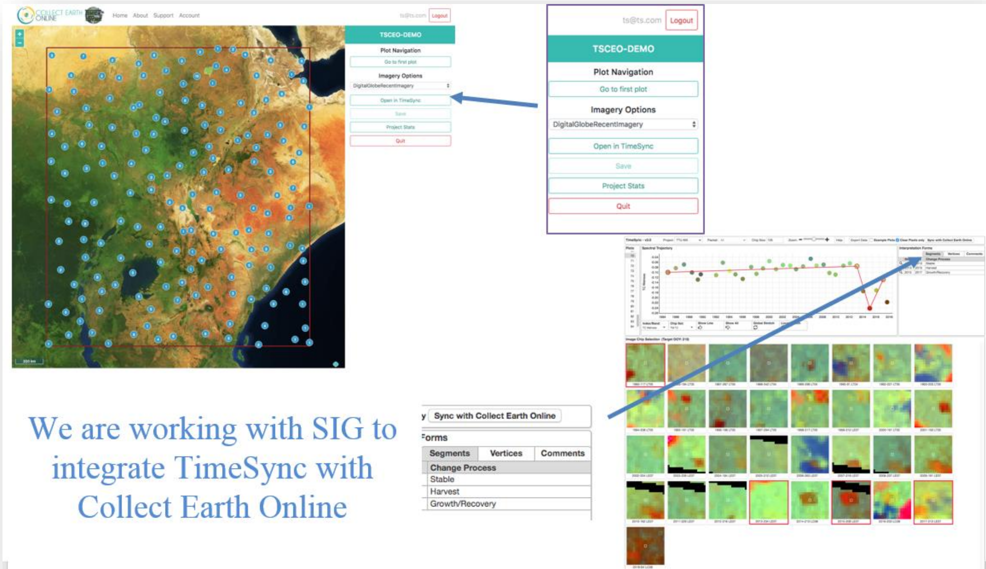
Sean Healey started his presentation by answering two questions, what is CCDC and why is needed.

CCDC methodology fits a harmonic function to the time series of Landsat spectral values. The algorithm requires 24 values to begin, identifies breakpoints and then fits a new harmonic function.

The CCDC will be good for near real time on line monitoring. With using all available observations, we can separate/sort out the real change from the noise. Some classes are not distinguishable in some parts of the year, they are spectrally undistinguishable and that is why we need the data from the entire year. That is another reason to use all imagery. In time series analysis of land, there are certain number of parameters (such as slope off the function, amplitude, etc.) that stay the same through the segment and a pixel can be classified the same till the system tells you that there is a brake.

One option to classify CCDC time series parameters is with photo-interpreted control points. As the importance of using all available observations over a study area was emphasized, Sean talked about TimeSync, an app which quarries GEE to acquire a chip (image) for every year to monitor change over time. There are rules of how these chips are selected and one can choose a replacement for a chip (image) if a different one is needed. It is a tool to record reference level and help you look at the reference images. Soon TimeSync will be linked to SIG to integrate it with Collect Earth on line.

This is how one can collect reference data, it is for sampling only, not mapping. It gives us important insight into land cover dynamic over time.



Sean presented a study, mapping conversion to agriculture since 1990 in Ethiopia, Uganda, Kenya, Rwanda, Tanzania, Malawi, Zambia. They measured land cover history using 2,000 randomly selected points suitable for statistical estimation, but not for classifying CCDC map parameters. Their results showed that the forests have been reduced in general.
If a country has a legacy map which they want to keep and use, but it is only for one year, Sean shared their approach. The country can use that map by locally sampling certain amount of locations and then applying model that used CCDC parameters and use these parameters over time at a one-year time steps. Local sampling of well-accepted single-point-in-time maps gives us better calibration of models using CCDC time series parameters. Sean talked about their work with estimating changes in both carbon and water related to land cover change. He emphasized the importance of updated maps which can tell many stories about food security, carbon estimates, public health (mosquitos), water use, storage and others.

Sean explained that their technical capacity building transfer in East Africa runs through RCMRD (Regional Center for Mapping of Resources for Development) in Nairobi. Linking it to objectives of this workshop to exchange of experiences, Sean said that RCRMD can provide trainers and technical support moving forward.

For estimating emission factors, Sean talked about OBI-WAN, the Online Biomass Inference using Waveforms And iNventory. OBI-WAN will use the Japanese spaceborne LiDAR Global Ecosystem Dynamics Investigation (GEDI)'s sample of forest structure measurements with wall-to-wall imagery to create on-demand statistical estimates of forest biomass. The user identifies an area of interest in a Google Earth Engine app and gets back a forest carbon storage report. It can measure canopy structure for biomass estimates, with a 25 meters footprint. User can input shapefile/s to a Google Earth Engine app. OBI-WAN accesses GEDI's plot, model, LiDAR database and is supplemented with Landsat archive stored on Google Earth Engine.

Customized forest biomass report is generated, including estimates of mean biomass, standard error of the mean, and thorough documentation. Sean clarified that his team are collecting field plots which will be used for calibration. The model data uses field data and LiDAR flown over the same area and at the same time of field data collection. The potential applications of OBI-WAN include reporting carbon stocks for forest reserves, individual companies as well as municipalities from villages to countries.

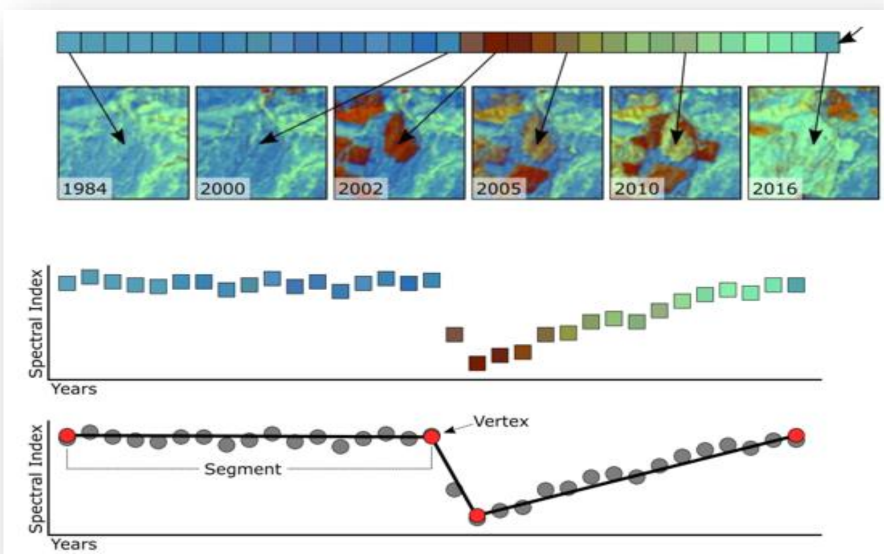
8. Sean Healey, USFS

LandTrendr (LT) in the GEE Planform: How and Why

LandTrendr is similar to CCDC but while CCDC uses every acquisition, the LandTrendr uses singe acquisition per year. One can use different compiling of images to get rid of the clouds. In cases when over a single area, there are less than 12 Landsat images available, LandTrendr provides yearly acquisition. LandTrendr is a better solution where there is no dense distribution of Landsat images available.

- **How does it work?** https://emapr.github.io/LT-GEE/landtrendr.html

It is fitting brakes, for examples at start of deforestation and then another brake it starts recovering. It can create a smooth value by eliminating wiggling in the data. It is used to smoothen the time series analysis.



Basically, LT breaks the time series into segments using rules based on goodness of fit. You can look at different segments to create different maps, you can just look at the recovery, so you will start looking from the start year and duration, end year and ask for smoothing images. GEE has an application with LT to look at different indices and the fits that are applied to the data.

Use of a learning ensemble creates dramatically better maps: If you make 5 different maps and you put them in assemble it gives us much better map. Some of the classes are not distinguishable in the dry season and another one in the rainy season and that can make a difference.

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Discussion:

- Sean Healey clarified that if TimeSync shows you twice as much disturbance than your map is telling you, you can change the threshold in the decision tree to map disturbance based on your samples.

- Andy Lister asked what could go wrong with LandTrendr. Sean answered that LandTrendr is very accessible but local sampling is not locally accessible so that is one issue. Second possible issue is that quality of the shared data (the reference data).

- Brian Mutasha asked how you can composite imagery in LandTrendr? Sean explained that there are a lot of ways to make the composite, (the closest to cloud free, the greenest pixel) so this should be decided locally. For example, in the Pacific Northwest, you mask out the clouds and use the peak of the growing season, so his advice was to use whatever compositing makes sense.

- Gustavo Galindo shared with the participants that they have run the LandTrendr but have no way to validation of their results. Gustavo Galindo also shared a concern that the information in Collect Earth is not updated for Colombia.

9. Eric Bullock, Boston University
Monitoring Forest Degradation on the Google Earth Engine

Eric Bullock started his presentation by defining forest degradation as a disturbance in a forested landscape without a change in land cover. He listed two main reasons why it is hard to monitor degradation: 1) scale: degradation events usually occur at a smaller spatial scale than freely available remote sensing could detect and 2) magnitude: the change is not very large and obvious.

Variability is not easy to pick on an automated approach thus to address this; Eric Bullock uses spectral unmixing where each pixel is divided into spectrally different elements of a pixel. The Landsat data are transformed into spectral endmember fractions and are used to calculate the Normalized Degradation Fraction Index (NDFI; Souza et al., 2005). The spectrally unmixed data are used for disturbance monitoring and land cover classification via time series analysis. The NDFI is good at identifying subpixel small vegetation disturbances. Due to the temporal nature of degradation events, such as fire, clearing events and other, two images might not show you the disturbance.

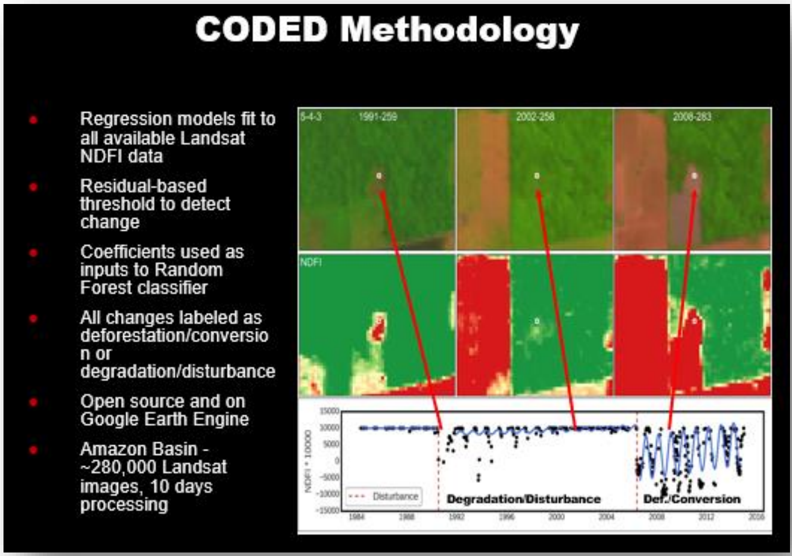
With all available Landsat, high resolution and field data, one could expect to be able to reconstruct the landscape from the past using a new method, CODED (Continuous Degradation Detection).

It is similar to CCDC but with focus on degradation. Eric Bullock "combined" two existing algorithms to create an algorithm for degradation monitoring.

Spectral Mixer Analysis + CCDC = CODED

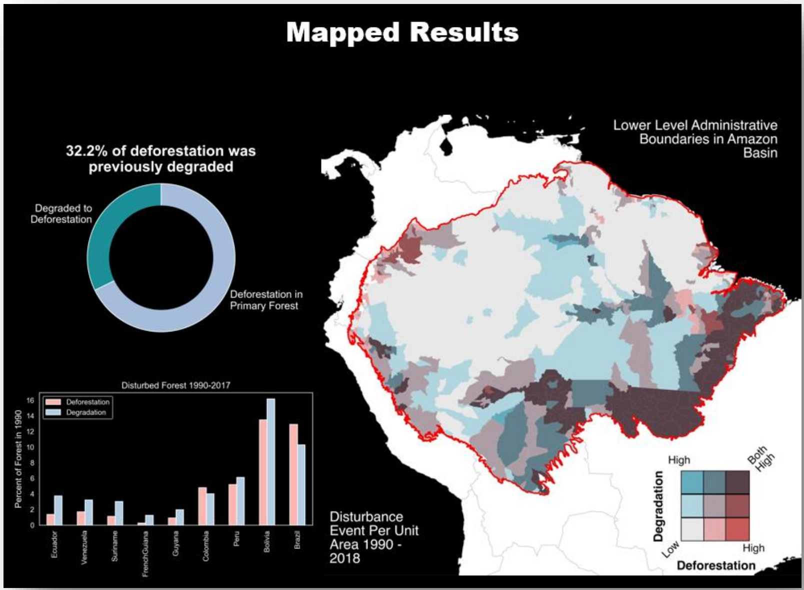
CODED Algorithm: The change detection and classification are the same with fitting regression lines. CODED is an open source on GEE.

Eric Bullock shared his methodology and some preliminary results (shown in this map)



from mapping degradation in the Amazon Basin between 1995 – 2017 keeping track of 4 change events for each pixel location. The layers are: change date, change magnitude, type (conversion/disturbance), post-even recovery, and forest and non-forest mask.

Sample-based area estimation: To evaluate the results, they had ca.15 interpreters to



check the data who worked for 3 months to identify and consolidate their results.

The next steps are to give the data to the public and see how it can be used, on regional to country scale. They are using Peru as a test case. Eric said that he has created a GUI in GEE, so the counties can pick up the tools he developed and produce a more accurate map since they know the landscape. In conclusion, Eric Bullock said that degradation mapping is possible due to the large amount of freely available Landsat data.

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Discussion

- Brian Mutasha asked how they could do degradation monitoring since changes in tree cover could be almost lost in a particular period due to seasonality? Eric explained that the first step is to calculate a base line for the state of the forest stand. Then using seasonal regression model, like CCDC, if you have seasonality, it will be captured by the model, and will fit the harmonic regression models and not in the highest possible NDFI – so we need to use seasonality as means of classifying the data.

- Andres Espejo asked if you could use the ***n members*** from the Amazon in other locations? Eric responded that if it works in other places, then the ***n members*** can be used. We tested them in Georgia and they did not work as the climate is not humid tropical. Eric also added that they have tried the method in smaller scale areas and in order to make it work in a different country, you need training data, so the local knowledge is very important. The parameters to be tweaked are the same as CCDC; sensitivity to change, weighting the errors of omission and commission, how long you have to wait for disturbance, and how many consecutive images you need to use to label it as a change, which is the threshold between normal variability and real change.

- Sebastian Wesselman asked where do we start once we get back to our country, with Zambia in mind? Eric and Pontus answer his question by saying that you should consider starting with what you want your end results to be and then figure out what you need to do to get there. So first you need a sample, then you need a map to draw the sample. It will be also good to look at the ISFL requirements as a starting point. Using the scenarios presented by Noel Gorelick (The Land Cover Toolbox) to select what is best for your country.

- Sylvia Wilson made a comment that a lot depends on how degradation is defined, and the countries are saying they cannot map degradation with 30-meter spatial resolution Landsat data. Pontus acknowledged her comment by saying that monitoring degradation with 30-meter spatial resolution is not a perfect solution but if you cannot do any better, it is better than not do any degradation mapping at all. Gustavo Galindo agrees with Sylvia Wilson. Oswaldo Carrillo shared his experience that in Mexico they have used existing maps in combination with Collect Earth to develop biomass maps correlating field data and imagery. This approach will be use from now on but reconstructing the past will be more challenging.

- Evan Notman emphasized that while degradation monitoring is very important, it is only one aspect and we need to be able to understand the underlying causes leading to the degradation. Could the methodology you presented do this? Eric answered that we can map change in forest and change in biomass without change in landcover, that is a starting point. This can get you a sample. How much it would help us learned depends on what kind of details we want to get out of it. To map types of disturbance without high resolution data is hard to do. Sean Healey made a comment that if you map degradation, but the forest recovers with altered amount of biomass and carbon, you would need field data. Gustavo Galindo added to Sean's comment that if a pixel is marked as degraded and reported as such but recovers in less than a year that is problematic for the country in terms of results-based payments for emissions reduction.

Day # 2
Tuesday, 26 March 2019

10. Karis Tenneson, SIG
Mixed Tools and Platforms

Karis Tenneson started her presentation by stating that the motivation behind her work and those of many others from a multi-agency team is to assist scientists across the world to translate and apply Earth observing science and research to inform sustainability policies that promote human wellbeing. She also talked about the work done by SERVIR. SERVIR Mekong initiated a geospatial needs assessment with their network of regional partners, including government agencies, civil society organizations, and research institutions. The key need that was identified was assistance to get land cover map updates in a timely and efficient manner. This system guides users in applying peer-reviewed methods and cloud computing power to produce a wide variety of high-quality land cover information products that can be

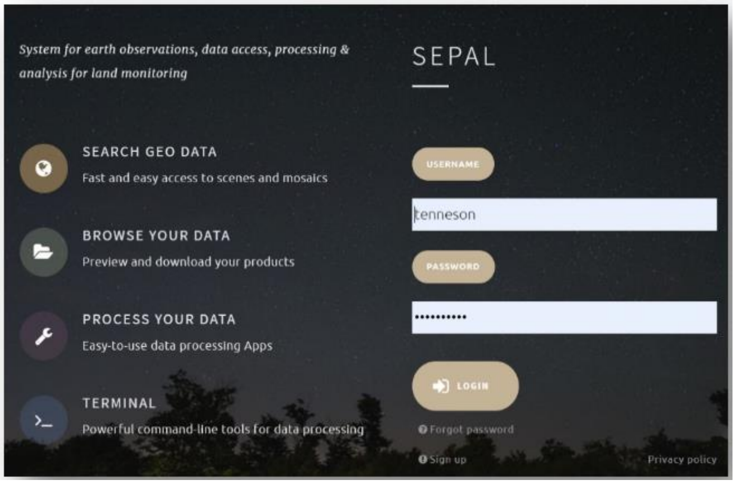
updated regularly and consistently.

Karis went over some of the current status and challenges: 1) timely updates limited by financial and staff resources, training on ever evolving EO data and processing methods, costs to purchase and maintain hardware and software licenses, access to imagery, 2) Methods are not always transparent and documented, 3) methods are not always kept consistent over time, 4) each country and even agencies within political units work to map different land cover classes, 5) the variation in land cover definitions challenges regional planning efforts.

The system uses Google Earth Engine and relies in most cases on field observations and the interpretation of high-resolution imagery. Once the system has been customized to produce a given product or set of products, these can be updated regularly in a structured way to serve ongoing monitoring needs. One of the first service deliveries was to Myanmar to help them update their GHG emissions activity data.

The path of capacity building is similar to those of SilvaCarbon, identify the needs and provide targeted training. The implementation was done through 4 workshops.
During **workshop #1**, the system architecture is defined and the land cover typology (e.g. 22 land cover classes) is established. **Workshop #2 &3** are focused on developing the thematic primitives (e.g. canopy, cropland, evergreen, mixed forest, mangrove, etc.), develop the maps and uncertainties, land cover assemblage, identify field and imagery reference data. Legacy data for training models was used. Our team does primitives validation: Probability primitive (%): Our ability to predict aquaculture is not as good as predicting evergreen broad forest. For the assemblage, a manual decision tree with thresholds is used. For time series analysis logical transitions rules are implemented (for example, urban cannot transition to mangrove). For map assessment: independent probabilistic data was used. **Workshop 4#** is a launch workshop.

Karis also talked about the next step: SEPAL integration. Anyone can sign for SEPAL account.



Using SEPAL, you can select your study areas, upload your own data, reference, run your supervised classification, apply a smoothing algorithm, perform validation using TimeSync and AREA[2]

Eric Lindquist, FAO is working with them on land cover change, degradation and near real time alerts.

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Discussion

- Noel Gorelick asked her what is missing that GEE could assist with and Karis said they are interested in having a mapping accuracy assessment on time series analysis. Pontus responded that the research community is not there yet, but it is definitely coming.
- Evan Notman: Is it easy for the countries to use it? Karis: At this point, it is not intuitive, but it should be getting easier to use with an interface. At this point it takes training, so we work through the system with our user groups. Pontus: “It’s easy if know how to do it otherwise it is not.” The process she presented needs to be documented and he said they are working on some such materials.

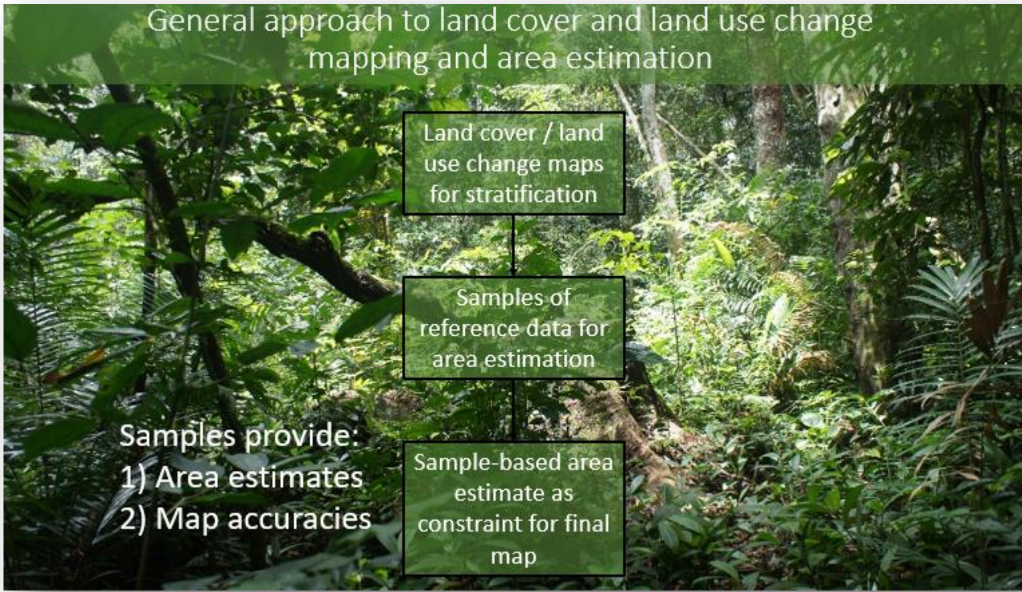
11. Matt Hansen, University of Maryland
Experiences using GLAD System

Matthew Hansen started his presentation by acknowledging the improvements to the remote sensing community brought by the opening of the USGS Landsat achieve in 2008 and the progression on how GLAD got where it is now using 30 m Landsat.

He also stated that GLAD is not on the cloud 😊

UMD has high-computing abilities and their algorithms are stable with stable datasets. The GLAD method does not require any scripting. Matt Hansen and his team provide the countries they work with the global feature space data.

Matt provided a summary of the GLAD methodology which is analyst-driven supervised



change classification based on an "active learning" method. Active learning focuses on the interaction between the analyst (or some other information source) and the classifier. The model returns the classification outcome to the analyst and helps to highlight the most uncertain areas. After accurate labeling by the analyst, these areas are added to the training set in order to reinforce the model. In this way, the model is optimized on well-chosen difficult examples, maximizing its generalization capabilities.

Matt talked about how to create your training data. The commonly used approach is using homogeneous patches which the algorithm knows how to divide however Matt Hansen and his team do not agree and they work on trading at the edges between classes. They modify the training data more than they modify the metrics. Matt believes one does not need to do preprocessing when good readily available data is accessible and then focus only on creating a good training data.

He presented some of their mapping efforts in Mato Grosso, Brazil (time series of height using LiDAR data), Uruguay (forest gain/loss maps where they observed net gain), and others.

In order to map a class, you need to know what the classes that look like the class we are trying to map look like. For example, if you want to map water, you need to pay attention to shadows, dark wet soil, etc. and train in these areas. If you do have a good quality map, you can do a simple random sample for area estimation. Graphs are good to look at change – easy to understand. The map tells you where to look on the ground (or higher resolution data) to get good area estimates for a given land cover and then the process seeks to target both false positives and false negatives. Wall-to-wall forest cover and change products may be used to create a stratified sampling design which is more efficient that random or regular sampling: it has lower uncertainty of sample-based estimates; a smaller number of samples needed; reduces requirements for commercial high spatial resolution data.

Moving into mapping the 6 IPCC classes: Matt explained that they are looking into bare ground increase is an indicator for a process of urbanization. It is hard to map ***settlements***, but it is easy to map increase in bare ground and use this as a proxy for urbanization/settlement change.

Mapping various types of ***crops*** is really hard to do, differentiating between soybean and cotton for example. The approach we are using is making good maps for field work, indicated for soybean in 20x20 km sample plot to visit. Then you map the block of soybean and validate it.

Matt presented some of the work they have done with Colombia to map the 6 IPCC classes working with Gustavo Galindo's team. They have also added more classes of interest to Colombia, such as plantations and paramos.

Gustavo Galindo shared his experience from this process and advised the countries to use their available maps. Colombia had 2000 and 2015 maps as part of the CORINE land cover maps and then start updating them annually. Matt said with the GLAD methodology they can produce maps on a national scale in a week.

In conclusion, Matt reemphasized that you need to know what you are looking at, how to interact with data, how to do the algorithm implementation, build the tools for the statistical analysis and training materials. Gustavo Galindo gave an example how during the shutdown in the United States, they had to do the pre-processing themselves as Landsat was not processed during this time, so his take-home message is that it is important for the countries to have the capacity to do all the analysis themselves. In relation to Gustavo's comment, Matt Hansen stated that now the Global South has more land cover change maps developed then the North.

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Discussion

- Brian Mutasha asked when you have your final map, but your results are not good, what do you do? Matthew Hansen answered him by saying that you could add more training data to the areas estimate, we can adjust the 0-100 probability per pixel of the new map to be the area estimate. And even though we know it is not perfect, we will know it is not biased.

- Sean Healey commented that it gets more complicated when you have more classes and they have to add up to 100% probability. The sample itself can be off a little, not fully representative.

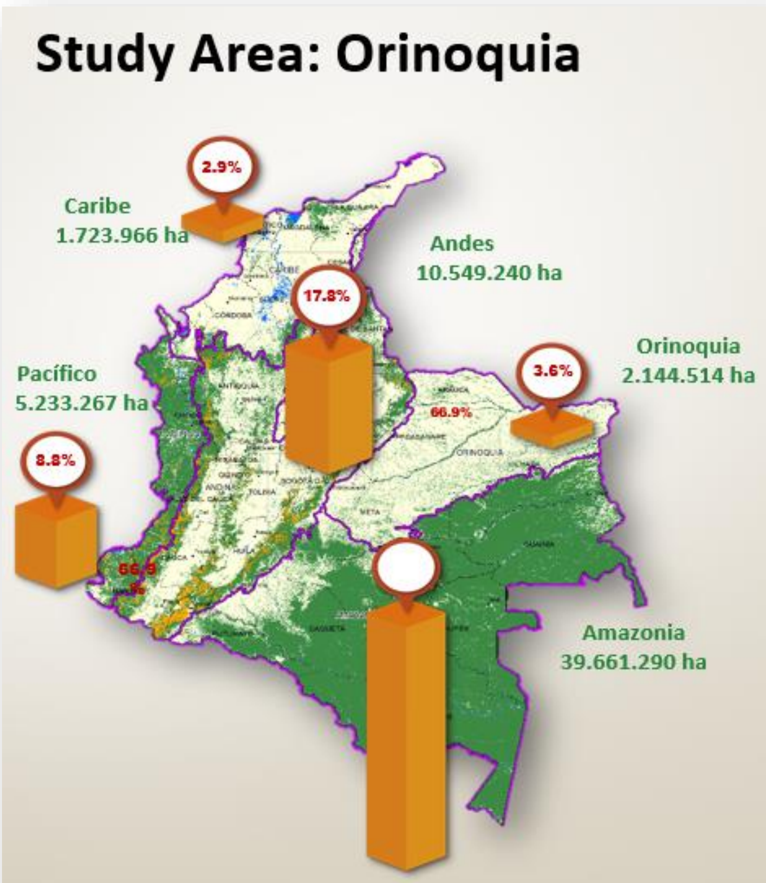
- Naikoa Aguilar had a comment and a question about sampling and response design, especially the second. It is not particularly well written up, so he wanted to know if Matt's group are developing protocols about QA/QC. Matthew Hansen said: We work in a pyramid approach doing the samples, all the labeled change will be checked by someone. You need certain amount of people, 7 people at minimum, each sample is agreed by a review team looking at each sample unit. And then you assume the sample data is correct but if you have error, the rest is questionable, so you still need to go to the field if possible. In general, disturbance areas are almost always accessible. Matthew also added that municipalities available data could be made to work but you need shortcut for driving down your uncertainties, such as collecting more samples, but this is not always possible. Countries do not need to start from scratch to do image processing even though there are counties, such as Colombia that can do the image processing on their own from scratch, but most countries cannot.

COUNTRIES' PRESENTATIONS

12. Gustavo Galindo, IDEAM, Colombia
Colombia Mapping Activities for ISFL Reporting

Gustavo Galindo started his presentation by providing a summary for the jurisdictional area selected for the ISFL, Orinoquia. The area is 25 million hectares in size with 2 million hectares covered with forests and not much deforestation

Gustavo presented mitigation actions to reduce emissions in AFOLU sector where mapping could support monitoring and reporting.



1. Reducing deforestation
2. "Rational grazing" by stabilizing cattle herds
3. Managing pasture lands
4. Natural ecosystems restauration (savanna, forests)
5. Increase in oil palm and agroforestry plantations
6. NAMAS (forestry, sustainable cattle ranching and ecosystem restauration).

Activity data with low uncertainties cannot be incorporated into the reporting on national level which is a big challenge for Colombia. A year ago, Colombia started mapping oil palm and now they have info where the oil palm areas are, but they are lacking baseline and emission estimates.

Data sources for the land sector activity data is in the GHG inventory. The data for croplands comes from the statistical yearbooks while data for forest is produced using remote sensing data analysis. It is important to have a consistent land representation. Monitoring through REDD was only looking into forests, how to map activity data and the emission factors but we need to have all the classes mapped with error estimates and uncertainties. There is disconnection between reporting, monitoring for the different areas, emission factors so they believe they need a general framework. Gustavo stated that Colombia wants to extend the work done for the ISFL region, Orinoquia to national level for AFOLU.

Activity Data to estimate emission and absorptions associated with the key land change categories have to be updated for the time frame 2000-2018, following IPCC guidelines. Gustavo discussed what Colombia expected mapping results are:

- Biannual change detection time series for at least forestlands, grasslands and wetlands (croplands?) at a national level for 2000-2018 using the most recent IPCC guidelines.
- Adjust the regeneration and restauration change detection for 2000-2018 with reduced levels of uncertainty.
- A coherent land representation of land cover/uses for the 2000-2018 time frame.
- Support an improved estimation of the emissions associated with land use change.
- Support the construction of a baseline for forest degradation emissions with acceptable levels of uncertainty.
- Generate baselines for sectoral mitigation activities (e.g. oil palm, forest plantations, and agroforestry).

Gustavo provided the country's definition for forest degradation:
A persistent reduction of the carbon stocks stored in forests that could be associated with a sustained decreased of the forest canopy and/or the number of trees per hectare, being always the percentage of cover greater than 30%.

He shared their experience and said that you need to look at the trajectory of change for at least 6-year intervals because if the time interval is shorter then you will have a large error. Colombia is generating time series on an annual basis and are using the GEE, while also working with Matt Hansen's team but customizing the GLAD metrics to fit Colombia needs and with python code, you can generate other metrics to do quality control for example.
After the change detection, you can use random forest for analysis and QGIS for QA/QC. The QA/AC process takes them about half a month for the entire country (65 images) afterwards they can create the final report for area estimation.

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Discussion

- Sebastian Wesselman asked Gustavo when Colombia will be ready with the 6 IPCC classes? Gustavo Galindo: We will need at least two more years, but ISFL has not requested such baseline. We are willing to work with other counties, we also need to start publishing and writing training materials. We would like to get help with writing up the methodology of everything we have done so far to achieve transparency.

As asked by the organizers of the workshop, Colombia and other countries presented their needs, benefits/success stories, challenges that have faced and what lessons they have learned as well as their future plans.

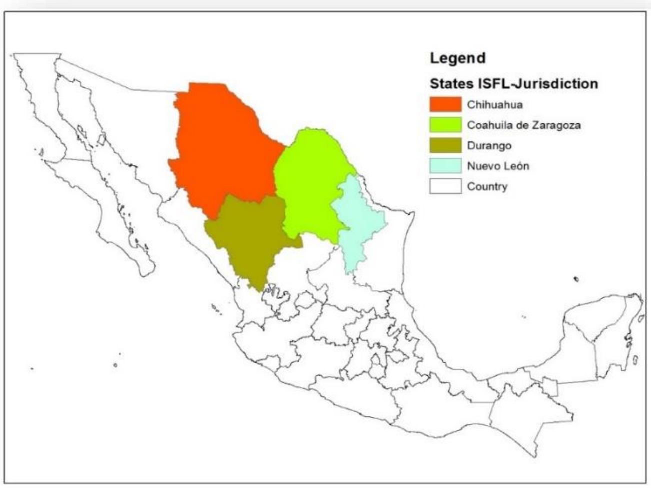
COLOMBIA
NEEDS
➢ Institutional level: Collaboration between departments and team (e.g., data sharing) ➢ Technical level related to monitoring. What's missing? 1. Linking monitoring and sample design with specific ISFL implementation activities/treatments (e.g., palm oil, cacao, coffee baseline) 1.1. Connecting main drivers of change to implementation activities 1.2. Prioritize magnitude of activity data (specific to mitigation) to inform monitoring to inform monitoring resources (land tenure) 2. Defining transition classes (to – from) and characterize trajectories (carbon accounting that fully represents the carbon life cycle or complete process of land use transitions between to and from), establishing base for monitoring transition classes. 2.1. Grassland, cropland, and other forest lands (agroforestry, shrub lands, etc.) 2.2. Identify what we can map, what we can photo-interpret (high res or time series), census or field monitoring; and timeline that we can monitor 3. Stocks, emission, and sequestration factors for stable categories, transitions, and slow changes (e.g., forest degradation) 3.1. Gap analysis, literature search, identify field work to fill gaps 4. Soil monitoring 5. Degradation estimation for country 6. Regrowth – mapping and permanent plots

COLOMBIA			
BENEFITS/SUCCESS	**CHALLENGES**	**LESSONS LEARNED**	**FUTURE PLANS**
Forests are now included in the mainstream political discourse – planning discussion at all political scales/levels take deforestation into account.	**Political and institutional:** 1) privatization pressures (outsource monitoring) 2) Lack of shared understanding among government stakeholder in Colombia about the level of monitoring required to deliver results-based payments effectively given understanding of land-based drivers of emissions **- Technical challenges:** performance-based payment	Plan on doing process solo without support from outside resources Do it by yourself. Need process to be operational, but still important to continue to explore improvements via a research phase.	Capacity building for monitoring deforestation (in GEE) Develop (and build capacity to use) monitoring tools in GEE Documentation of the processes and methods Better soil monitoring Develop consistent and coherent monitoring and

	for AFOLU sector, so it's the first time to integrate stocks, gases, of a specific area of all categories (mapping - degradation and growth are missing). 2) performance-based payment for all sectors.	Biggest resource is the people, need a critical mass of people that can continue with process to ensure continuity	reporting plan for all representative land uses Degradation and regrowth

13. Oswaldo Carrillo, National Forestry Commission CONAFOR, Mexico Satellite Forest Monitoring System (SAMOF)

Oswaldo Carrillo started his presentation by providing a summary for the four jurisdictional areas selected for the ISFL: Chihuahua, Coahuila de Zaragoza, Durango, and Nuevo León. For these four states, Mexico is creating a land cover map for 2016 and land cover change maps for the following periods using Landsat: 2000 – 2003, 2003 – 2011, 2011 – 2014, 2014 – 2016.



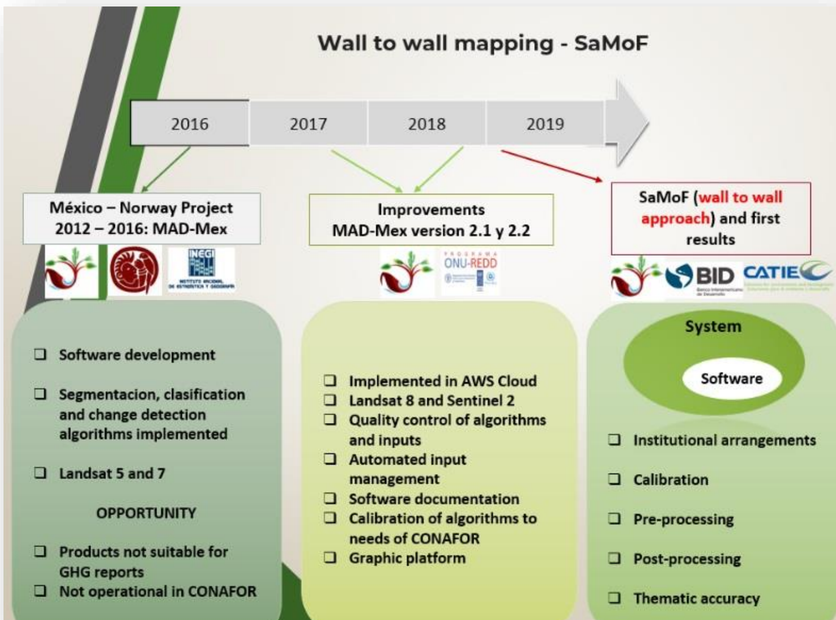
Due to its high biodiversity, with 67 types of vegetation, producing land cover and land cover change maps is very complex. That is why Mexico is using three main approaches to map land cover changes and degradation:
1) reference grid: deforestation and degradation rates (through visual interpretation)
2) wall-to-wall mapping: deforestation (automated approach)
3) wall-to-wall mapping for forest degradation (automated approach)

The reference grid is a systematic sampling that can be a quickly implemented to assess rates of deforestation and degradation through the multi-temporal analysis of satellite images on the plots of the National Forestry and Soils Inventory (INFyS), from 2000 to 2018. Mexico is using Collect Earth tool to do these analyses. They are using systematic sampling located directly over the INFyS plots, so there are more than 26,000 plots at national level and soon

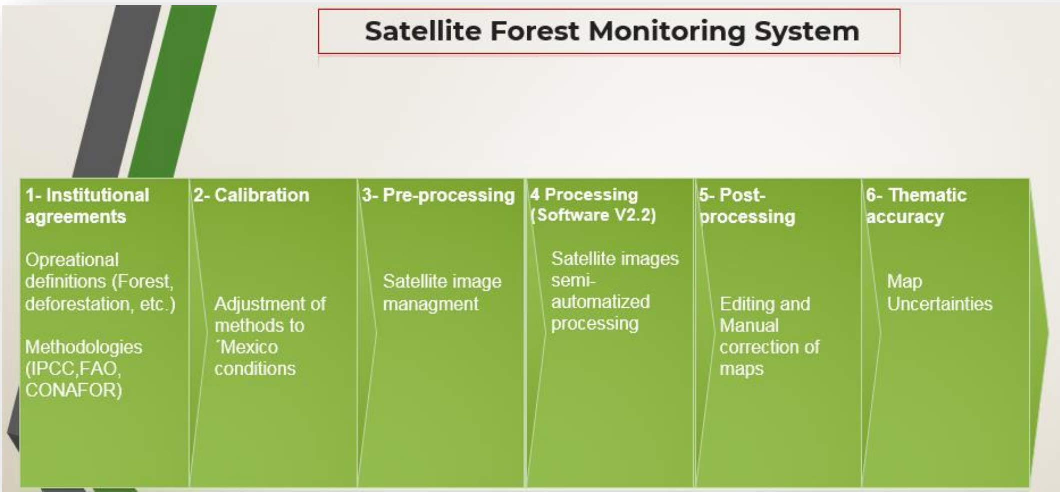
Mexico is planning to increase the number of samples. The tool for interpretation is Collect Earth so they can use images of high resolution. Each plot has a size of 1 ha (MMU). They are analyzing the evolution of the tree cover to estimate the deforestation and degradation rates following the IPCC approach. Mexico will have these products finalized by the end of 2019 and will write up a technical document with the results and the methodology used.

For the wall-to-wall deforestation mapping, Mexico has tried several methods to produce land cover and land cover change maps. From 2012 to 2016, the national forestry commission in coordination with the national commission of biodiversity and the national institute of statistics and geography developed the MAD-Mex software which is a monitoring activity data software.

Due to its complexity, the products generated with it were not suitable to be used for reporting. As a result, in 2017 and 2018, CONAFOR, with support from different international initiatives improved the software, with the next versions created by CONAFOR and now the software is operational, and it is on the cloud.



Mexico is using satellite forest monitoring system with its set approaches and tools to assess rates of deforestation, degradation, recovery, reforestation, afforestation and other transitions to generate activity data and to produce information for different reports regarding mitigation and adaptation to climate change. The graphic below shows the process behind the satellite forest monitoring system.



The processing of the images was done using MAD-Mex v2.2.During the post-processing stage, at least 17 interpreters are engaged to evaluate the final products and at the end an accuracy assessment is performed as well. In the last 5 months, they have developed 5 land cover maps for 2016 with MMU of 1 ha. with 32 land cover classes and with an accuracy of 86%. They have also developed land cover change maps with a national coverage for the periods described above 2000-2003, 2003 – 2011, etc. with MMU of 1 ha with 6 land cover change classes which will be updated every 2 years.

Mexico is currently working on wall-to-wall mapping approach for forest degradation. The methodology includes the generation of biomass time series, combining data from the national forest inventory and Radar data. They are in the process to implement this methodology in the 4 jurisdictional areas and then to scale it up to national level.

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Discussion

- Rama Reddy: For first phase of the ISFL process what type of land use are you planning to include? Oswaldo: Mexico will focus on the LULUCF sector for the first phase for the 4 states presented.

- Pui-Yu Ling: Did you collect ground plots for validation of your biomass mapping? Oswaldo: We have a methodology but with big plots that we have received help from Edinburg university and our plots are small, so we have a large variability in the estimates. Andrew Lister asked if Mexico could label the classes using NFI data. Oswaldo: Yes, but the problem is that they are not permanent plots, some plots have variability. More plots are being made permanent, so in the near future we can use the NFI. But now we do not trust the plot data.

- Rama Reddy commented that Mexico can start with Approach 2 and use the plot data and later move to Approach 3 (as soon as possible).

As asked by the organizers of the workshop, Mexico and other countries presented their needs, benefits/success stories, challenges that have faced and what lessons they have learned as well as their future plans.

MEXICO
NEEDS
▪ Training on Biomass initiatives (RADAR/LiDAR) ▪ Develop a platform to disseminate the cartographic products elaborated using the SAMOF System ▪ Straightens technical capacities to:1) reduce cost and time of post-processing, 2) Consolidate and implement the degradation approach, and 3) develop/adapt a near real time alert system ▪ Improving postprocess: test/improve detection algorithms ▪ Test other Degradation approaches ▪ Platform to share the data (maps, database, etc.) ▪ Early Warning Systems on deforestation and forest fires ▪ Improve the accuracy assessment methods ▪ Participate on SSKE on related tasks and activities ▪ Training in the country ▪ Long-term training and assistance

MEXICO			
BENEFITS/SUCCESS	**CHALLENGES**	**LESSONS LEARNED**	**FUTURE PLANS**
Maps elaborated with the SAMOF System to update State Forest Reference Level and Reports for FCPF and ISFL States (2019). **Using Satellite Monitoring System (SaMoF) to update the National Forest Reference Level (2020).** Better information for public policy and for decision making.	Mapping all types of vegetation (32 classes) is challenging **The different process of deforestation and degradation at regional level** Improve the efficiency of the change detection algorithm used or test other algorithms, such as Bfast, FYEO, CCBC, etc. **To complete and implement at national level the degradation approach**	Post-processing (visual and manual correction by photo-interpretation) is necessary because is very complex to map landcover and landcover changes **The institutionalization is a big issue because the long learning curves and the required technical capacities are very high** The development of the simplest and the most cost-efficient tools and approaches are required because the satellite monitoring is expensive **Working with staff of México´s States**	To transfer the system and the cartographic products at State Level **To straightens collaboration with other countries to receive feedback to reduce the cost and time of post-processing** To share lesson learned and tools

	To develop a platform to disseminate the land cover maps and land cover change maps at state and national level	**Governments is necessary to straightens the implementation of SAMOF**	

14. Brian Mutasha, Ministry of Lands and Natural Resources, Zambia

Implementation and utilization of existing codes for land use change mapping to serve the country's unique needs

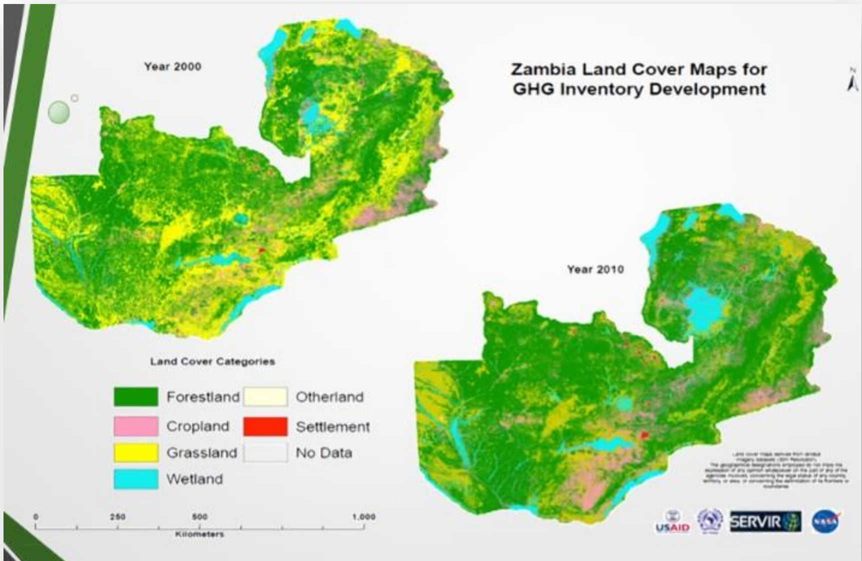
Brian Mutasha started his presentation by providing a summary for the jurisdictional area, the Eastern province under the ISFL. The entire area is 5.1 million hectares, the protected areas cover approximately 4.4 million hectares and the forest covers about 71% which is 3.6 million hectares of the total area.

Zambia's ISFL priorities are:

- Land cover Mapping (Recent Period)
- Land use Mapping
- GHG emission accounting (Activity Data)
- Deforestation assessment
- ISFL specific Emissions Factors
- Establishment of the MRV System at ISFL jurisdiction
- Development of Standard Operating Procedures
- Improved Data Collection Methods and forest inventory results enhancements
- Degradation mapping

At the moment, Zambia does not have a specific methodology to do the land cover change mapping at jurisdictional level because everything so far has been done at national level. However, there have been some effort in the past involving USFS to do work on a provincial level in Zambia. The process involved data preparation for the province, realignment of the boundaries, covered by 9 Landsat images, assessing the quality of the image (cloud cover, etc.) and the best available images were selected. Total of 229 images were downloaded for the period 1990 – 2010 and out of these, 88 scenes are selected for the final analysis. They tried to use the LandTrendr but found it too difficult to adopt due to phenology of the vegetation and the missing Landsat data for the period 2004 – 2007.Thus an approach had to be developed to perform the change detection at provincial level. NDVI was used for the time periods, 1990 – 2000 and 2000 – 2010. The next steps involved forest/woodland mask creation, non-forest masking and post-processing with supervised classifying for the 6 IPCC classes. Brian concluded that these methodologies at the jurisdictional level are not aligned with methodologies at the national level.

Zambia has land cover maps for 2000 and 2010 for GHG emissions. Their 2000 was not accepted, only 2010 was accepted.



Mapping forest degradation: Zambia got assistance from the University of Edinburgh under a project funded by the World Bank to develop tools for degradation mapping and 4 specific tools were developed. Samples have been collected to identify change that include deforestation and forest degradation. The steps are: creating a mosaic, mapping the forest change, identifying causes of change and biomass mapping. Sentinel imagery is used. At the moment Zambia does not have the results for forest degradation, the methodology is still being tested and the results will be sent to Zambia. Brian also talked about soil sampling and the production of a Soil Map for the ISFL jurisdiction. They will be done with the process soon and then would need to figure out how to scale it up to national level to update the old soil map of Zambia.

As asked by the organizers of the workshop, Zambia and other countries presented their needs, benefits/success stories, challenges that have faced and what lessons they have learned as well as their future plans.

ZAMBIA
NEEDS
▪ Immediate need for capacity building in GEE and Collect Earth ▪ Technical assistance ▪ LU classification protocol (response design) ▪ Development of a sampling plan (sampling design) ▪ Interpretation of sampling units, e.g. collect earth, collect earth online ▪ Area estimation (analysis design) ▪ Pre-processing and processing (classification) using cloud-based solutions ▪ SOP development for all MRV operations of the MRV system ▪ Capacity at the project level in mapping for operational purposes ▪ Short term training and workshops both in the country and abroad should be conducted to meet immediate objectives. ▪ Long-term training and assistance

ZAMBIA			
BENEFITS/SUCCESS	**CHALLENGES**	**LESSONS LEARNED**	**FUTURE PLANS**
NFMS is already in its advanced stage **Forest Reference Emission Levels** Biodiversity studies **National Investment Plan to Reduced Deforestation and Forest Degradation** WISDOM Report **GHG Inventories** REDD+ Strategy **Carbon sink despite large deforestation in African tropical dry forests (miombo woodlands)**	Not enough technical expertise **Knowledge Gaps** Software **Institutional challenges** Mapping challenges: fires, stripes, lack of complete coverage for Landsat) **Slow internet**	Collaboration with FAO, JICA, USAID and others is useful for advancing the implementation and utilization of land-use change mapping techniques. Currently FAO is building capacity to utilize SEPAL **SADC/JICA Project for Sustainable Forest Management is being implemented. This project has utilized the JAXA Forest and Non-Forest to map change** World Bank funded Satellite Monitoring for Forest Management Project is developing methodologies to map degradation and Estimation of Biomass **WAVES also funded by the World Bank has also developed the Landcover for 2015**	Need to establish baseline for reporting emission reduction **SMFM is being implemented in Zambia and Mozambique** SADC/JICA Forest Project is at Regional level with 15 MS **FAO implements Collect Earth** Regional collaborations RCMRD **Update Landcover/Land use map every 2 years** Engage new technology

15. Jose Galvez and Sofia Garcia, Ministry of Natural Resources, Guatemala Guatemala's Specific Experience in Land-Use Change

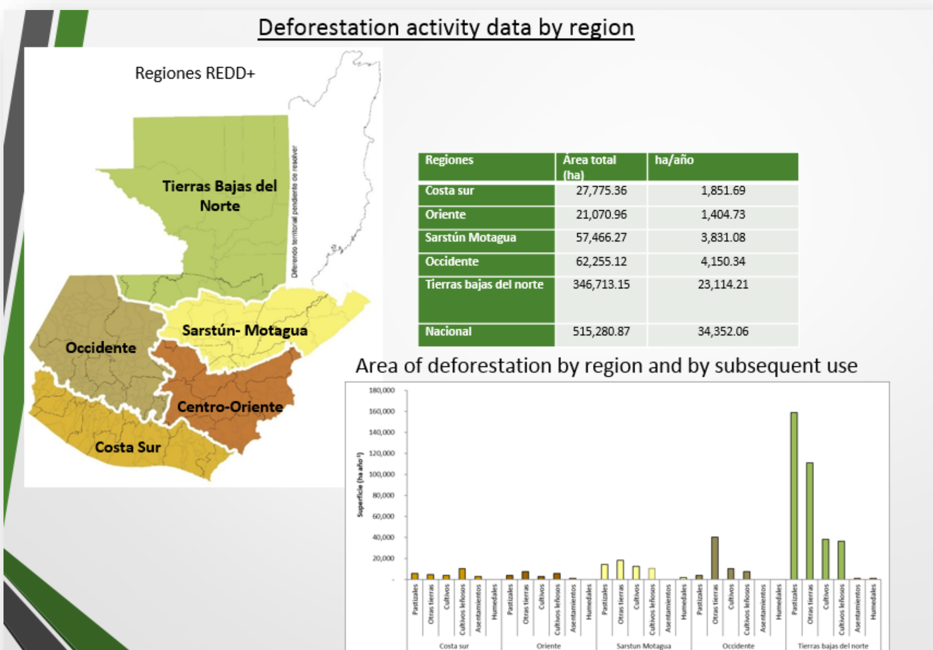
Jose Galvez started by stating that at this point Guatemala is not part of the ISFL jurisdictional mapping, but they are interested in the methodologies that have been presented at

this workshop and that they share the same problems with Mexico. The country of Guatemala is divided into five subnational regions, agreeing on maps of ecosystems, life zones and other variables.

The methodologies used in Guatemala for the mapping of forest cover and land use: For the following time intervals 2001-2006; 2006-2010; 2014; 2010-2016 a supervised classification was used with the maximum likehood classification algorithm with Landsat images.

Guatemala has produced a 2012 map of forest types using RapidEye using maximum likehood classification. In 2017, they worked collaboratively with the University of Maryland on implementing an approach for forest mapping using 3,000 samples at national level for the period 2000 – 2016. But the country has done anything with UMD since then.

In 2018, they started using Collect Earth Methodology. Activity data was generated by the analysis of 11,369 samples. They were assessed through visual interpretation to determine the dynamics of the land cover in the selected period. Each sample evaluated in Collect Earth



comes from a grid of 3.1 km x 3.1 km that covers the country.

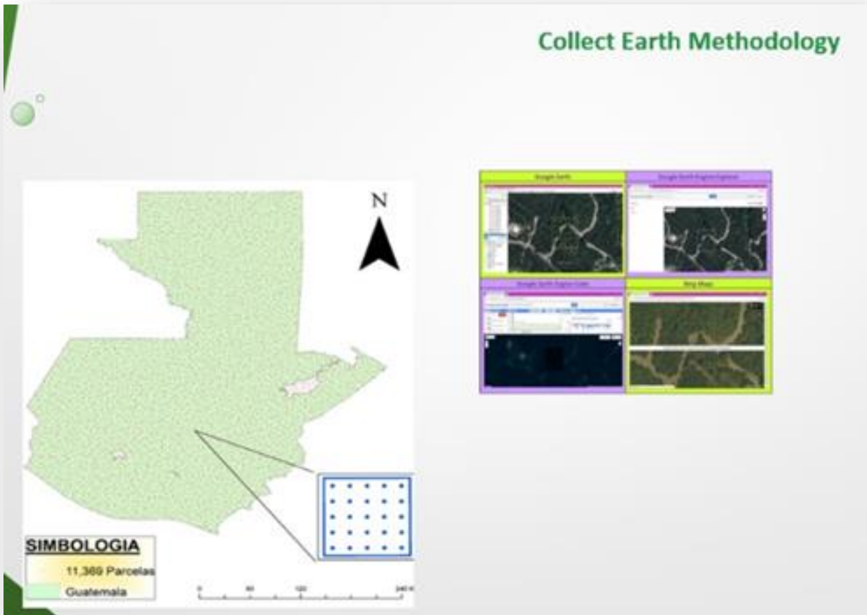
The grid is determined by random sampling. The samples have an area of 1 hectare and an internal grid of 25 point (5x5).

Sofia Garcia presented the deforestation activity data by region for the period 2001 – 2016. Loss of forest to other land uses in the period 2001-2016 is 34,352 ha per year.

Jose Galvez provided the degradation definition Guatemala: Degradation is the decrease of carbon stocks in forests that remain as forests caused by anthropogenic activities (fire, extraction of firewood and wood).

Guatemala has mapped degradation using CLASlite, but the results could not be validated due to the lack of field information. They used random forest to make this map which was just an exercise, it was not meant for reporting purposes, but it could help in the future.

Guatemala is also mapping degradation using Collect Earth by analyzing samples of forest that remain forest with high resolution images. It is not easy to measure the drivers of degradation.



They reported that their wall-to-wall deforestation map is 60% higher than that mapped by Collect Earth, but they have not done an accuracy assessment.

Pontus suggested that they use the 11,369 available to increase the accuracy and actually this is something that the countries could turn for assistance to SilvaCarbon. Guatemala needs support to create these maps and to produce the accuracy assessment. The country has not submitted their reference levels yet.

As asked by the organizers of the workshop, Guatemala and other countries presented their needs, benefits/success stories, challenges that have faced and what lessons they have learned as well as their future plans.

GUATEMALA

NEEDS

- Capacity building by workshops and MRV strengthening
- Training in GEE
- Development of specialized tools for uncertainty estimation (Pontus's group)
- Training in uncertainty estimation
- Apply the way to validate with a systematic algorithm
- Need a workshop in MARN for how to create a strong MRV/monitoring system
- General technical assistance: general monitoring system design, sampling statistics (meaning of confidence interval, principles behind scientific monitoring), combination of ground and remote sensing data, possible use of SAR in a standardized way; background material for explaining these things to ministry officials in a non-technical way

- Work with FCPF training needs initiative; we could provide technical support – contact Kenset Rosales (MARN)
- Map of fire scars – burned area delineation, BAER Forest Service (contact Karis Tenneson, Andy)
- Help with development of SNICC – Sistema nacional de informacion sobre cambio climatico – (Kenset = contact) – Information technology support, suggestions for software, database management, that kind of thing (USFS has database people who have helped Peru, contact Andrea VonDerH……, AJ Doty FS people)
- Get specialists to help with AFOLU and GHG reporting – i.e., can we help support a contractor to help them produce their reports

GUATEMALA

BENEFITS/SUCCESS	CHALLENGES	LESSONS LEARNED	FUTURE PLANS
Currently, we are updating our national refence level and it will be ready next year. **Implemented CE desktop for entire country**	Challenging to establish MRV that feeds the National Environment System of Climate Change (SNICC) **Combine methodologies/technologies to make cost-effective monitoring and reports** Build capacities in GEE, specifically in degradation topics and IPCC categories **Institutional challenges: Get reports each two years, from 2018** Difficulties institutionalizing the methods, collegiality of technical staff within and between agencies Choosing from among several options Stability of staff – a lot of turnover	CE desktop; evaluated Matt Hansen maps **CCDC** CODED **There are innovative options for land use mapping** We need a methodology for get better emissions factor	To share our experiences and knowledge with other countries **Our goal is to build a reference level to be presented to the UNFCCC, to move from subnational to national, including more activities and/or carbon sink, or making an update of the historical series that reference period for estimate results** We want to combine methodologies to make comparisons, so we can reduce the uncertainty **We will use the Maryland methodology for generating early warning of deforestation (Landsat)** **Fire mapping research/products**

Day # 3
Monday, 27 March 2019

The objective for the third day of the workshop was for each of the countries to be paired with two/three experts to summarize their specific needs, benefits, challenges, lessons learned and future plans. After the exercise, the countries gave a brief presentation which was followed by a discussion involving all participants. The results of this exercise are organized in the table below and the notes.

SUMMARY OF THE COUNTRIES' CHALLENGES & NEEDS	Countries
Technical level assistance	All 4 countries
Institutional level assistance	Colombia Zambia Guatemala
Agreement and consolidating of ground data and/or National Forest Inventory and Remote Sensing data	Mexico Zambia Guatemala
Develop a methodology for degradation mapping & accuracy assessment for degradation	Colombia Mexico Guatemala
Post fire mapping	Zambia Guatemala
MRV strengthening	Zambia Guatemala
Training in GEE and Collect Earth	Zambia Guatemala
Long-term training and assistance	All 4 countries
Improving post-processing and change detection algorithms	Mexico Zambia
The need for writing up the documentation of the work was identified by all countries.	All 4 countries
Assistance with choosing from various available methodologies	Guatemala
Write up the validation and accuracy assessment protocols	Colombia
Need for Monte Carbon simulation in the GEE	Mexico
Develop a common platform for them to share with other institutions	Mexico
Training in CCDC on the GEE on jurisdictional level and scale it up afterwards	Mexico
Training on Biomass initiatives (RADAR/LiDAR)	Mexico
Develop Early Warning Systems on deforestation and forest fires	Mexico
Improve the accuracy assessment methods	Mexico
Short-term training and assistance to meet immediate needs	Zambia

Need speed batch processing	Zambia
Collect ground truth data	Zambia
Vegetation regrowth mapping	All 4 countries
Slow Internet	Zambia
Needs for software	Zambia
Need for assistance to develop sampling design and analysis design for area estimation	Zambia
Need for assistance for interpretation of sampling units	Zambia
Development of specialized tools for uncertainty estimation & training in uncertainty estimation	Guatemala
Specific assistance with creating AFOLU and GHG reports	Guatemala

GENERAL DISCUSSION:

- In terms of mapping, **Zambia** depends on support from FAO. They need batch processing to speed up the process and deliver their products in a timely manner. **Sylvia Wilson** mentioned that FAO will do training in the country on Collect Earth and they are also organizing a workshop on sample design in June/July this year. **Andres Espejo** emphasized the need for a protocol for sampling design to be produced. **Sylvia Wilson** added that SilvaCarbon will be coordinating with FAO for the sampling design effort.

- **Colombia** shared that the process for decision making is challenging. In the government if there is change in any technical process then it is difficult to change the decisions already made.

- **Andres Espejo** commented that in Africa there are many initiatives which are not synchronized, and the countries don't know what to choose. Changeable environment is complicated for the countries. **Naikoa Aguilar** said one way around is to identify a country that can serve as a regional lead. Particularly is they have similar geographies. Documenting what they are doing is the key. Usually it does not happen for lack of people and resources. Countries rarely publish or document.

- **Sebastian Wesselman** raised a question about what the expectations of the counties within ISFL are and how they should balance adapting new methodologies and be consistent with reporting estimates. **Rama Reddy** stated that ISFL does not impose new requirements on the countries other than going back 10 years of land use change mapping and monitoring. **Andres Espejo** was curious to find out what kind of new technologies were the countries talking about. **Gustavo Galindo** mentioned that Approach 3 is wall-to-wall but Colombia does not need wall-to-wall as the uncertainty of the results is high. Also, the models are not efficient sometimes and in many cases the countries are forced to test new models, when they know that they have more accurate results with Approach 2. **Gustavo Galindo** also emphasized the need for the countries to be able to modify the model and the methodologies in general themselves. **Oswaldo Carrillo** agreed that the countries need to understand what the algorithms does before they start using it. **Brian Mutasha** added that even at the level of scientific research, the technicians for the country need to be involved.

- Colombia needs assistance with the validation and accuracy assessment protocols. **Pontus Olofsson** is working to put such document in the public repository of AREA2. **Andrew Lister** and **Karis Tenneson** are going to investigate sampling design documentation that is already done at USFS International Program.

- **Colombia** strongly emphasizes the need of assistance in mapping degradation and the accuracy assessment for degradation. They need to investigate how they can link the changes between the changes on area, and what is happening in the field. It was suggested to have a statistician working with Colombia on this.

- Regrowth analysis of the woody vegetation for the time frame of more than 10 years is tricky for all countries.

- Comment was made by Oswaldo Carrillo that in Mexico people use the Global Forest Watch as it is good for visualizing results. Pontus Olofsson suggested that Mexico should also consider visualizing their results as people expect that.

- Creating alerts is outside of the ISFL priorities.

- It was recommended to have an exchange of experiences among the ISFL countries and getting structured feedback.

Name	Institution	Country	
Naikoa Aguilar	WWF – World Wildlife Fund	USA	
Juliann Aukema	USAID – US Agency for International Development	USA	
Eric Bullock	Boston University	USA	
Oswaldo Carrillo	CONAFOR – National Forestry Commission	Mexico	
Thomas Cecere	USGS – US Geological Survey	USA	
Peter Doucette	USGS – US Geological Survey	USA	
Andres Espejo	WB – World Bank	USA	
Rama Chandra Reddy	WB – World Bank	USA	
Gustavo Galindo	IDEAM – Institute of Hydrology, Meteorology and Environmental Studies	Colombia	
Chris Dragisic	US Department of State	USA	
Jose Galvez	MARN – Ministry of Natural Resources	Guatemala	
Andrea Garcia	GIMBUT – Group of Forest and Land Use Monitoring	Guatemala	
Julian Gonzalo	WB – World Bank	USA	
Noel Gorelick	GEE – Google Earth Engine	USA	
Noel Gurwick	USAID – US Agency for International Development	USA	
Matt Hansen	UMD – University of Maryland	USA	
Sean Healey	USFS – US Forest Service	USA	
Moses Jackson	USFS – US Forest Service	USA	
Monica Jeada	USGS – US Geological Survey	USA	
Pui-Yu Ling	WWF – World Wildlife Fund	USA	
Andrew Lister	USFS – US Forest Service	USA	

Tom Maiersperger	USGS – US Geological Survey	USA	tmaiersperger@usgs.gov
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Alex Moad	USFS – US Forest Service	USA	amoad@fs.fed.us
Miguel Munoz	CONAFOR– National Forestry Commission	Mexico	miguelmunoz.ute@conafor.gob.mx
Bupe Musonda	National Forest Monitoring System	Zambia	bupemusonda84@gmail.com
Brian Mutasha	Ministry of Land and Natural Resources	Zambia	bmmutasha@gmail.com
Evan Notman	GFOI – Global Forest Observation Initiative	USA	evan.notman@gfoi.org
Katie O' Gara	WB – World Bank	USA	kogara@worldbank.org
Pontus Olofsson	BU – Boston University	USA	olofsson@bu.edu
Elitsa Peneva-Reed	USGS – US Geological Survey	USA	epeneva-reed@usgs.gov
Karis Tenneson	SIG – Spatial Informatics Group	USA	karistenneson@gmail.com
Sylvia Wilson	USGS – US Geological Survey	USA	snwilson@usgs.gov
Sebastian Wesselman	USFS – US Forest Service	USA	Sebastian.wesselman@fs-ip.us