Forest degradation: A Mixed Approach

To address the issue of forest degradation in Peru, the methodological proposal called "Mixed Approach" is being developed, which involves the indirect and direct approach proposed by GOFC-GOLD (2017), but also incorporates the IPCC Good Practice Guidelines (2014) of transparency, completeness, consistency, comparability and accuracy.

The proposed methodology has technical support in Peru from the Specialized Technical Advisory Group in Forest Degradation (GCTE-DF), formed on January 28/2019 by specialists from State Entities, NGOs, Universities, Regional Governments and Research Centers. Likewise, The Regional Governments with SERFOR specialists, will also support the logistical process of information gathering in field plots. The information captured, as well as the design of plots, will be in accordance with the guidelines of the National Forestry Inventory (NFI), being also consistent with the guidelines for the Carbon inventory and Socioeconomic component of the NFI.

At the international level, there is technical support from FAO experts, as well as the Network of Experts in Forest Monitoring of Latin America linked to the Mesoamerican Virtual Center of Excellence in Forest Monitoring based on the National Forestry Commission of Mexico.

The mixed approach is initially oriented to detect forest areas with "probability of being degraded" (indirect approach) and subsequently verify those areas from a more rigorous and detailed analysis with Remote Sensing (direct approach) to finally validate with field data.

The indirect approach is based on the methodology Morphological Spatial Patterns Analysis (MSPA), where under fragmentation metrics, "proxy" indicators are generated to identify "potentially degraded forests" at different scales. A main input for the analysis is the Forest Reference Emission Level (FREL) for the Peruvian Amazon biome (2000-2014), specifically the forest/non-forest thematic layers and their changes over time. This guarantees the consistency of GHG emissions and removals estimates between the Reference Period and monitoring period, and it shall not relate to any change to policy and design decisions affecting the Reference Level[1]

The MSPA takes into account the estimation of the changes in the above-ground biomass present in different forest cover classes assigned by means of a fragmentation analysis of the edges of the forests. For this purpose, data will be used from the first INF panel to compare the biomass / carbon maps of the Carnegie Air Observatory (Asner et al 2014) and the Ministry of Environment of Peru, as well as information on global initiatives (Baccini et al 2012, Saatchi et al 2011, Avitabile et al 2015), in order to generate statistics and trends to select the source with less uncertainty.

Using technical corrections like the NFI data and field plots to estimate emissions from forest degradation to replace default emission factors, will not result in an increase in uncertainty about the activity data or the emission factors[2]. Likewise, these estimates do not use data interpolation and therefore, the mixed approach does not result in an increase in the uncertainty about the activity data or the emission factors.

[1] Guidance Document 2 on Technical corrections to GHG emissions and removals reported in the reference period of the FCPF

[2] Guidance Document 1 on the use of interpolation of data in relation to the Reference Period of Emission Reduction Programs of the FCPF

The indirect approach developed for the ERPD has the same methodological principle as the new degradation proposal for the Amazonian biome, but to obtain better estimates, improvements will be made on:

1. Definition of forest:

The degradation analysis made for the ERP Reference Level adopts the definition of forest of the FREL, based on three thresholds: minimum area of 0.09 ha (Landsat pixel area), minimum tree height of 5 m and a canopy cover of more than 30%.

The Mixed Approach takes the same parameters but makes an adjustment to the definition of minimum area (0.5 ha)[3], for the analysis of the area likely to be degraded; given that:

1.1. A degradation analysis on isolated pixels increases the uncertainty and possible methodological limitations of the mixed approach.
1.2. By taking 6 pixels instead of 1, the analysis focuses on areas with greater certainty of being forest.
1.3. MSPA analysis generates edges that are more likely to be degraded.
1.4. The results of the analysis of time series on "groups of pixels" are more consistent.
1.5. Conservation actions require precise quantification of habitats, so it is essential to correctly identify edge and core areas that help to understand changes in dynamic landscapes of fragmented forest areas.
1.6. From the analysis of fragmentation, it is wrong to consider that an isolated pixel of loss of coverage (0.09 ha), can generate an area of 13.8 ha of degradation.

2. Edge proposal: 2.1 km

The Mixed Approach considers a 2100 m distance to forest edge. This is different from the current distance being used in the ERP proposal, using the indirect approach. This methodological change is argued by:

2.1. The edge distance affects the estimation of the area defined as degraded and must be much larger than the pixel size (Chaplin-Kramer et al 2015).
2.2. The carbon map from which the forest degradation emissions were estimated in the ERPD has a spatial resolution of 100 m^2 (Asner et al 2014), which makes it difficult to represent the proxy value since it would only take into account 2 edge pixels versus a 20 pixel's edge of the method.
2.3. A 2.1 km distance is conservative. It may result in the inclusion of non-degraded forest areas but at the same time, avoids exclusion of the degraded ones.
2.4. Biomass within the first 500 m of the edge of the forest is on average 25% lower than in the interior. and reductions of 10% extend to 1.5 km (Chaplin-Kramer et al 2015).
2.5. The study "Degradation Spatial patterns of Amazonian forests" conducted by the Fundación Amigos de la Naturaleza (FAN) in San Martin, Ucayali and Madre de Dios, found that the average distance penetration for forest use through the inventory of stumps was 1.86 km.

The integration of the results of the annualized MSPA analysis with the biomass/carbon data will be done based on the indirect degradation estimation methodology of Shapiro et al (2016), which will allow obtaining the changes throughout the analysis period associated to the

[3] 0.5 ha of minimum cover, according to the official definitions from the NFI and the Clean Development Mechanism (CDM).

characteristics of a forest degradation process: forest fragmentation in patches that could continue to decrease in size over time, increasing border areas, continuous forest isolation, greater accessibility, lower biomass, higher tree mortality, etc. From this, an indirect assessment of where and to what extent degradation has occurred will be possible.

The indirect approach does not allow monitoring the degradation process in areas identified as degraded in a year and that are not considered degraded in subsequent years. Likewise, not all forests are under immediate threat of conversion and under this assumption the threat stratification principle is adopted, which allows us to use the proxy information of forest degradation and link it with the Spectral Mixture Analysis (SMA) and the Time Series (TS) under the direct approach.

In the direct approach, the analysis starts from vegetation indexes[4] to extract from the reflectance of an image, information of the physical properties of the terrestrial coverage at the pixel level. Advances in satellite remote sensing techniques have improved the possibilities of detection, mapping and monitoring of alterations specifically in the forestry sector, with the SMA being the most promising methodology.

From the SMA approach, it is possible to calculate for each class the occupied proportion of the coverage and obtain information at the sub-pixel level from pure spectra (*Endmembers*), previously defined by the detected wavelengths and the number of sensor bands.

The information generated will be incorporated into the TS analysis from seasonal (Harmonics, BFast, CCDC, YATSM) and non-seasonal (PVts-β) approaches for a robust analysis of forest disturbance under the period 2000-2017. This will guarantee the coherence of time series and the coincidence with the calendar years (January to December) for an annual estimate of emissions and removals[5].

Finally, the development of a validation scheme with field data is planned, where a stratified random design based on the results of the direct approach is taken into consideration. The field data will be obtained from panel 2 of the NFI and the development of new field plots, to improve the information on the degradation activities, history of the affected areas, floristic composition and biomass that will be used to estimate the emission factors.

The uncertainty analysis will be based on the good practices proposed by GFOI 2014 and Olofsson et al. (2014), which will be applied to the indirect approach, direct approach and final validation.

The results will make it possible to understand the dynamics and possible trends of historical emissions due to forest degradation, increasing the capacity of the country to present an approach to the preparation of the most appropriate FREL and adjusted to national circumstances.

Likewise, the methodological proposal with respect to the preliminary one made in the ERPD, presents changes from the technical side and adopts a gradual approach based on the incorporation of improved data and methodologies that will serve to re-estimate the ERP RL and for monitoring in general.

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[4] Proposed Vegetation indexes and metrics: NDFI, ΔNBR, NDVI, LAI, EVI, SAVI, ACP, Tasseled Cap, Temperature, Texture, bands, ratios.

[5] Guidance Document 3 on the definition of Reporting Periods of Emission Reduction Programs of the FCPF

The activities planned, as well as the delivery dates, are detailed below:

Forest Reference Emissions Level (FREL) that integrates emissions data due to forest degradation		
Technical capacities developed and strengthened to update the FREL		
Activity	**Date**	**Description**
First GCTE-DF meeting	28 January 2019	Work meeting where the best methodological option is defined, harmonization of processes and generation of geospatial products, training plan for updating the FREL and processes to follow
Second GCTE-DF meeting – SEPAL workshop	25 February- 1 march 2019	Work meeting and technical session for the incorporation of SEPAL[6] platform as a support tool in the analysis and estimation of the magnitude of forest degradation processes in the Amazon biome.
Third GCTE-DF meeting. Presentation of results from the indirect approach for forest degradation (Morphological of Spatial Patterns Analysis)	3 July – 5 July 2019	Work meeting, technical session and videoconference to socialize the results obtained in the indirect method and training to specialists in the estimation of emissions due to forest degradation
Fourth GCTE-DF meeting. Presentation of result from the direct approach for forest degradation (Spectral Mix Analysis and Time Series)	11 -13 December 2019	Work meeting, technical session and videoconference to socialize the results obtained in the direct method, analysis of time series and training to specialists in the estimation of emissions due to forest degradation.
Fifth GCTE-DF meeting. Presentation of field-phase results and validation of degradation map	2-3 July 2020	Work meeting and videoconference to socialize the results obtained in the field phase and validation of satellite information and training to specialists in the estimation of uncertainties due to forest degradation.
5th GCTE-DF meeting. Presentation of total results and methodological replicability	17-18 December 2020	Work meeting and videoconference for the creation of technical dialogues about the results obtained and presentation of the FREL proposal.
FREL proposal for the Amazon biome that integrates data on forest degradation		
Milestones	**Date**	**Description**
Forest degradation indirect approach results (MSPA)	21 June 2019	• Spatial database • 17 proxy maps of forest degradation • Technical report

[6] https://sepal.io/

Disaggregation of Secondary Vegetation to identify Secondary forest area	30 august 2019	• Spatial database • 4 maps classified in at least three categories of use from the secondary vegetation class • Technical report
Forest degradation direct approach results (SMA and TS)	2 December 2019	• Spatial database • map of forest degradation under direct approach to 2017 • Technical report • Technical note
Field-phase and map validation results	22 June 2020	• Carbon database • Validation database • Technical report
Final results and methodological replicability	7 December 2020	• Final report • Consolidated spatial database