Submission to SBSTA: Views on robust, transparent forest monitoring systems for REDD+

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Summary

Robust, transparent forest monitoring systems are critical to the success of national REDD+ mechanisms. Although existing guidance and methodologies for forest monitoring can provide a starting point, additional guidance is needed from SBSTA to ensure that national systems can support the achievement of REDD+ goals.

This submission is presented in four sections:

- *What is a national forest monitoring system for REDD+?* – Forest monitoring is not unique to REDD+, and some countries may already have some form of monitoring system in place. However, traditional forest inventory-based approaches alone cannot provide estimates of forest carbon stocks with the accuracy or resolution required for REDD+ implementation. Monitoring systems for REDD+ should be designed to take advantage of new and emerging methodologies and datasets that can complement and improve upon inventory-based approaches.
- *Principles of robust national forest monitoring systems* – We define what the IPCC's five principles—accuracy, consistency, completeness, transparency, and comparability—mean in the context of forest monitoring for REDD+. We also provide examples of how each should be operationalized in the design and implementation of forest monitoring systems. These examples emphasize the importance of high-quality data and robust, peer-reviewed methodologies for achieving a successful results-based REDD+ mechanism.
- *Characteristics and technical recommendations*—The characteristics and recommendations presented build off of the five principles outlined above and represent areas in which additional guidance from SBSTA may be warranted. We provide recommendations on how to address six characteristics of forest monitoring systems for REDD+, including the integration of ground-based inventory and remote sensing approaches, inclusion of monitoring for safeguards, and incorporation of local and traditional knowledge. These recommendations reinforce that the unique policy and technical requirements of REDD+ will require innovative approaches, a strong methodological framework, and robust guidance for forest monitoring.
- *Technical resources*—We provide a brief list of available datasets and methodological guidance for forest monitoring for REDD+. These resources can help both policy makers and REDD+ practitioners to develop and implement monitoring systems based on peer-reviewed and commonly accepted data and methodologies.

Introduction

A successful results-based REDD+ mechanism will produce significant verified reductions in emissions from deforestation and forest degradation. The role of national forest monitoring systems in this context is to detect and quantify the impacts of REDD+ activities on forest carbon. Monitoring further

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informs and should be informed by all elements of an operational REDD+ mechanism, including reference levels, MRV systems, compensation frameworks, and information systems for safeguards. The central role of forest monitoring underscores the importance of technical guidance and guidelines to ensure that national systems are consistent with policy guidance and methodological requirements of REDD+ mechanisms under the UNFCCC.

Rapid development of national forest monitoring systems has begun under several bilateral and multilateral initiatives. While REDD+ countries will necessarily adopt a range of approaches and methodologies based on their unique national forest circumstances and goals, without strong guidance from the UNFCCC there is a danger that a patchwork of inconsistent, non-comparable national mechanisms will preclude the effectiveness of REDD+ as a global mitigation effort.

In this submission, we first clarify the purpose of national forest monitoring systems as required for REDD+, followed by definitions of several important terms and concepts. In the second section we propose five high-level principles that can promote the development of robust and transparent forest monitoring systems, and we include examples of how these principles may be operationalized in system design and implementation. Next, we offer technical recommendations that can inform the scope and content of SBSTA's work on providing methodological guidance for forest monitoring for REDD+. The final section contains a list of resources, including methodological guidance and datasets that may be used in the design and implementation of national forest monitoring systems.

What is a national forest monitoring system for REDD+?

Monitoring systems for forests and other, non-forested lands have been implemented in many countries for a range of purposes, including tracking timber production, surveying biodiversity, and assessing forest health. In the context of REDD+, national forest monitoring systems will be required to produce robust estimates of the amount of carbon contained in forest ecosystems. More specifically, countries will need to track changes in the density of forest carbon over time and space in order to consistently and accurately calculate the CO_2 emissions and removals attributable to anthropogenic activities. A forest monitoring system for REDD+ may be a component of a broader national system to monitor forests and/or other land uses that assesses changes in carbon stocks, ecosystem services, and/or anthropogenic activity.

Many REDD+ countries have ground-based national forest inventories (see below for definition) in place. Inventory-based approaches to forest monitoring have traditionally been used to measure non-carbon forest attributes, such as merchantable timber volume, and generally rely on plot-based sampling networks. Information obtained from these plots can be converted to data on carbon stocks based on allometric equations and extended to larger spatial scales using statistical methodologies. Ground–based inventories will remain an important component of a national forest monitoring system for REDD+; however, inventory approaches alone cannot provide estimates of forest carbon stocks with the degree of accuracy or resolution (both spatial and temporal) required for a successful REDD+ mechanism. Forest monitoring systems for REDD+ should therefore be designed to take advantage of

new and emerging methodologies and datasets, such as the range of available remote sensing technologies, that can complement and improve upon inventory-based approaches.

The definitions and explanations below refer specifically to concepts as used in this submission on national forest monitoring systems for REDD+. It is important to recognize that these terms may have different meanings when applied in other contexts.

***Forest Inventory*:** Data on forest carbon stocks and/or associated attributes, obtained through or derived from a ground-based plot sampling network.
***Monitoring*:** Using a combination of data sources and methodologies to determine the area of forest subject to REDD+ activities and the associated fluxes of greenhouse gases. This is accomplished through repeated (e.g., annual) assessments of forest area, carbon stocks, and the extent of REDD+ activities at the national level.
Activity data: Information on the area over which a specified REDD+ activity occurs during a given period of time.
Emission factor: The quantity of greenhouse gas emitted for a given activity. For REDD+, the emission factor is typically the amount of forest carbon per hectare that is emitted or removed from the atmosphere as a result of the REDD+ activity of interest.

Note: The terms "activity data" and "emission factor" have specific meanings in the context of the IPCC's default methodology for estimating emissions and removals. Using this methodology, net REDD+ emissions at the national scale are calculated by multiplying activity data by the appropriate emission factor and summing across the full range of REDD+ activities, including both those that result in removals (e.g., afforestation/reforestation) and emissions. While this methodology is one option for REDD+, it should not be regarded as the only acceptable approach. For example, stock-change methods based on emerging approaches for direct remote sensing of biomass over time may eliminate the need for distinct sources of activity data and emissions factors. We include the terms "activity data" and "emissions factor" here because they are commonly referenced in the REDD+ arena; however, by including them it is not our intent to preclude consideration of emerging or future monitoring approaches that otherwise achieve the principles and recommendations described below.

Principles of robust national forest monitoring systems
The following five principles are adapted from the Intergovernmental Panel on Climate Change's 2003 Good Practice Guidance for Land Use, Land-Use Change and Forestry. These high-level considerations should underlie and inform technical and methodological considerations and guidance. The bullet points following each principle represent specific actions that can contribute to the operationalization of national forest monitoring systems for REDD+.

Accuracy – A relative measure of the exactness of an estimate. Estimates should neither systematically over- nor under-estimate true emissions or removals, so far as can be judged, and uncertainties should be reduced as far as is practical.

- Guidance should encourage REDD+ countries to work towards increasing the accuracy of both activity data and emissions factors.

- Uncertainties arising from each step of the data processing chain should be quantified, propagated and reported.
- National forest monitoring systems should produce data and information that is at least as accurate as available global datasets (see below for more information).

Consistency – Monitoring systems should supply data and information that is internally consistent over space and time. Consistency also requires that the same methodologies, approaches, and assumptions used in a country's forest monitoring system also be used as the basis for the calculation of reference levels and accounting for emissions and removals resulting from REDD+ activities.

- When methodological changes are made in order to improve the quality of estimates, these changes must be transparently documented and all historical analyses should be recomputed in order to maintain the temporal consistency of the data record.
- Whenever possible, data should be obtained from "like" sources and methodologies in order to maximize the internal consistency of the monitoring system.

Completeness – National monitoring systems should supply information and data on all significant activities, pools, and gases within a REDD+ country. A national monitoring system should also demonstrate that any activity, pool, or gas not covered is not a significant source of emissions or removals.

- Identification of significant activities, gases, and fluxes should be undertaken in accordance with IPCC Good Practice Guidelines and Guidance, including current or future supplementary guidance. Methodologies for conducting key category analysis of levels, trends, and uncertainties should be adapted for the forest sectors of REDD+ countries.
- To ensure that all significant activities and fluxes are included, monitoring frameworks should track changes to and from forest land in a spatially-explicit manner. Wall-to-wall mapping should be undertaken in order to capture the full spatial extent of REDD+ activities, including any leakage occurring at the sub-national scale. Global datasets (of, *inter alia,* land cover, biomass, and canopy density) may be available to augment national forest monitoring systems. Additionally, the temporal and spatial resolution of monitoring should be sufficient to capture all relevant anthropogenic impacts on forests.
- When data are available from many time steps, it is better to use the information from the whole time series, rather than just comparing two dates (i.e., the first and last points in time). This increases the likelihood that all gross changes in land cover and land use during the period of interest are captured in the dataset. (Using all data in the time series will also maximize the accuracy of the analysis.)

Transparency – All datasets, approaches, methodologies, models, and assumptions used in establishing and implementing a national forest monitoring system should be made available to facilitate replication and assessment by an independent third-party.

- Information should be reported in accordance with UNFCCC guidance for National Communications, biennial update reports, international consultation and analysis, and/or any

other relevant transparency and reporting mechanisms. All relevant information should be made available in a timely manner on the UNFCCC REDD+ web platform.

- Datasets and explanations of associated approaches, methodologies, models, and assumptions should be supplied in a standardized format and made available to the public.

Comparability – All forest monitoring systems for REDD+ should be based on peer-reviewed and commonly accepted approaches and methodologies and must comply with policy and technical guidance supplied in UNFCCC decisions, including 4/CP.15, 1/CP.16, and -/CP.17 (Guidance on systems for providing information on how safeguards are addressed and respected and modalities relating to forest reference emission levels and forest reference levels), and any further decisions taken by the COP.

- Estimates of emissions and removals resulting from all REDD+ activities should be expressed in tons of carbon dioxide equivalent per year.
- A "one size fits all" solution to forest monitoring is not likely to emerge. The technologies and methodologies employed will be determined by countries' national forest circumstances, their technical and institutional capacities, cost-effectiveness, and the financial, technical, and institutional support received. There are, however, resources countries can take advantage of to maximize the comparability of forest monitoring systems, such as global datasets derived from optical and radar sensors that can inform estimates of forest carbon stocks and fluxes.

Characteristics and Technical Recommendations for REDD+ national forest monitoring systems

The following characteristics and recommendations address aspects of forest monitoring systems specific to REDD+. These elements build off the principles described above and represent areas in which further elaboration and guidance from SBSTA may be warranted.

Integration of ground-based forest inventory and remote sensing approaches – Decision 4/CP.15 requires countries to "[u]se a combination of remote sensing and ground-based forest carbon inventory approaches for estimating, as appropriate, anthropogenic forest-related greenhouse gas emissions by sources and removals by sinks, forest carbon stocks, and forest area changes." The appropriate balance of ground-based sampling and remote sensing approaches in a forest monitoring system will vary from country to country based on forest characteristics, technical and financial capacities, and the design of national REDD+ policies and incentives.

- Systematic integration of ground-based and remote sensing data is the foundation of robust and cost effective forest monitoring systems. Remote sensing alone cannot achieve the accuracy, consistency, or completeness necessary for REDD+, and it is not technically feasible to collect ground-based data for every point that needs to be sampled. However, remotely-sensed data calibrated and validated with on-the-ground information allows field data to be spatially extended to obtain consistent, accurate estimates across large areas.
- Ground-based inventories and plot-based sampling can perform multiple functions in a forest monitoring system, including calibration and assessment ("validation") of remote sensing estimates, obtaining data on non-aboveground biomass carbon pools, and gathering information on processes and activities that cannot be monitored remotely.

- There are currently several examples of forest monitoring approaches that integrate ground-based data stocks with remote sensing to obtain spatially-explicit estimates of forest carbon stocks at the national scale (e.g., Baccini et al., 2012). These datasets can be used in combination with activity data to obtain estimates of forest-based emissions and removals; alternatively, repeated assessments of forest carbon over time can be compared to derive an estimate of emissions based on net forest carbon stock change.

Incorporation of local and traditional knowledge and engagement of indigenous peoples and local communities – The engagement of indigenous peoples and local communities (IPLCs) can improve the robustness of national forest monitoring systems with regard to the five principles described above. SBSTA should acknowledge efforts already underway to develop frameworks for incorporating input from indigenous peoples and local communities in both the planning and implementation of national forest monitoring systems for REDD+. Recognizing that IPLCs often have a broad understanding of the forests where they live and the processes that impact them, they are in a strong position to:

- Inform decisions regarding the appropriate temporal and spatial scales for monitoring;
- Contribute to data collection, particularly in remote and otherwise difficult to access regions; and
- Track changes in activities and carbon on the ground at scales relevant for REDD+, e.g., helping to monitor activities such as degradation in and around protected areas/indigenous and community forests.

Continuous improvement – SBSTA guidance should encourage Parties to continuously improve the accuracy and efficiency of their forest monitoring systems, including through a step-wise approach that takes into account advances in national capacities and capabilities. Additionally, forest-monitoring systems should be designed so that they can evolve with continuing advances in technologies (e.g., lidar) and methodologies that result in improved estimates of forest-based emissions and removals.

- Early results of an analysis that uses an economic framework to assess the implications of various approaches to forest monitoring indicate that the benefits of improved accuracy have the potential to outweigh the costs. For some potential REDD+ countries, participation in REDD+ will not be economically feasible unless monitoring approaches and methodologies are able to detect changes in forest carbon with relatively low uncertainty. Without the option and ability to increase the accuracy/lower the uncertainty of estimates of emission reductions, REDD+ will be less environmentally effective, fewer countries will benefit from participation, and there will be a loss in cost efficiency.

Determining the appropriate resolution – To maximize the accuracy and completeness of emissions estimates, a national forest monitoring system must capture the impacts of anthropogenic activities at the scale/s at which they impact the forest. Although higher-resolution monitoring may be necessary to robustly monitor some REDD+ activities, increased resolution does not necessarily result in increased accuracy of estimates. However, it does typically result in higher costs. Countries should determine what resolution is most appropriate in various parts of their forest. Higher-resolution monitoring can be

targeted on hot spots of change, such as frontiers of deforestation, and where significant emissions result from fine-scale forest disturbance processes.

Monitoring safeguards

National forest monitoring systems should also supply information needed to assess whether the REDD+ safeguards contained in Appendix I to decision 1/CP.16 are being respected and addressed. Forest monitoring systems are especially suited to gather information relevant to environmental safeguards, including the conservation of natural forests and biodiversity and the protection of environmental services. Additionally, synergies and cost efficiencies may be gained by integrating carbon and safeguard monitoring systems.

- Forest monitoring systems can help to prioritize areas for REDD+ interventions, including high-biodiversity forests and areas critical to the provision of ecosystem services. Coupled field and remote sensing approaches can be used to map the spatial distribution of biodiversity (e.g. species richness and abundance) and assess the responses of species and of ecosystems to forest disturbance and management. Spatial assessments of carbon stocks and other environmental data should be integrated, or at least developed using comparable datasets that can be combined to identify high-priority sites.[2]
- Monitoring systems should take advantage of economies of scale to integrate collection and management of forest carbon, biodiversity and other environmental data. Networks of field plots may be designed such that sampling for carbon, biodiversity, and information on ecosystem services occur on the same or nearby sites.
- Forest monitoring systems for REDD+ can also contribute to ongoing assessment of safeguards for input in safeguard information systems. Monitoring of biodiversity and ecosystem services may be accomplished through proxy indicators such as forest fragmentation and patch size, connectivity, and structural degradation.

Sub-national forest monitoring systems

Paragraph 71(c) of decision 1/CP.16 permits REDD+ countries to use, "if appropriate, subnational monitoring and reporting as an interim measure". Because these sub-national systems will likely be integrated into the national system upon conclusion of the interim period, they should be designed and implemented using the same or comparable approaches and methodologies as the anticipated national system. All principles and recommendations outlined here are thus relevant for both sub-national and national forest monitoring systems.

Resources for Negotiators —Forest Monitoring for REDD+

End-to-end processing of satellite imagery is a complicated and demanding technical task; where appropriate, users should leverage existing pre-processing capabilities to facilitate product generation. Countries should also take advantage of existing resources whenever possible, including consistent times series of satellite imagery, derived products such as forest cover change and biomass maps,

[2] Secretariat for the Convention on Biological Diversity. 2011. CBD Technical Series No. 59: REDD-plus and biodiversity. http://www.cbd.int/doc/publications/cbd-ts-59-en.pdf

topography, and open source algorithms for data analysis, among others. Using pre-existing processing capabilities and data sources can maximize efficiency and minimize costs while adhering to the principles of accuracy, consistency, completeness, comparability, and transparency.

Spatial Datasets (pan-tropical to global scale)

- Maps of carbon density from Baccini et al. 2012 – Spatially explicit (500 m) estimates of carbon density spanning the entire pan-tropical belt.
  Available for download at http://www.whrc.org/mapping/pantropical/carbon_dataset.html
  See also Baccini A, SJ Goetz, WS Walker et al. 2012. Estimated carbon dioxide emissions from tropical deforestation improved by carbon-density maps. Nature Climate Change. http://eorder.sheridan.com/3_0/display/index.php?flashprint=1608
- Several globally-available medium resolution optical and cloud-penetration radar image datasets are available from the Woods Hole Research Center (see http://whrc.org/mapping/pantropical/alos.html for radar example)
- Benchmark map of biomass carbon stocks across three continents for the early 2000s. Saatchi S et al. 2011. Benchmark map of forest carbon stocks in tropical regions across three continents." PNAS: June 3, 2011.http://www.pnas.org/content/108/24/9899.full.pdf+html

Methodological Guidance

- GOFC-GOLD REDD Sourcebook – Provides a consensus perspective from the global community of earth observation and carbon experts on methodological issues relating to quantifying carbon impacts of REDD+ activities. http://www.gofc-gold.uni-jena.de/redd/
- Field guide for biomass and carbon estimation from Walker et al. – Provides an introduction to the basic tools and techniques used in obtaining ground-based estimates of aboveground forest biomass and carbon. http://www.whrc.org/resources/fieldguides/carbon/index.html
- Guidance Documents developed under the Group on Earth Observations Forest Carbon Tracking and Global Forest Observation initiatives – National-scale demonstrations with select countries. http://geo-fct.org
- Good Practice Guidance for Land Use, Land-Use Change and Forestry. 2003. Intergovernmental Panel on Climate Change. Ed: J Penman, M Gytarsky, T Hiraishi, T Krug, D Kruger, R Pipatti, L Buendia, K Miwa, T Ngara, K Tanabe, F Wagner. http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_contents.html
- Collaboration under FAO to systematically analyze literature on methods to measure and assess terrestrial carbon stocks using an evidence-based process for scientifically-grounded decision-making. Petrokovsky, G., Kanamaru, H., Achard, F., Goetz, S.J., Holmgren, P., Joosten, H., Lehtonen, A., Menton, M., Pullin, A.S., & Wattenbach, M. Comparison of methods for measuring and assessing carbon stocks and carbon stock changes in terrestrial carbon pools: A systematic review protocol. *Environmental Evidence, forthcoming* http://www.un-redd.org/NewsCentre/EvidencebaseforMeasuringandAssessingTerrestr/tabid/1474/language/en-US/Default.aspx

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