Forest Monitoring, Measurement, Reporting and Verification: from Principle to Practice

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Abstract: Under the United Nations Framework Convention on Climate Change (UNFCCC), many tropical developing countries have agreed to participate in the Reducing Emissions from Deforestation and Forest Degradation as well as conservation and enhancement of carbon stocks and sustainable management of forests (REDD+) programme so as to receive payments for their contribution in reducing emissions from forestry sector. The emission reduction is measured in terms of quantifications of carbon dioxide (CO_2) equivalent, upon which payments are made. To quantify emissions in terms of CO_2 equivalent, a process called measurement/monitoring, reporting and verification (MRV) has been developed, which forms the backbone of performance-based payment under the REDD+ mechanism. This paper primarily reviews the principles and methods of MRV. By taking the case of the Terai Arc Landscape (TAL) of Nepal, a sub-national level proposed project, the paper demonstrates how an institutional mechanism for MRV can be designed and practiced at national level considering national circumstances and existing institutions. Also, the cost effectiveness and transparency of the MRV process are identified as important elements.

Key words: Climate Change, UNFCCC, REDD+, MRV, CO_2

INTRODUCTION

Forestry sector has been responsible for approximately 20 percent of the global greenhouse gas (GHG) emissions (CIFOR 2010; van der Werf *et al.* 2009) and, therefore, standing forests that sequester and sink atmospheric carbon dioxide (CO_2) and reduce emissions from forests are critical to combat global warming. In this context, a financing mechanism in the forestry sector, Reducing Emissions from Deforestation and Forest Degradation as well as conservation and enhancement of carbon stocks and sustainable management of forests (REDD+) has been under prolonged debate under the United Nations Framework Convention on Climate Change (UNFCCC) negotiations. Initially started as Reducing Emissions from Deforestation (RED) at the eleventh Conference of Parties (COP 11) in 2005 in Montreal, the concept expanded to Reducing Emissions from Deforestation and Degradation (REDD) in 2007 during COP 13 held in Bali and eventually termed as REDD+ in 2009 during COP 15 held in Copenhagen. Yet, till date, new ideas and issues around REDD+ keep emerging that delays the implementation of the REDD+ mechanism. According to the Ad Hoc Working Group for Long term Cooperation for Action (AWG-LCA) in COP 18 in Doha and follow up Subsidiary Bodies session in Bonn in June 2013, REDD+ and its associated technical and financial issues need to be further discussed, debated and resolved under the Subsidiary Body on Scientific and Technological Advice (SBSTA) and Subsidiary Body on Implementation (SBI) so as to ease and fasten the REDD+ implementation process. In order to quantify emissions in terms of CO_2 equivalent from forest and take stock of the carbon in the forest, a process called measurement/monitoring, reporting and verification (MRV) has been developed as one of the technical issues and being discussed under SBSTA and SBI.

Under the REDD+ mechanism, emission reduction is measured in terms of quantification of CO_2 equivalent upon which payments are made. The MRV system is, therefore, designed to quantify emissions in terms of CO_2 equivalent and take stock of carbon in the forest, which forms the backbone of performance-based payment under the REDD+ mechanism. Therefore, in order to make REDD+ functional at national and sub-national level, countries should have a National Forest Monitoring System (NFMS) that drives design and functionality of national and/or sub-national MRV systems to help access payments. A national MRV system guide will be important to understand the whole performance-based systems (CIFOR 2010). With MRV, other issues that run parallel are reference levels, safeguards, drivers of deforestation and forest degradation, non-market approaches and non-carbon benefits.

The Intergovernmental Panel on Climate Change (IPCC) Good Practice Guidelines for Land Use Land Use Change and Forestry (LULUCF) and IPCC Guidelines for National Greenhouse Gas Inventories could be used as a basis to help develop the designing of the national-level MRV systems. Recognizing the need for an MRV system, the World Bank under the Forest Carbon Partnership Facility (FCPF), has also started a process for developing an MRV framework such as in the Democratic Republic of Congo and Costa Rica. This initiative is expected to bring new lessons and insights into MRV so as to make the REDD+ mechanism more robust.

In this paper, I bring some of the ideas to bridge the gap between the principles and practices of MRV by taking a case of a Terai Arc Landscape (TAL) programme of Nepal, a sub-national-level proposed project. The paper demonstrates how the institutional mechanism for MRV can be designed and practiced at the national level considering national circumstances and existing institutions. Also, the cost effectiveness and transparency of MRV process are identified as important elements.

APPROACHES TO MRV

Generally, both the NFMS and MRV framework should be designed to oversee the national forest cover and land use change over time. The MRV process can be made easier using various statistical and analytical tools and Geographic Information System (GIS) software that convert data into desired form. Examples of some tools include Arc-GIS, E-cognition, Forest Canopy Density Mapper (FCD), Normalized Differential Fractional Index (NDFI), Google Earth, LiDAR Assisted Multisource Programme (LAMP), Participatory Rural Appraisal (PRA), surveys and grievance mechanisms.

Individual countries can also develop a sub-national project based on national circumstances to start or test the functionality of NFMS and MRV mechanisms. To start with the choice of project area, the country will have to look into the forest and non-forest cover in the proposed area, forest classes based on national forest inventory, forest cover change (both positive and negative) in that area within a span of time and emission factors for the change in forest cover so as to integrate them with the NFMS and MRV framework.

PRINCIPLES AND NEED BEHIND MRV

Monitoring

Monitoring systems are the physical and technical methods used to generate forest cover data, to provide information on non-forest area and to detect land use changes. The information collected from the national forest monitoring process is the primary data source and should be a derivative of or coherent with the national forest inventory process. These data are, therefore, critical for overall accuracy and precision of the MRV system, as well as for developing a reference scenario. Therefore, the

NFMS needs to be comprehensive enough to allow the tracking of all forest classes within the country, as well as sensitive enough to be able to detect forest presence/absence based on how forest has been defined.

Developing NFMS needs to be done integrating two ways: (i) *indirectly* using remote sensing technologies (e.g. satellite-based time series images or airborne detectors) and other ancillary -data (e.g. maps, historical records); and (ii) *directly* using the ground crew to collect field data. In both cases, data should be comprehensive enough to allow monitoring of all forests in the country as well as sensitive enough to detect changes in forest cover according to the country's definition of forests. Some of the relevant concepts and practical considerations regarding both systems are briefly described below.

Remote Sensing Technologies

Over the past decade, ranges of free and paid satellite technologies have become available for forest monitoring. The choice of remote sensing data is driven by just a few key factors such as acquisition period and frequency, spatial resolution and spectral band as these factors have different impact on the data.

Acquisition period: The timeframe for which data are available is critical. Satellite data are ideally required over a continuous period for developing reference levels, which is generally done on the basis of historical deforestation and associated emissions and for monitoring of forest dynamics in the future.

Acquisition frequency: Satellite data is typically not continuous; therefore, the time period between images capture is a key factor in the choice of remote sensing technologies.

Spatial resolution: The spatial resolution of remote sensing systems ranges from sub-meter (e.g. Quickbird, Pleiades) up to sub-kilometre (e.g. MODIS). Common wisdom says higher resolution associates with better quality of data as we get to 'see the forest'. However, this often comes with a trade-off in cost, processing time, storage space and in some cases acquisition frequency and spectral resolution. Low-resolution Landsat images are also available free of cost and have the advantage of more spectral bands.

Spectral bands: Perhaps the most important consideration for remote sensing is the bandwidth or frequency of image detection system. Different bandwidths allow for different land use and forest characteristics to be measured (e.g. biophysical parameters of vegetation such as chlorophyll content and humidity), as well as offering other benefits (e.g. cloud penetration).

Field Data

Field plots are the second cornerstones of forest monitoring system (WWF 2010). Forest cover data generated via remote sensing sources need field validation to enhance and calibrate the quality of monitoring system, a process that is often referred to as 'ground-truthing'. Deriving activity and/or forest cover change data and ground-truthing via fieldwork are iterative processes allowing constant enhancement of accuracy in a monitoring system. As accuracy, cost and time of field measurements are some of the key components of the overall forest monitoring system, selection of field sites through stratification and sampling is essential to enhance accuracy in shorter time and lesser cost.

Stratification: Before any field measurements are taken, forests need to be stratified into reasonably homogeneous types so that relatively small numbers of sample plots laid out become representative of the entire strata. Those strata can be derived either from remote sensing or from other ancillary data. The quality of stratification would be a key determinant for the degree of accuracy in carbon estimates. In practice, generally two-step stratification is recommended: (i) a preliminary stratification with sample field plots to assess how estimates behave statistically and (ii) ideal sample sizes (e.g. number of plots needed) and/or strata are generated based on initial estimates. It is a common practice to base such stratification on a combination of factors, including forest type, soil type, topography, eco-region and so forth. In order to optimize logistical resources, it is advisable to incorporate additional factors into the stratification approach such as likelihood of deforestation in a given area. If the areas are most likely to produce emissions, higher accuracies are desired.

Sampling: Once the stratification is completed, field measurements can be taken from sample plots within the strata. The number of samples depends on the level of certainty needed for the MRV system, which in turn depends on heterogeneity within the individual strata and the number of strata. Various tools that can be used for this process are available, e.g. Winrock Sampling Calculator (Winrock International 2013). If very large numbers of samples are required for a given stratum because of large variance in forest data, a reassessment of stratification may be needed to make more homogeneous strata.

Carbon Pools

Typically field measurements of carbon pool follow a standardized approach. Since field measurements are the primary source of data to estimate forest carbon, key data need to be collected. The IPCC has identified above-ground biomass (AGB), below-ground biomass (BGB), dead wood and litter (DOM) and soil organic matter (SOC) as carbon pools that the parties in the UNFCCC are encouraged to report against. Therefore, during field measurement practitioners need to gather data across all of these pools. In some cases, assessing all these pools is not possible and, therefore, only the most relevant pools are assessed. Usually, the most significant pool in terms of carbon fluxes is AGB, i.e. tree biomass[1]. Direct measurement of AGB would mean felling trees and drying them to measure biomass and, thereby, carbon content. This is an expensive process, and is often neither possible nor desirable. Therefore, it is often advisable to rely on estimates of AGB derived through allometric equations (see measuring for more detail) that are based on the correlation between measured variables with tree volume and hence biomass.

Community Based Forest Monitoring

Communities can play an important role in NFMS, including MRV. Studies have clearly established (Danielsen *et al.* 2010) that data collected by communities on the ground are comparable with those collected by trained scientists. Examples of tools that can help incorporate communities in forest monitoring activities include the Geo-Wiki project with its biomass branch (Geowiki 2013; Bottcher *et al.* 2009) and Google's Open Data Kit.

Measuring

Measuring is the physical process of accounting carbon stock in different carbon pools as decided by a country and may include any of the five carbon pools using appropriate technologies such as ground-based inventory or air-borne laser scanning or a combination of both, as appropriate. The IPCC Good Practice Guidelines (GPG) for LULUCF defines measurement system as the continuous collection of data on anthropogenic forest-related GHG emissions by sources and removals by sinks, forest carbon stocks and forest area changes. The purpose of the measurement is to convert information from forest monitoring

[1] This is not always the case, e.g. in peat swamps BGB is the dominant source of carbon fluxes.

systems into the emissions reductions and removals that result.

Deriving Carbon Estimates

The first step in converting forest monitoring data into reportable measurements expressed in ton CO_2 equivalent (tCO_2e) is to use allometric equations to estimate carbon content in individual trees. Allometric equations can either be a set of predefined equations based on general species types and forest compositions, or be specifically tailored to a particular forest area developed using local measurements and even destructive sampling of forest areas. The latter approach, however, is both costly and environmentally degrading as it requires destruction of a representative number of trees for a given forest type[2]. In any case, the difficulties involved with carrying destructive sampling and developing new specific allometric equations mean predefined equations are often used to estimate forest carbon stocks.

The IPCC has established a system of three-tier levels for the estimation of biomass: tier one uses generic equations and data; tier two uses generic equations but uses data acquired at national level by means of a national forest inventory; and tier three uses both nationally produced allometric equations and national field data. It is assumed that as tier levels increase, the accuracy of our estimates also increases (IPCC 2003).

From Plots to a Carbon Map

The second stage under measuring is to scale up plot estimates of forest carbon to the jurisdictional or national or sub-national level that use remote sensing and ancillary data. The most common and simple approach is to average plot data across each of the forest strata[3] to estimate forest carbon content, including error estimates. This redoubles the importance of accurately mapped forest strata since poorly defined strata lead to large variance in forest carbon estimates and, therefore, to large confidence intervals.

When plot data are not sufficient, relationships between plot data and other independently collected variables (e.g. tree height, canopy density, elevation and NDFI) may be used. These variables are often derived from remote sensing data or other ancillary data (e.g. topography and elevation maps). Examples of synergies between plot data, canopy and other datasets are currently being explored in some cases. For example, remote sensing high spatial resolution data like Rapid Eye and Light Detection and Ranging – LiDAR is being used (to estimate tree height) for the ongoing Forest Resource Assessment project in Nepal. The feasibility of using such synergies has been established (Asner *et al.* 2012) elsewhere. These datasets, however, can also be technologically demanding and expensive to obtain in terms of the total forest coverage of large countries.

Reporting

Reporting is the process of combining data from NFMS and measured carbon stocks from appropriate pools in a complete, transparent and accountable manner and providing information to all national and international shareholders, including the UNFCCC, UN systems and agencies, bilateral and multilateral agencies, national entities, international/national non-governmental organizations (I/NGOs), local communities, indigenous people, civil society organizations (CSOs), research institutions and academia. Reporting also entails information on reference levels, drivers of deforestation and forest degradation, implementation and monitoring of safeguards and non-carbon benefits. It needs to be done transparently, consistently, accurately and with reduced uncertainties that ensure capturing verifiable processes and methodologies.

[2] This type of data can be gathered from forest management concessions; however, this approach limits the scope to commercial species only.
[3] Identified in the stratification process.

Reporting requirements for REDD+ differ depending on the level (national or sub-national) at which REDD+ is implemented. However, only the reporting requirements for national-level REDD+ implementation are discussed here. The national reporting is data-intensive and, therefore, many countries may need expanding their technical capacity on forest carbon measurements, particularly when a country chooses a stepwise approach through various tiers. As developed by different organizations, the countries should develop online interface systems to manage the data. Depending on the level of advancement in reporting systems, they should provide information on carbon stock and land cover changes. Ground survey requirements for these types of information are extremely high, and may only be practical over relatively small, homogeneous, or well-known areas. Countries need to have a proper information collection and analysis system to undertake reporting effectively. Effective reporting should account for all technical and social issues of concerns, including drivers of deforestation and forest degradation, safeguards and non-carbon benefits.

Verification

Verification is the process whereby an independent third party with the right technical skills is able to crosscheck, examine and validate the information reported regarding emissions reductions so that the country can claim performance-based payments ensuring there is no conflict of interest. According to the agreement made under the UNFCCC, verifications for REDD+ process probably go through the International Consultation and Analysis (ICA) process, which is not through the verifiers or auditors of verifying companies accredited by the UNFCCC, as followed in the Clean Development Mechanism (CDM) projects. The ICA process consists of two steps. First, a *technical analysis* of Biennial Update Reports (BURs) prepared by a team of technical experts in consultation with the Party, resulting in a summary report. The information considered should include the national GHG inventory report; Nationally Appropriate Mitigation Action (NAMAs), their impacts and progress made in their implementation. Second, a *facilitative sharing of views*, which will have BUR as input and summary report referred above.

MRV CASE IN NEPAL

Nepal was one of the applicants for REDD+ as a participant country in the Forest Carbon Partnership Facility (FCPF) under the World Bank in 2008 through a Readiness Project Idea Note (R-PIN). Upon the approval of the R-PIN, the Bank invited Government of Nepal (GoN) for submitting a Readiness Preparation Proposal (RPP). With the approval of RPP, GoN received a funding of US$3.4 million for implementing it. With this grant, the REDD, Forestry and Climate Change Cell (REDD cell) under the Ministry of Forests and Soil Conservation (MoFSC) is currently developing an MRV framework.

More specifically, the GoN is currently developing a sub-national level Emissions Reduction Project Idea Note (ER-PIN) for Terai Arc Landscape (TAL), covering 12 districts, for submission to the FCPF. Though the process is outside of the UNFCCC process, it is expected to bring important lessons for the preparation and implementation of REDD+ projects in the future. The Department of Forest Research and Survey (DFRS) is the supporting agency for the MRV process in the project. The measurement in the project area will be carried out using ground plots and LiDAR. Landsat and Rapid Eye images will be used for analysis. Five carbon pools will be considered and measured using local resource persons and government staff supported by the World Wide Fund for Nature (WWF)–Nepal at field level. Moreover, WWF Nepal is now technically supporting the development of a reference level. Based on the reference level and the emissions reduced from deforestation and forest degradation and carbon stored from conservation, enhancement and sustainable management of forests, GoN, on behalf of the project, can claim payments for its performance till 2020. The emission reductions need to be reported along with the drivers of deforestation and forest degradation, safeguards and non-carbon benefits by the project. The report will be subjected to verification by an independent third party prior to release of payments. However, verification for this project will not be under the ICA.

DISCUSSION

The GoN is in the process of developing an MRV framework. In this context, a proposed framework is given below, which still needs further clarification through discussion (Figure 1).

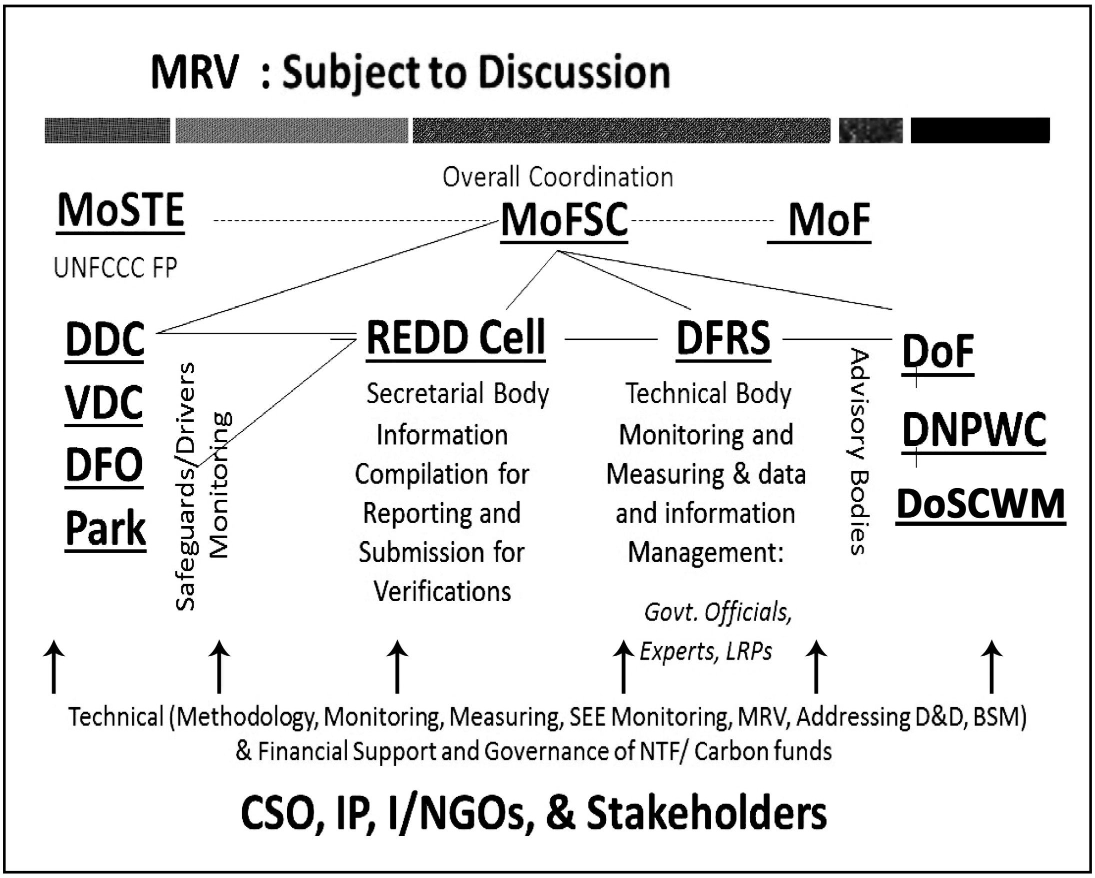

Figure 1: Proposed MRV framework

According to the framework, the overall coordination role is to be played by the MoFSC, while the Ministry of Science, Technology and Environment (MoSTE) acts as the nodal agency for the UNFCCC processes and the Ministry of Finance (MoF) takes care of the carbon financing part.

The REDD cell will be playing the secretarial role in the implementation of the REDD+ project and will be responsible for the overall compilation of data and information regarding reference level, emissions reduction, drivers of deforestation and forest degradation, safeguards, and non-carbon benefits and, therefore, will report all necessary information needed for verification. The REDD cell will be supported by the DFRS for monitoring and measuring data and conducting all remote sensing and ground measurement work. Furthermore, the Department of Forest (DoF), Department of National Parks and Wildlife Conservation (DNPWC), Department of Soil Conservation and Watershed Management (DoSCWM) and other organizations will be providing advisory support at the central level, whereas the District Forest Office (DFO), national park offices, District Development Committees (DDC), Village Development Committees (VDC) and other local line agencies will be supporting in terms of addressing the drivers of deforestation and forest degradation at the local level. Finally, other than government line agencies, CSOs, indigenous people, I/NGOs and other stakeholders may play a supportive role in the implementation of the MRV system. However, care should be given to ensure the accuracy, time and cost of the overall MRV system. In the context of designing an MRV framework and its implementation, it will be very important to ensure the cost effectiveness. If this is not taken into account, most of the payments received may result in the expenditure during the MRV process and nominal amount of money will be retained with the actual beneficiaries of REDD+, i.e. the local communities.

CONCLUDING REMARKS

Generally, the governments of participating countries take the responsibility in designing an MRV framework and mechanisms. However, the governments are not the only entity to be involved in the overall MRV process; rather, they need to engage a broad range of stakeholders and maintain transparency in the process of development and implementation of the MRV framework. The stakeholders for MRV include local communities, indigenous peoples, women groups, youth groups, representatives of different government agencies, CSOs, I/NGOs and academia. Finally, it is important to look into the cost effectiveness and transparency issues of designing and implementing MRV framework. This is particularly important to reduce uncertainties and unnecessary costs. The framework also needs to provide adequate and appropriate space for spatial analysis over time so as to monitor, report and verify the carbon emissions and the changes in deforestation, forest degradation, carbon stock enhancement and re-growth of forest.

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