



Food and Agriculture
Organization of the
United Nations

Strengthening National Forest Monitoring Systems for REDD+



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“This publication is dedicated to the memory of Joe Pokana. (Pictured in the far right of the photo below.) A true pioneer of REDD+ in Papua New Guinea, and a friend to many.”



Acronyms

96GL	Revised 1996 <i>IPCC guidelines for national greenhouse gas inventories</i>
2006GL	<i>IPCC guidelines for national greenhouse gas inventories (2006)</i>
AD	Activity Data
AFOLU	Agriculture, Forestry and Other Land Use
AGB	Above-Ground Biomass
BC3	Basque Centre for Climate Change
BGB	Below-Ground Biomass
BUR	Biennial Update Report
COP	Conference of the Parties
DOM	Dissolved Organic Matter
FAO	Food and Agriculture Organization of the United Nations
FCPF	World Bank Forest Carbon Partnership Facility
FRA	Global Forest Resource Assessment
FREL	Forest Reference Emission Level
FRL	Forest Reference Level
GCF	Green Climate Fund
GFOI	Global Forest Observations Initiative
GHG	Greenhouse Gas/Gases
GHGI	Greenhouse Gas Inventory
GIS	Geographic Information System
GPG2000	<i>IPCC good practice guidance and uncertainty management in national greenhouse gas inventories (2000)</i>
GPG2003	<i>IPCC good practice guidance for land use, land-use change and forestry (2003)</i>
ICA	International Consultation and Analysis
ILUA	Integrated Land Use Assessment

IPCC	Intergovernmental Panel on Climate Change
KCA	Key Category Analysis
LULUCF	Land Use, Land-Use Change and Forestry
MGD	Methods and Guidance Document
MRV	Measurement, Reporting and Verification
NC	National Communication
NDC	Nationally Determined Contribution
NFI	National Forest Inventory
NFMA	National Forest Monitoring and Assessment
NFMS	National Forest Monitoring System
QA/QC	Quality Assurance/Quality Control
REDD+	Reducing Emissions from Deforestation and Forest Degradation (Conservation of Forest Carbon Stocks, Sustainable Management of Forests, and Enhancement of Forest Carbon Stocks)
SBSTA	UNFCCC Subsidiary Body for Scientific and Technological Advice
SEPAL	Cloud-based Earth Observation image-processing platform
SIS	Safeguards Information System
SLMS	Satellite Land Monitoring System
SOC	Soil Organic Carbon
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UN-REDD	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (participating organizations FAO, UNDP and UNEP)
VGNFM	<i>Voluntary guidelines on national forest monitoring</i>

Executive summary

The Food and Agriculture Organization of the United Nations (FAO) has been providing support to member countries on national forest monitoring for decades. Best practices and lessons learned from this support are summarized in FAO's *Voluntary guidelines on national forest monitoring* (VGNFM). The guidelines provide principles, elements and best practices for the establishment and implementation of a multipurpose National Forest Monitoring System (NFMS).

The aim of this paper is to strengthen the elements and guidelines provided in the VGNFM in the context of Reducing Emissions from Deforestation and Forest Degradation (REDD+). It also includes a deeper analysis of the United Nations Framework Convention on Climate Change decisions and the most recent methodological recommendations provided by the Intergovernmental Panel on Climate Change, focusing on the three pillars of an NFMS for REDD+: a Satellite Land Monitoring System, a National Forest Inventory, and REDD+ reporting, including the combination of remote-sensing and ground-based forest inventory to estimate anthropogenic forest-related Greenhouse Gas emissions by sources and removals by sinks. Section 4 includes six country case studies of FAO support for NFMS in REDD+ Measurement, Reporting and Verification in the context of results-based payments. Finally, specific actions and recommendations are provided that countries can follow towards the implementation of a multipurpose NFMS, in the context of REDD+.



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1. Introduction

The future vitality of the world's forests, and the globally significant environmental services they provide, are increasingly under threat from human activities. Not only do these activities have negative impacts on biodiversity and hydrological services, they also contribute to global climate change. Global forest cover loss is addressed under a range of international agreements and conventions, including the UNFCCC which has specific provisions for REDD+ (Reducing Emissions from Deforestation and Forest Degradation) and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries.

REDD+ activities have the potential to mitigate between 10 percent and 12 percent of annual global Greenhouse Gas (GHG) emissions through voluntary action by developing countries in their land-use sectors. Reduced emissions/increased removals are supported by results-based payments if a National Forest Monitoring System (NFMS) provides information that is transparent, consistent and suitable for MRV forest-related GHG emissions/removals estimates as a result of implementing REDD+ activities. FAO has been providing support on all aspects of national forest monitoring for many years. Launched in 2017, *Voluntary guidelines on national forest monitoring* provides principles, elements and best practices for the establishment and implementation of a multipurpose NFMS (FAO, 2017d). Establishment of a robust and sustainable NFMS requires institutional and technical capacities to be enhanced at national level. An NFMS also serves many forest monitoring purposes –



both to support domestic policy-making and to report on other international processes. Figure 1 provides the core elements of an NFMS (FAO, 2017d). This paper aims to strengthen the elements and guidelines provided in the VGNFM, in the context of REDD+.

FAO promotes multipurpose NFMSs, one objective of which is REDD+ reporting. Thus, FAO also assists countries to participate in results-based payments for REDD+ by supporting their efforts to construct the systems and establish the capacity that is necessary for REDD+ MRV. FAO is aware of the importance of building upon existing systems and capacities. A sustainable and reliable NFMS requires the development of technical and functional capacities for Satellite Land Monitoring Systems (SLMSs) and National Forest Inventories (NFIs) which often already exist in more or less developed form, and a good understanding and knowledge of estimation methods consistent with national Greenhouse Gas Inventory (GHGI) systems and IPCC guidelines.

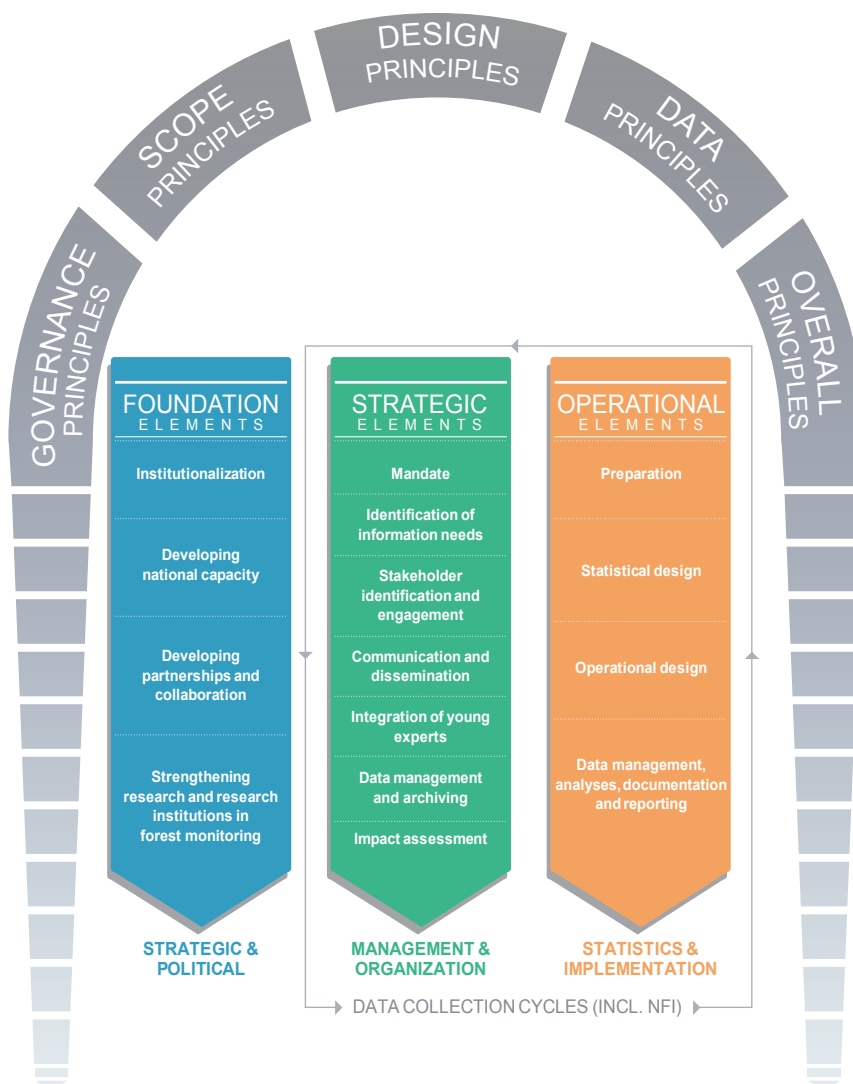


Figure 1. Core elements of a National Forest Monitoring System

2. REDD+ implementation concepts

2.1. Overview of REDD+ decisions of the UNFCCC

Negotiations on REDD+ have been part of the UNFCCC for over a decade and begun in the 11th session of the UNFCCC Conference of the Parties (COP, Montreal 2005), where the concept was first raised as an agenda item that later initiated a two-year process under the UNFCCC's Subsidiary Body for Scientific and Technological Advice (SBSTA). This led to the introduction, of what is now termed REDD+, as part of the Bali Action Plan at COP 13 in 2007.

Since then, REDD+ has been strengthened and consolidated through the COP negotiations culminating in the UNFCCC Warsaw Framework for REDD+ which established MRV modalities as they apply to REDD+ (Box 1).

Countries opting to voluntarily report reduced emissions and enhanced removals as a result of the implementation of REDD+ activities in the context of results-based payments may adopt a phased approach to establishing, according to national circumstances and capabilities, robust and transparent NFMS and, if appropriate, subnational systems as part of a NFMS that, in the context of REDD+:

- use a combination of remote-sensing and ground-based forest carbon inventory approaches for estimating anthropogenic forest-related GHG emissions by sources and removals by sinks, forest carbon stocks and forest area changes;
- provide estimates that are consistent, accurate (as far as practicable), and that reduce uncertainties, taking into account national capabilities and capacities;
- are transparent and their results are available and suitable for review, as agreed by the UNFCCC COP.

To achieve this, countries should follow the most recent methodological recommendations issued by the IPCC, as adopted or encouraged by the COP, as a basis for estimating the sources of anthropogenic GHG emissions, their removal by sinks, and for measuring carbon stocks and changes in forest area. Countries are also encouraged to take a stepwise approach towards the development of their Forest Reference (Emission) Level and the systems for REDD+.

2.2. REDD+ in three phases

Given the technical and procedural complexity involved in the implementation of REDD+ activities, the following phased implementation approach is outlined in UNFCCC decisions.¹

- development of national strategies or action plans, policies and measures, and capacity-building (Phase 1);
- implementation of national policies and measures, and national strategies or action plans that could involve further capacity-building, technology development and transfer, and results-based demonstration activities (Phase 2);
- results-based actions that should be fully measured, reported and verified (Phase 3).

The importance of national circumstances for the implementation of REDD+ activities, in the context of the phased approach, should be noted.²

¹ Decision 1/CP.16, paragraph 73: "Decides that the activities undertaken by Parties ... should be implemented in phases, beginning with the development of national strategies or action plans, policies and measures, and capacity-building, followed by the implementation of national policies and measures and national strategies or action plans that could involve further capacity-building, technology development and transfer and results-based demonstration activities, and evolving into results-based actions that should be fully measured, reported and verified".

² Decision 1/CP.16, paragraph 74: "Recognizes that the implementation of the [REDD+] activities ... including the choice of a starting phase as referred to in paragraph 73 above, depends on the specific national circumstances, capacities and capabilities of each developing country Party and the level of support received".

Box 1

Overview of key decisions relevant to REDD+ since 2007

COP 13, 2007	2/CP.13 Reducing emissions from deforestation in developing countries: approaches to stimulate action.
COP 15, 2009	4/CP.15 Methodological guidance for activities relating to reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries.
COP 16, 2010	1/CP.16 The Cancún Agreements: Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention.
COP 17, 2011	<p>2/CP.17 Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention.</p> <p>12/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 as referred to in Decision 1/CP.16.</p>
COP 18, 2012	1/CP.18 Agreed outcome pursuant to the Bali Action Plan.
COP 19, 2013	<p>9/CP.19 Work programme on results-based finance to progress the full implementation of the activities referred to in Decision 1/CP.16, paragraph 70.</p> <p>10/CP.19 Coordination of support for the implementation of activities in relation to mitigation actions in the forest sector by developing countries, including institutional arrangements.</p> <p>11/CP.19 Modalities for national forest monitoring systems.</p> <p>12/CP.19 The timing and the frequency of presentations of the summary of information on how all the safeguards referred to in Decision 1/CP.16, Appendix I, are being addressed and respected.</p> <p>13/CP.19 Guidelines and procedures for the technical assessment of submissions from Parties on proposed forest reference emission levels and/or forest reference levels.</p> <p>14/CP.19 Modalities for measuring, reporting and verifying.</p> <p>15/CP.19 Addressing the drivers of deforestation and forest degradation.</p>
COP 21, 2015	<p>16/CP.21 Alternative policy approaches, such as joint mitigation and adaptation approaches for the integral and sustainable management of forests.</p> <p>17/CP.21 Further guidance on ensuring transparency, consistency, safeguards referred to in Decision 1/CP.16, Appendix I, are being addressed and respected.</p> <p>18/CP.21 Methodological issues related to non-carbon benefits resulting from the implementation of the activities referred to in Decision 1/CP.16, paragraph 70.</p>

2.2.1. Phase 1 – REDD+ readiness

Phase 1 includes all the efforts required to define a national REDD+ strategy, including the policies and measures that a country will need to implement in the context of REDD+ activities, and the concomitant capacity-building needs. This phase also includes the definition and selection of the elements underpinning the NFMS, and the testing and selection of methodologies for reliable, robust and transparent national MRV functions. Phase 1 is often referred to as REDD+ readiness and should also include a Safeguards Information System (SIS) which demonstrates that the Cancun safeguards are being respected.

2.2.2. Phase 2 – REDD+ readiness and implementation

Phase 2 entails implementing demonstration activities to test and refine the methodologies, action plans and policies and measures defined during Phase 1. Demonstration activities focus on establishing whether the policies and measures can produce positive and measurable results in terms of GHG emissions and removals. They may focus on monitoring and reporting at the subnational level as an interim measure,³ and be used to test potential NFMS applications at both the national and sub-national scales.

2.2.3. Phase 3 – REDD+ implementation and results-based payments

During Phase 3 the NFMS should enable national-level MRV to demonstrate the effectiveness of policies and measures in the context of results-based payments. For consistency, data obtained from the NFMS should be used consistently in all UNFCCC reporting efforts.

In Phase 3, REDD+ MRV will be fully operational, allowing countries to report the mitigation performance of REDD+ activities at a national scale (in terms of tonnes of carbon dioxide equivalent/year), using a combination of remote-sensing and ground-based forest carbon inventories.⁴ This performance can be voluntarily reported to the UNFCCC Secretariat in the context of results-based payments in an annex to the Parties' Biennial Update Report (BUR) (see Section 2.4).

2.3. National Forest Monitoring Systems

National forest monitoring is a comprehensive process that includes the assessment, evaluation, interpretation and reporting of data and the derivation of information, usually from repeated inventories (of both remote-sensing and ground data) that allow for the monitoring of change and trends over time, and NFMS comprises the people, institutions and resources to implement an NFMS at country level in collaboration with other stakeholders. An NFMS is led by a governing body responsible for its conceptualization, planning and execution within a clear and well-defined mandate, based on the principles and elements of the voluntary guidelines (FAO, 2017d). When establishing an NFMS, countries should, where possible, build on existing systems to make effective use of resources. The NFMS should be capable of providing data that are transparent and consistent over time, and suitable for MRV (see Section 2.4), including some or all of the following design decisions, in the context of REDD+:

- data collection, analysis, Quality Assurance/Quality Control (QA/QC)⁵ (see Box 2) and archiving processes;
- forest definition and stratification descriptions for consistent representation of land;
- consistency in estimation methods, approaches and tiers between FREL/FRL, REDD+ reporting and GHGI reporting.

In an NFMS, information comes from different sources, however, sample-based field observations and remotely sensed data are commonly the most important data sources in forest monitoring (FAO, 2017d). The VGNFM promotes the integration of field and remote-sensing data, as summarized in Figure 2.

³ As specified in Decision 1/CP.16, paragraph 71(c).

⁴ Decision 4/CP.15, paragraph 1(d).

⁵ QA refers to review and audit procedures conducted by personnel not actively involved in the inventory development process, while QC is implemented by inventory development personnel to measure and control the quality of the inventory as it is being developed (IPCC, 2006).

Box 2

Quality Assurance and Quality Control

It is important to be able to determine the quality of measures taken in the field, as well as the quality of assimilation and analysis of data, in order to estimate uncertainty and improve future measures.

For the NFMS, the VGNFM provides some operational recommendations on data management, data analysis, documentation and reporting. After data are collected, they must be safely and permanently stored to ensure they are easily accessible for reference and further analyses. Permanence of data availability is one of the constituent elements of an efficient NFMS. Quality control should be systematically carried out before analysis, based on the field data collection methodology. Before any analysis is performed it is important to enact a final data quality check (FAO, 2017d).

In addition, QA and QC procedures for the GHGIs are provided by the IPCC (IPCC, 2003; 2006). QC procedures are internal to inventory preparation, whereas QA consists of an external (independent) control of the quality of reported estimates. The UNFCCC Secretariat, through its roster of experts, could carry out periodical reviews of the methods used and the figures reported by countries in their national GHGIs and through the Biennial Update Report (BUR) process. This could be seen as the verification component of MRV function of the NFMS, and is separate to QA/QC procedures.

Recommendations for QA and QC:

- assess which internal procedures are necessary to gradually establish quality controls in order to comply with the IPCC recommendations on GHGIs;
- assess which procedures are necessary to establish an independent view that will form the basis of quality assurance, in order to comply with the IPCC recommendations on GHG;
- consider implementing these procedures.

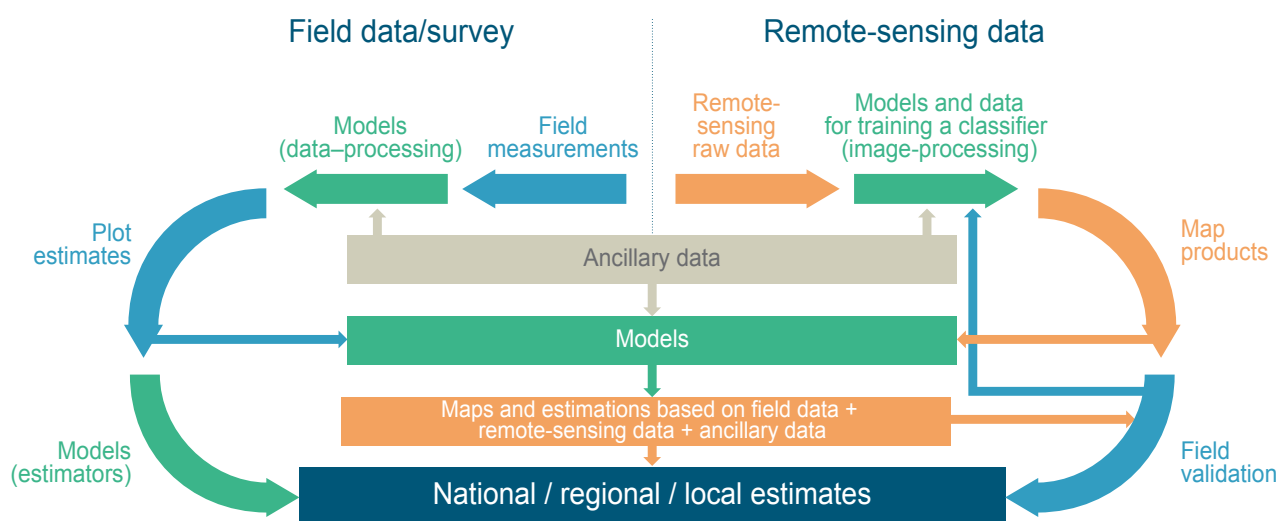


Figure 2: Major processing steps for data from field and remote-sensing sources and their typical integration into NFM (Source: FAO, 2017d)

The integration of field and remote-sensing data is also promoted in the framework of the COP, with an emphasis on providing estimates that are transparent, consistent and accurate (as far as possible). Estimates should reduce uncertainties, taking into account national capabilities and capacities; with results that are available and suitable for review.⁶ Should countries choose to voluntarily report REDD+ activities, their NFMS can support the MRV process, through data provision to demonstrate impacts and outcomes of national mitigation policies and measures.

An NFMS includes data and information useful to provide historical emissions estimations from forests which may form the basis for national or interim subnational Forest Reference Emission Levels and/or Forest Reference Levels (FRELs/FRLs) (see Box 3). The FREL/FRL is a benchmark for assessing results of REDD+ implementation.

⁶ NFMS characteristics in the context of REDD+ activities are described in *Decisions 4/cp.15* and *11/CP.19*.

Box 3

Forest Reference Emission Levels/Forest Reference Levels

FREs/FRLs are benchmarks for assessing countries' performance in implementing REDD+ activities. Countries implementing REDD+ activities under the UNFCCC will need to develop their FREs/FRLs and submit them to the UNFCCC. These will then be used to measure the country's emission reductions as a result of the implementation of the REDD+ strategy.

The first UNFCCC guidance on FREs/FRLs was provided in Decision 4/CP.15, which recognized that FREs/FRLs should be transparent, take historical data into account, and be adjusted for national circumstances. Subsequently, decision 1/CP.16 identified national FREs/FRLs as an essential prerequisite for Parties aiming to undertake REDD+ activities, with subnational FREs/FRLs as a possible interim measure. The most comprehensive guidance on FREs/FRLs emerged from COP 17 (Durban, 2011), indicating that:

- FREL/FRLs expressed in tonnes of carbon dioxide equivalent per year are benchmarks for assessing each country's performance in implementing REDD+ activities;
- FREs/FRLs should maintain consistency with anthropogenic forest-related GHG emissions by sources and removals by sinks as contained in each country's GHGI;¹
- Parties are invited to submit information explaining how their FREs/FRLs were developed, including how national circumstances were considered;
- Parties can consider a stepwise approach to the development of FREs/FRLs to enable the incorporation of improved data and methodologies; and
- subnational FREs/FRLs may be elaborated as an interim measure, while transitioning to a national forest reference emission level and/or forest reference level, and that interim FREs and/or FRLs of a party may cover less than its entire national territory of forest area.

The annex to Decision 13/CP.19 covers elements that Parties should present in their FREL/FRL: in summary, transparent, complete,² consistent and accurate information on:

- the data, approaches, methods, models (if applicable) and assumptions used in the construction of the FREL/FRL;
- consistency with corresponding anthropogenic forest-related GHG emissions by sources and removals by sinks between the FREL/FRL and the national GHGI;
- how historical data have been taken into account in the establishment of the FREL/FRL;
- relevant policies and plans, as appropriate;
- changes to any previously submitted FREL/FRL, taking into account the stepwise approach;
- pools and gases, and activities included in the FREL/FRL, and justification of why omitted pools and/or activities were deemed not significant;
- the definition of forest used, and why and how the definition used was chosen;
- coverage of the forest area (i.e. national or less than the entire forest area);
- assumptions about future changes to domestic policies have been included in the construction of the FREL/FRL.

For more specific information on FREs, see UN-REDD (2015) and FAO (2017c).

¹ Paragraph 8 of Decision 12/CP.17 says that consistency between FREs and FRLs and national GHGIs should be maintained.

² Complete here means the provision of information that allows for the reconstruction of the FREs and/or FRLs.

NFMS functions will ultimately depend on national circumstances. These may include working with national policy-makers to choose REDD+ activities under consideration; associated data requirements; identifying existing data and any data-acquisition needs; and providing information relevant to the SIS.

Establishing an NFMS may involve engaging with a range of stakeholders, including national authorities with responsibilities for forest land,⁷ agencies responsible for collecting national data such as the NFI or census information, or agencies responsible for estimating forest-related emissions and removals for the national

⁷ Such agencies could include those responsible for forestry, agriculture and the environment.

GHGI. Stakeholders, including community representatives and the private sector, should at all times be included in the development of the NFMS.

FAO supports countries in establishing an NFMS based on the principles and guidelines provided in the VGNFM, and in the case of NFMS for REDD+, the following pillars are reinforced:

- Satellite Land Monitoring System (SLMS) (see Section 4.1.1);
- National Forest Inventory (NFI) (see Section 4.1.2);
- estimation of GHG emissions and removals (see Section 4.1.3).

2.4. Measurement, Reporting and Verification

In the context of voluntarily reporting REDD+ activities, MRV represents procedures, agreed by the UNFCCC, associated with the communication of mitigation actions where:

- Measuring is estimating the effect of the action in terms of emission reductions / removals;
- Reporting is the communication of the measured effect to the international community; and
- Verifying is checking the estimation methods and approaches of the measured and reported effect.

The measurement (M) component of the MRV function is the most intensive, in terms of information and labour, comprising the collection of national area-change data through an SLMS, implementation of an NFI, compilation of relevant data and the estimation of emissions and removals through a GHGI for the forest sector.

At the international level, REDD+ reporting (R) is implemented through the submission of a FREL/FRL which is the benchmark used to quantify emission reductions that are subsequently reported in an annex to a country's Biennial Update Report (BUR). Verification (V) is addressed through international consultation and analysis (ICA), which is a process designed to increase the transparency of mitigation actions and their effects while being non-intrusive, non-punitive and respectful of national sovereignty.⁸

In the context of REDD+ results-based payment, ICA (Box 4) leads to the technical assessment of submitted FREL/FRL and the subsequent technical analysis of the REDD+ annex to the BUR.

In addition to addressing external requirements, MRV processes can form part of internal Quality Assurance

Box 4 UNFCCC international consultation and analysis

The modalities and guidelines for conducting ICA were adopted in Durban (Annex iv to Decision 2/CP.17) and outline the requirements of the ICA process of the BURs (and any annexes). These requirements state that the ICA process:

- is non-intrusive, non-punitive and respectful of national sovereignty;
- aims to facilitate the universal participation of developing country Parties in the ICA process;
- aims to increase the transparency of mitigation actions and their effects;
- is a consultative approach through a facilitative sharing of views between the team of technical experts and the Party;
- does not include discussion on the appropriateness of domestic policies and measures;
- will result in a summary report.

In the context of REDD+ results-based payments, the ICA principles apply to the technical assessment of the BUR and may also be relevant to the FREL/FRL TA.

Notes: The purpose of transparent action is to provide the UNFCCC with a clear understanding of actions being taken by Parties, including clarity and tracking of progress towards achieving Parties' Nationally Determined Contributions (NDCs). See Article 13 of the Paris Agreement.

More information: <http://redd.unfccc.int/>

⁸ See Decision 2/CP.17, annex IV, and 20/CP.19.

and Quality Control programmes and provide useful experience for the consideration of prioritizing stepwise improvements.

The elements measured, reported and verified under the current UNFCCC MRV framework and the means through which this occurs, are summarized below (UNFCCC, 2014):

What is measured:

- GHG emissions by sources and removals by sinks;
- emission reductions (or enhancement of removals by sinks) associated with mitigation actions compared with a Technically Assessed FREL/FRL;
- progress in achieving climate change mitigation and adaptation (i.e. GHG emission reductions or enhancement of sinks and reduction in vulnerability), achievement of sustainable development goals and co-benefits;
- support received (finance, technology and capacity-building);
- progress with implementation of the mitigation actions.

What is reported:

- Forest Reference Emission Level/Forest Reference Level (FREL/FRL);⁹
- data on emission reductions (or enhancements of removals by sinks) associated with mitigation actions compared with the FREL/FRL (REDD+ annex to the BUR), which includes:
 - key assumptions and methodologies;
 - sustainability objectives, coverage, institutional arrangements;
 - information on constraints and gaps as well as support needed and received.

What is verified:

- all quantitative and qualitative information relating to the development of the FREL/FRL is subject to technical assessment;
- all quantitative and qualitative information relating to the REDD+ annex to the BUR is subject to technical analysis.



⁹ See 12/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 as referred to in Decision 1/CP.16.



3. Methodological guidance for National Forest Monitoring Systems in the context of REDD+

In 2011, the UNFCCC agreed¹⁰ that the *IPCC good practice guidelines (96GL)*, in conjunction with the *IPCC good practice guidance and uncertainty management in national greenhouse gas inventories (GPG2000)* and the *IPCC good practice guidance for land use, land-use change and forestry (GPG2003)*, should be used by developing countries for estimating and reporting anthropogenic emissions and removals (GFOI, 2016). Countries are encouraged to use scientific updates in the *2006 IPCC guidelines for national greenhouse gas inventories (2006GL)* and the *2013 wetlands supplement* within this framework.

Although guidance from the IPCC does consider deforestation in the Kyoto Protocol context,¹¹ in general it does not specifically identify REDD+ activities, as these were established after the relevant IPCC guidance and guidelines were written.

In addition to the IPCC good practice guidelines (see Box 5) and the Subsidiary Body for Scientific and Technological Advice (SBSTA), countries taking part in the REDD+ programme also receive guidance from the FAO VGNFM, which provides principles, elements and best practices for the establishment and

Box 5 IPCC concepts relating to land use, land-use change and forestry

The “managed” land proxy

Estimates of changes in carbon stocks (emissions and removals) are limited to land where these changes are induced by human activities. The IPCC suggests the use of the “managed” land concept as a proxy for human-induced emissions and removals in the LULUCF sector. When human activities are carried out on land that had previously not been used (i.e. “unmanaged” land), it immediately becomes classified as “managed” land.

Land-use categories

Once a country has divided its managed from its unmanaged land, it will have to further subdivide its national territory among the six land-use categories defined by the IPCC for reporting through a GHGI (IPCC, 2003; 2006): forest land, cropland, grassland, wetlands, settlements, other land.* These categories can subsequently be subdivided to reflect national circumstances.

The five carbon pools that describe the carbon cycle and carbon fluxes

The IPCC identifies five carbon pools: (i) Above-Ground Biomass (AGB); (ii) Below-Ground Biomass (BGB); (iii) dead wood; (iv) Dissolved Organic Matter (DOM); and (v) Soil Organic Carbon (SOC), which can be measured and reported as part of national GHGIs.

Parties are encouraged to report on significant carbon pools in a methodologically consistent manner, according to national circumstances.

Emissions and removals of carbon as a result of REDD+ activities can be created by either continuous processes (i.e. growth and decay) or discrete disturbance events (such as harvest, fire, land-use change). Continuous processes can affect all forest carbon stocks year after year, while disturbance events cause emissions (and in rare cases, uptake) and at the time of the event, and redistribute ecosystem carbon where the disturbance occurs. It is therefore important that the methodology selected to measure changes in carbon stocks is able to collect data for both continuous and discrete processes (cf. IPCC, 2006).

* See IPCC (2003, Ch. 3) or IPCC (2006, Vol. 4, Ch. 2) for a description of each category.

¹⁰ See Decision 4/CP.15 and Part III of Annex III to the Durban Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention (Decision 2/CP.17), developed countries will use the 2006GL (IPCC, 2006).

¹¹ See GPG2003 Section 4.2.6.

implementation of a multipurpose NFMS and the Methods and Guidance Document (MGD) of the Global Forest Observations Initiative¹² (GFOI, 2016). The MGD guide uses remotely sensed and ground-based data to estimate and report GHG emissions and removals associated with forests in a manner consistent with the GHGI guidance from IPCC.

3.1. Good practice guidance

Good practice is defined by the IPCC¹³ as applying to inventories that contain *neither over- nor under-estimates so far as can be judged, and in which uncertainties are reduced as far as practicable*. Although there is no predefined level of precision, this definition aims to maximize precision without introducing bias, given the level of resources reasonably available.

In the context of MRV for REDD+, good practice entails the following general principles:¹⁴

- transparency – documentation sufficient to assess the extent to which good practice requirements have been met; includes a clear description of input data, methods and assumptions;
- accuracy – delivered by the use of methods designed to produce neither under- nor over-estimates and reduce uncertainties so far as practicable – this addresses both accuracy and precision;
- completeness – the provision of sufficient information should allow for reconstruction of the results;¹⁵
- consistency – differences between years reflect differences in emissions or removals, not changes in methodology or data availability.



3.2. Key categories

Key Category Analysis (KCA) is IPCC's method for deciding which categories of emissions or removals to prioritize.¹⁶ A category is deemed to be *key* if, when categories are ordered by magnitude, it is one that is contributing cumulatively to 95 percent of total national emissions or removals; or to 95 percent cumulatively of the trend in national emissions or removals. As it is not known at the outset which categories are key, KCA may need to be iterative with the initial ordering undertaken using Tier 1 methods (see Section 3.3.2).

¹² GFOI is an initiative of the intergovernmental Group on Earth Observations that aims to foster the sustained availability of observations for National Forest Monitoring Systems. The GFOI Secretariat is hosted by FAO and its work is complementary to UN-REDD and other FAO programmes that support REDD+ capacity development and implementation.

¹³ See Section 1.3, GPG2003 (IPCC, 2003) or Section 3 in the overview in Vol. 1, 2006GL (IPCC, 2006).

¹⁴ The REDD+ MRV Decision 14/CP.19 refers to the IPCC good practice principles with the exception of comparability, as such this IPCC good practice principle does not directly apply to REDD+ countries.

¹⁵ It should be noted that GHGI only requires the inventory to be complete with regard to capturing all sources and sinks of emissions. On the other hand, REDD+ requires that countries share their entire process such that an independent party can recreate and validate their results.

¹⁶ A key category is one that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level, the trend, or the uncertainty in emissions and removals. Whenever the term key category is used, it includes both source and sink categories. See Vol. 1, Ch. 4, 2006GL (IPCC, 2006).

KCA¹⁷ can be used to determine if particular subcategories such as biomass, dead organic matter and soils¹⁸ are *significant*. Significant subcategories are those which contribute between 25 percent and 30 percent – at a minimum – of the emissions or removals in the parent category to which they belong. This does not mean that subcategories may be omitted, but for subcategories which are not significant in this sense, countries may use Tier 1 methods if country-specific data (Tiers 2 or 3) are not available. Identifying key subcategories assists in the allocation of resources to collect country-specific data and also focuses efforts to reduce uncertainties relating to these key subcategories.¹⁹

3.3. Approaches, methods and tiers of the IPCC guidance and guidelines

3.3.1. Approaches to generating Activity Data

According to GPG2003, Activity Data (AD)²⁰ are defined as data on the magnitude of human activity resulting in emissions or removals taking place during a given period of time. The IPCC proposes three “approaches” to generate AD when referring to land identification. These approaches are not presented hierarchically and are not mutually exclusive. National entities responsible for GHGI should select an approach according to national circumstances and capabilities.

Approach 1 represents land-use area totals within a defined spatial unit, which is often defined by administrative borders, such as a country, province or municipality. Approach 1 is not spatially explicit²¹ and simply uses net areas associated with land use. Only net changes in land-use area can be tracked within the boundaries of the spatial unit through time, following this approach. Consequently, the geographical location of each land-use change is not known, and the exact changes that occur between land uses cannot be ascertained and thus are not suitable for generating REDD+ estimates (GFOI, 2016).

Approach 2 provides an assessment of both the gross and net losses or gains of specific land uses and involves tracking of land conversions between categories, resulting in a non-spatially explicit land-use conversion matrix (i.e. the location of specific land-uses and land-use conversions are not known).

Approach 3 extends Approach 2, which involves tracking of land conversions between categories using spatially explicit land-use conversion information. Only Approach 3 allows the estimation of gross-net changes within a category, e.g. to detect deforestation followed by afforestation, and is derived from *sampling* and *wall-to-wall* mapping techniques (Box 6).

Box 6 Approach 3 considerations

Wall-to-wall (an analysis that covers the full spatial extent of forested areas), and sampling within the forest mask, are both reliable approaches for analysing forest area change at national scales. In both cases, estimates of the parameter of interest (forest change, for example) come from the use of a sampling approach (probability sample). Sampling approaches can be used alone or in conjunction with a corresponding wall-to-wall map to generate estimates.

Generally speaking, sampling in conjunction with a wall-to-wall map will require fewer sample points and produce estimates with lower standard errors than sampling strategies alone. Maps are also useful for many other land monitoring and management purposes (GFOI, 2016) for which sampling alone may not be suitable. This is something to consider when deciding whether to use sampling alone, or a combination of maps and sampling to generate area (change) estimates.

¹⁷ The decision trees provided by GPG2003 in Section 3.1.6 (IPCC, 2003).

¹⁸ See Table 3.1.3, p. 3.20 of GPG2003 (IPCC, 2003). For N₂O the subcategories used for KCA are fire, Soil Organic Carbon mineralization, nitrogen inputs and cultivation of organic soils. For CH₄ the subcategory is fire.

¹⁹ For more detail on key category analysis specific to REDD+ activities, see GFOI MGD, Section 2.3.3 (GFOI, 2016).

²⁰ In the land-use change and forestry sector, data on land area, management systems, or timber volumes extracted, are examples of Activity Data.

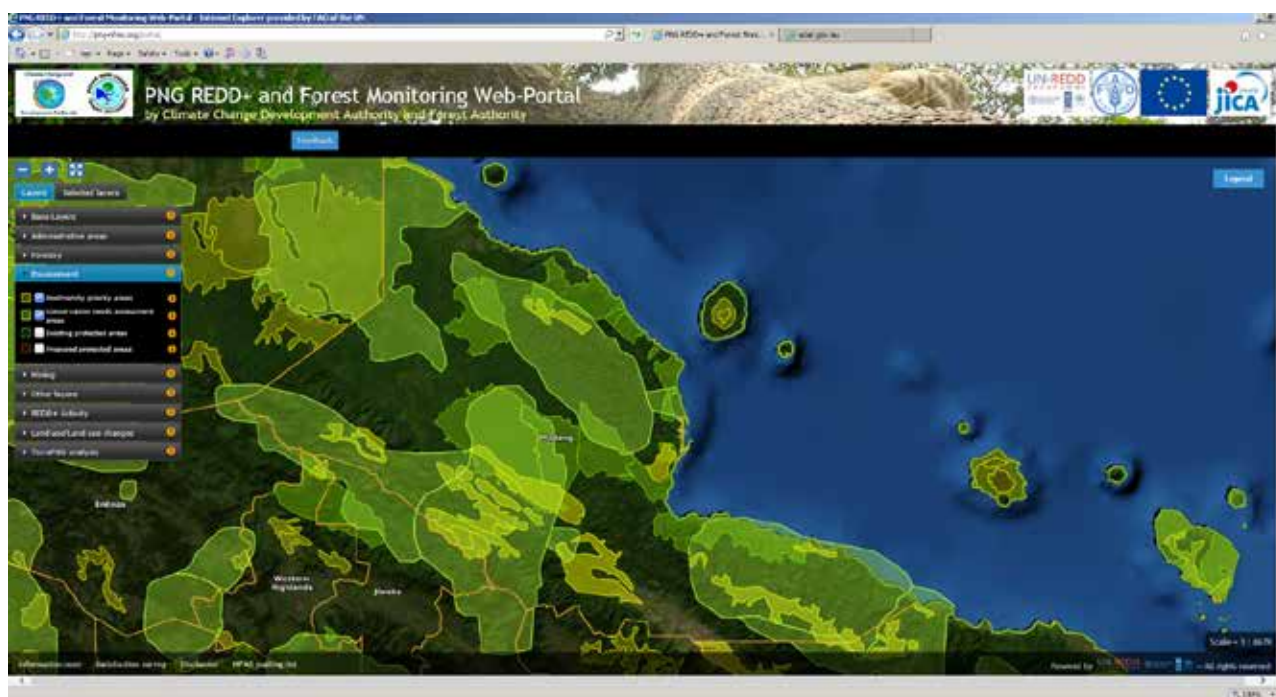
²¹ Spatially explicit means having a location that can be identified on the ground using geographical coordinates and applies to both individual sampling sites and exhaustive tessellations obtained from wall-to-wall remotely sensed data.

Consistent, multidecade, forest-area change AD, with associated uncertainty estimates, are required for generating REDD+ estimates. AD generated from Approaches 2 or 3 are suitable for generating REDD+ estimates.

In summary, Approach 1 identifies the total change in area for each individual land-use category within a country, but does not provide information on the nature and area of conversions between land uses. Approach 2 introduces tracking of land-use conversions between categories, but is not spatially explicit. Approach 3 extends Approach 2 by allowing land-use conversions to be tracked on a spatially explicit basis (IPCC, 2003; 2006). Remote-sensing data are likely to be used to greatest advantage with Approaches 2 and 3.

The following good practice principles relate to the representation of land and are informed by both the IPCC good practice guidelines as well as the GFOI methods and guidance document:

- transparent: data sources, definitions, methodologies and assumptions should be clearly described;
- adequate: capable of representing land-use categories and conversions between land-use categories, as needed, to estimate carbon-stock changes and GHG emissions and removals (i.e. Approaches 2 or 3);
- consistent: capable of representing land-use categories consistently over time, without being unduly affected by artificial discontinuities in time series data.²² Use of remote-sensing data may require special attention to consistency, because satellites go out of commission or operability, new ones enter into use, and ways of using the imagery evolve. This may affect time series of emissions estimates and the consistency with historical data which is necessary for establishing FRELs or FRLs;
- complete: all land within a country should be included, with increases in some areas balanced by decreases in others, recognizing the biophysical stratification of land if needed (and as can be supported by data) for estimating and reporting emissions and removals of GHGs.



Papua New Guinea's Official National Forest Monitoring System Web Portal (<http://png-nfms.org/portal/>)

3.3.2. Methods and tiers for estimating emissions and removals

IPCC distinguishes between two methods for estimating emissions from sources and removals by sinks associated with annual rates of change in all forest carbon pools.²³

- stock-change²⁴ method: which estimates net annual emissions or removals from the difference in total carbon stocks at two points in time, divided by the number of intervening years.

²² Generic guidance for maintaining consistency is provided in GPG2003 (IPCC, 2003) and 2006GL (IPCC, 2006).

²³ For the gain-loss method see equation 3.1.1 in GPG2003 (IPCC, 2003) or equation 2.7 in Vol. 4, 2006GL (IPCC, 2006). For the stock change method see equation 3.1.2 GPG2003 in (IPCC, 2003) or equation 2.8 in Vol. 4, 2006GL (IPCC, 2006).

²⁴ The stock-change method is called the stock difference method in 2006GL (IPCC, 2006).

- **gain-loss method:** estimates annual net emissions or removals of CO₂ as the sum of gains and losses in carbon pools.

The carbon stock estimates for the stock-change method are commonly estimated from repeated field measurements of forest variables as part of an NFI or equivalent survey data. Remote-sensing data may be useful in improving the efficiency of sampling in an NFI by assisting in stratification and by providing auxiliary data during estimation to enable tracking of REDD+ activities. IPCC notes that the stock-change method provides good results where there are relatively large increases or decreases in estimated biomass, or where there are statistically rigorous NFIs.²⁵

Where countries do not have an NFI,²⁶ nor plans to establish one, the gain-loss method may be applied. This method estimates annual net emissions or removals of CO₂ as the sum of gains and losses in carbon pools occurring on areas of land subject to human activities. This may be achieved by the use of emissions/removals factors and AD or by the use of more sophisticated representative models and integrated systems.²⁷ The gain-loss method can be implemented using default emission/removal factor data from IPCC guidelines, or nationally relevant data from sampling, forest inventories or research sites.

In recognition of varying national circumstances relating to data availability and resources, the IPCC further classifies methods into three hierarchical tiers (IPCC, 2003; 2006):

- **Tier 1** is referred to as the default method, and the IPCC guidelines aim to provide the information needed for any country to implement Tier 1, including emission and removal factors and guidance on how to acquire AD. This tier is appropriate for countries where national data are scarce or absent.
- **Tier 2** usually uses the same mathematical structure as Tier 1, with countries providing data specific to their national circumstances, and usually allowing increased disaggregation in land-use categories, typically requiring fieldwork to estimate the values required if they do not exist.
- **Tier 3** methods are generally more complex, higher-order methods, normally involving modelling of all carbon pools and the transfers between them, tailored to address national circumstances, repeated over time, and driven by AD disaggregated at the subnational to fine-grid scales. These higher-order methods provide estimates of greater certainty than lower tiers and have a closer link between biomass and soil dynamics.²⁸

In summary, with respect to approaches, emission factors and tiers, a country should:

- adopt the most appropriate approach to characterize and account for all relevant land areas in a consistent and transparent way. Data should be able to reflect the historical trends in land-use area;
- conduct a key category analysis, using Tier 1 data if required, to establish key REDD+ activities and subcategories upon which to focus resources;
- identify existing national data suitable for generating emission factors for the identified key land-use categories, as well as any subcategories based on stratification of forest land;
- appraise available capacities and needs to develop national emission factors for the key land-use categories and subcategories;
- document at which tier(s) each category and subcategory will be estimated, based on available data, priorities, resources and capacities.

²⁵ See p. 3.25 of GPG2003 (IPCC, 2003) or p. 2.13 in Vol. 4, 2006GL (IPCC, 2006).

²⁶ Or may not have an NFI with suitable statistical design.

²⁷ For more guidance on how to select the correct method, see GFOI MGD, Section 2.2.2 (GFOI, 2016).

²⁸ For examples of Tier 3 national systems refer to GFOI MGD, Appendix C (GFOI, 2016).



4. FAO approach to national forest monitoring for REDD+

In the broader context beyond REDD+, FAO's work is guided by its *Voluntary guidelines on national forest monitoring*. Country support is based on the 14 principles included in the VGNFM, which include country ownership and responsibility, a legal and policy basis, a landscape view, institutionalization, and a multipurpose approach (FAO, 2017d).

FAO's approach in the context of National Forest Monitoring Systems (NFMS) for REDD+ promotes the following action lines

- Target ownership of government partners. Based on their national circumstances and development priorities, countries need to exercise full control over the entire NFMS development process, assuming full responsibility for the implementation and effective operation of their NFMS from Phases 1 to 3 of REDD+. International partner organizations and foreign institutions will be limited to providing support in technology transfer, technical capacity-building and the development of institutional capacities.
- Build on and iteratively improve available capacities. One of the key principles of the UNFCCC REDD+ framework is to build on existing capacities, programmes and initiatives in the country, region, and/or at international level, for implementation of an NFMS,²⁹ noting that a simple but complete NFMS is a good point of departure for iterative continuing improvements.
- Serve multiple purposes beyond REDD+ and UNFCCC submissions. Support aims to enable countries to produce useful domestic outputs from their NFMS, including various national purposes. Important international outputs include, but are not limited to, submissions to the UNFCCC. Beyond work strictly relevant to REDD+, a more holistic approach is taken to developing the components of the NFMS that should also be useful in other contexts beyond REDD+. For example, a multipurpose NFMS can serve reporting needs for FAO's Global Forest Resource Assessment.
- Adapt the approach to the country circumstances. The capacity-development approach is informed by country context and existing capacity and can take the form of varying roles in collaboration with government staff, coaching and facilitating, or training and teaching.
- Develop functional capacities alongside technical support. The mode of engagement takes a hands-on approach to developing sustainable functional capacities.
- Draw on a variety of approaches. Next to in-country work, methods for remotely supported capacity development include use of e-learning material, collaboration with country-based staff, use of interthematic working groups and webinars, and South-South exchanges or exchanges with developed countries.

On the basis of the principles of the VGNFM and these major action lines, FAO has been delivering technical support to countries in their efforts to construct the necessary NFMS elements for REDD+ MRV through development of technical and functional capacities in SLMS, NFI and REDD+ reporting, consistent with national GHGI estimation methods for the Agriculture, Forestry and Other Land Use (AFOLU) sector. As examples of this approach, six country case studies are provided in this section: Papua New Guinea, Ethiopia, Bangladesh, Zambia, Ecuador and Colombia.

4.1. National Forest Monitoring Systems

FAO support for countries within the context of REDD+ is informed by the decisions of the COP as well as the good practice guidelines provided by the IPCC. In the context of the elements of a National Forest Monitoring System, several COP decisions guide FAO's focus on Satellite Land Monitoring Systems and National Forest Inventories. In particular the combined use of both remote sensing and ground-based forest carbon inventory was proposed by 2/CP.13 in Bali and reiterated in several of the subsequent decisions.

²⁹ As specified in Decision 11/CP.19.

Case study 1

FAO-supported activities on the ground in Papua New Guinea (PNG)

Papua New Guinea (PNG) comprises the eastern portion of New Guinea which is the largest tropical island in the world. PNG contains approximately 37.7 million hectares of forest land (80.4 percent of total land area) and is well-known for its biological endemism and diversification. Forests in PNG are relatively well conserved but poorly studied. They face increasing pressure from commercial logging, family agriculture and clearing for commercial agricultural activities. The extent to which carbon stocks are affected by these activities is unknown. To gain a clearer picture of the current status of their forests and the potential role PNG could play in mitigating climate change the country is active in REDD+ and is currently working towards completing the Warsaw Framework elements in pursuit of emissions reductions and potential results-based payments.

FAO assists PNG by supporting their efforts to construct the systems and establish the capacity that is necessary for REDD+ MRV. A key pillar of support covers the development of a National Forest Monitoring System (NFMS):

National Forest Monitoring System: A major pillar of PNG's NFMS consists of TerraPNG and Collect Earth, a combination of which enables Approach 3 level data on LULUCF. In addition, remote-sensing analysis using Collect Earth has facilitated PNG's two-phased National Forest Inventory. FAO also supported the establishment of the SLMS laboratory, which will house the NFMS and related data-sharing capabilities. The development of wall-to-wall mapping and sample-based assessments further improves future REDD+ MRV capabilities.

National Forest Inventory: PNG's first NFI is collecting information on forest resources to assist in the conservation and management of the country's unique forests. The NFI methodology and design is based on remote-sensing analysis. Once completed, the inventory will provide PNG with Tier 3 level data with reduced uncertainty. FAO has provided and will continue to provide support in the implementation of the NFI as well as the forest inventory analyses required for quantifying emission factors.

Greenhouse Gas Inventory: PNG has collected data to prepare the AFOLU component of the national GHGI. To support this, FAO has organized hands-on workshops on data collection and integration of NFI data and emissions associated with LULUCF. Results will be reported as part of PNG's commitments to the UNFCCC.

Forest Reference Level: PNG constructed and submitted a FRL in January 2017 using data collated within the NFMS, which FAO supported. Reference levels serve as benchmarks for assessing each country's performance in implementing REDD+ activities. Capacity-development interventions continue to help prepare PNG for results monitoring as part of their MRV commitments.

The way forward. PNG and FAO continue to collaborate on:

- preparation of the national GHGI for the AFOLU sector, to be included in the first BUR;
- preparation of the REDD+ technical annex;
- training on geospatial data-processing using SEPAL;
- technical support to REDD+, NFMS and FRL;
- implementation of the NFI.

FAO resources/tools: Open Foris Collect, Open Foris Collect Mobile, Open Foris Calc, Collect Earth, SEPAL, NFMS web portals

Recommendations from the COP with regard to REDD+ reporting are contained in 9/CP.19, 12/CP.17, 13/CP.19 as well as 14/CP.19. Based on these decisions and guidance from both the IPCC, FAO proposes the following major technical elements of support in capacity development, including other principles and elements presented in the VGNFM:

1. **Satellite Land Monitoring System** to collect and assess, over time, the Activity Data relating to forest land;
2. **National Forest Inventory** to collect ground-based information on forest carbon stocks and changes, relevant to estimating emissions and removals and providing emission factors;
3. **REDD+ reporting** to integrate data and generate estimates for REDD+ activities as set out in UNFCCC decisions,³⁰ maintaining consistency with the AFOLU Greenhouse Gas Inventory (GHGI).

The three elements of the NFMS can be developed along the three phases for REDD+, allowing for the implementation of demonstration activities in Phase 2 and full MRV of REDD+ activities in Phase 3.

³⁰ This includes the reporting of a FREL/FRL and estimates for results-based payments reported in a BUR technical annex.

Case study 2

FAO-supported activities on the ground in Ethiopia

Ethiopia contains approximately 60 million hectares of forests including woodlands and shrub lands which cover approximately 50 percent of its land area. The Great Rift Valley which bisects Ethiopia creates a number of unique ecological environments resulting in a number of agro-ecological zones. Deforestation is mainly caused by the expansion of agriculture land, while degradation is mainly driven by collection of fuelwood and charcoal, livestock grazing, collection of construction wood and illegal selective logging. Deforestation is estimated to be between 1.0 and 1.5 percent per annum with the underlying drivers including legal and regulatory uncertainties around tenure and forest rights as well as inadequate institutional support, population growth and challenges around poverty. As such Ethiopia is active in REDD+ and in collaboration with FAO and other UN Agencies have been pursuing the fulfilment of the Warsaw Framework elements.

Institutional arrangements: REDD+ is implemented within Ethiopia's Climate Resilience Green Economy Strategy Framework which seeks to elevate Ethiopia to a middle income country by 2025. Technical activities are covered by the REDD+ Secretariat where Ethiopia has worked on the establishment of a MRV unit to support REDD+ activities in the country. The estimation and international reporting of national-scale forest emissions and removals will thus be put in place and made self-sustaining and consistent with UNFCCC's modalities. FAO has supported the implementation of the national MRV unit.

National Forest Inventory: A Technical Cooperation Program (TCP) between FAO and Ethiopia facilitated the National Forest and Landscape Inventory undertaken between 2013 and 2016. The inventory employed five non-overlapping classes to stratify sampling with sample densities defined using predefined stratum significance. The field data methods were informed using the FAO National Forest Monitoring and Assessment (NFMA) methodology. FAO has assisted in the collection and elaboration of the forest inventory data, as well as in the development of country-specific emission factors for the LULUCF sector. Country-specific emission factors were essential to constructing the national Forest Reference Level.

Forest Reference Level: Following support from FAO, Ethiopia constructed and submitted a national FRL in 2016 which included deforestation and afforestation, AGB, BGB, deadwood and which reports CO₂ emissions only. It is national and based on a historical average of emissions and removals between 2000 and 2013. FAO has supported the generation of Activity Data (AD) that were essential to the national FRL construction and the national MRV team will continue to receive support from FAO for the development of sub-national FRLs as well as the step-wise improvement of the national FRL.

The way forward. Ethiopia and FAO continue to collaborate on:

- preparation of the first BUR;
- preparation of the REDD+ technical annex;
- intensification of NFI in forest strata for improved emission factors in all biomes and regions;
- improvement of AD estimates and forest maps;
- training on geospatial data-processing using SEPAL;
- development and implementation of NFMS portal.

FAO resources/tools: NFMA Manual, Open Foris Collect, Open Foris Calc, Open Foris Geospatial Toolkit, Collect Earth, SEPAL, NFMS web portals

Following this strategy, each phase aims to strengthen capacities and prepare for the next phase, resulting in a degree of overlap between phases, notably in terms of capacity-building. In Phase 2, the NFMS becomes operational, through the SLMS and other relevant proxies. The transition into Phase 3 is achieved when data are collected and estimates generated at the national level, inclusive of ground data being collected from NFI, and REDD+ estimates are consistent with the GHGI.

4.1.1. Satellite Land Monitoring Systems

Satellite imagery can enable the consistent and transparent representation of land-use change over historical time frames³¹ required for UNFCCC reporting.

³¹ International satellite data archives, such as LandSAT, allow the analysis of historical imagery dating back 20 years.

The FAO NFMS strategy promotes satellite remote sensing as a central tool for the collection of data on land use and forest-area change as a result of human activities (i.e. Activity Data) in the form of an SLMS, combined with a web-GIS online dissemination portal.

The role of the SLMS is to ease collection and processing of satellite imagery to develop historical trends and consistent regular assessments of land-use change. These AD can then be uploaded into an openly accessible, web-GIS portal, promoting the transparency of the NFMS and facilitating the involvement of relevant stakeholders.

Recommendations for the development of an SLMS include the following:

- determine if countries are currently undertaking Earth Observation based forest monitoring and if they intend to incorporate an SLMS into their current activities.
- collect all the existing land-cover data and satellite images and establish needs in terms of technology and capacities;
- define data requirements and acquisition strategy (i.e. type sensors, temporal and spatial frequency of forest data acquisition);
- establish a clear and realistic roadmap for development of the SLMS;
- build up the required technology and the capacities needed for sustainable implementation of the SLMS;
- implement the SLMS with the objective of producing measurable and repeatable results.

4.1.2. National Forest Inventories

The term NFI is commonly used to describe the technical process of data compilation and analysis of forest resources from a multitude of data sources, including field inventories and remote sensing, to estimate relevant forest characteristics at particular points in time. FAO's approach to NFI is articulated in *Voluntary guidelines on national forest monitoring* (FAO, 2017d). An NFI is a valuable source of ground data to contribute to the generation of country-specific emission factors for each relevant forest category, as well as any subcategories based on the selected stratification of forest land to allow the generation of Tier 2 or Tier 3 estimates (see Section 3.3.2 and Box 7).

Data from an NFI can be a valuable source of multifunctional forest resource data and such ground data play a critical role in biomass estimation for REDD+ estimates. For countries that do not have an NFI, or for those that need to expand their ground-based inventory, a process of forest inventory planning, implementation, data analysis, biomass modelling and reporting that suits national circumstance may be required.

Recommended steps for establishing or extending an NFI include the following:

- align REDD+ NFI activities to current or planned in-country forest monitoring programmes. If these do not exist proceed using guidance from the COP as well as the IPCC good practice guide.

Box 7

Method to use in the absence of repeated National Forest Inventories

Almost all Parties to Annex I of the UNFCCC that use an NFI to assess carbon-stock changes for forest land make more than one inventory – thus creating a time series through the application of the stock-change method (see Section 3.3.2).

Few to zero historical ground-datasets exist for most developing countries; nevertheless, for REDD+ activities involving a change in land use, such as deforestation (i.e. change from forest land to non-forest land), one NFI could be sufficient to report on the changes of forest carbon stocks. Corroborated by auxiliary data on land-use changes from the SLMS and other ground-data sources, a country can utilize the gain-loss method (see Section 3.3.2) and relevant models to generate national estimates at Tiers 2 or 3.

For REDD+ activities resulting in intrinsic modifications, such as forest degradation and forest conservation (i.e. forest land remaining forest land), forest carbon stocks and changes will probably have to be estimated using information from at least two NFIs. They could also be partially estimated using data from a single NFI, if this NFI can provide information that will allow production of data on the dynamics of forest carbon-stock changes in combination with more sophisticated tools (i.e. models).

- define the approach to designing and implementing a sustainable, multipurpose³² NFI;
- establish a clear and realistic roadmap including the steps to be taken;
- build up the required technology and capacities needed.

4.1.3. REDD+ reporting

As per the recommendations of the COP, countries are encouraged to voluntarily estimate and report GHGs by sources and sinks if they wish to implement REDD+ activities under the UNFCCC.³³ Estimation of REDD+ emissions and removals should be:

- conducted in accordance with IPCC good practice guidance;
- consistent with GHGI estimates for the land sector;
- estimated using data on land-use changes from the SLMS and data on carbon-stock changes from the NFI.

The quality of the estimates depends not only on the robustness of the measurement results (in the SLMS and NFI elements), but also on the transparent manner and method in which the information is integrated (Box 8), reported and communicated.

Box 8 Integration frameworks

Developing systems for reporting GHG emissions and removals requires a combination of data from different sources, with data gaps filled through assumptions and expert judgement where necessary. Tools to facilitate this are known as integration frameworks. Decisions on approaches, methods and tiers (see Section 3.3), combined with the adopted land stratification schemes, will influence the complexity of the integration framework.

Integration frameworks can simplify reporting by automatically assigning land use and emissions to the required classes based on rules set by the user, consistent with national definitions. Ideally, an integration framework should be scalable and apply to forest stands, projects, regions or countries. It should also be able to start with simple, best-available data, and be improved progressively; at each stage meeting IPCC good practice requirements of neither under- nor over-estimation so far as can be judged, and reducing uncertainties as far as practicable.

There are two main methods for integrating remote-sensing and ground-based observations:

1. The Activity Data x emission/removal factor frameworks (representative of Tier 1 or Tier 2 methods).
2. Fully integrated frameworks, with two subcases:
 - a. spatially-referenced models (representative of Tier 3, Approaches 2 or 3 methods)
 - b. spatially-explicit methods (representative of Tier 3, Approach 3 methods) which track individual units of land (polygons or pixels).

All these methods have been used by countries in developing land sector GHG estimates and, when applied correctly, all comply with UNFCCC rules and IPCC guidelines. Methods of integration are not mutually exclusive. Most countries currently use a combination of integration methods, depending on the nature of forest land use and availability of data. Selecting an integration framework for MRV requires consideration of practical and scientific issues including:

- national and international reporting requirements;
- data availability;
- technical means and capacity;
- standards by which the system and its outputs will be assessed;
- availability of integration frameworks (also referred to as integration tools) and the expertise to implement these within the country;
- cost effectiveness.

Source: GFOI (2016)

³² The NFI should be designed to include collection of necessary data to assess forest carbon stock and stock changes, as well as additional multipurpose data that could be used to guide policies and measures.

³³ Decision 4/CP.15, paragraphs 1(d) and (d)(i).

The reporting element allows countries to demonstrate whether the implementation of REDD+ activities, policies and/or measures has resulted in measurable climate-change mitigation. To achieve this, countries are required to:

- analyse data (from the country's NFMS) suitable for constructing the FREL/FRL and reporting on REDD+ results, as well as compiling the AFOLU national GHGs;
- understand UNFCCC modalities for FREL/FRLs and REDD+ results reporting, as well as national GHGs; including exploration of practical solutions in line with these requirements, tailored to the country's national circumstances and capacities;
- submit BURs and National Communications (NCs), and in the context of results-based payments, submit a FREL/FRL and REDD+ technical annex to the BUR.

Case study 3 FAO-supported activities on the ground in Bangladesh

Bangladesh is a relatively small country with a high population and is especially vulnerable to natural disasters such as flooding and cyclones. The country is predominantly agricultural in terms of land use however only 18.6 percent of its GDP comes from the agricultural sector. FAO estimates indicate that 75.8 percent of the total land area is under some form of agriculture or pasture with forests concentrated mainly in the mangroves of the Sundarbans in the south-west and in the Chittagong Hills of the south-east. In Bangladesh 17.1 percent of total land is considered forest with the primary threat being population driven land use change. In August of 2010, Government of the People's Republic of Bangladesh became a partner country of the UN-REDD programme and has been progressing well with the establishment of the key institutions and programs required to actively partake in REDD+ activities.

The Bangladesh Forest Inventory (BFI) methodology was developed over a two-year period with direct inputs taken from stakeholders representing over 40 institutions and technical guidance from FAO. The BFI methodology targets the country's five major forest types: Sal, Coastal, Sundarbans, Hill and Village forests with the aim being to better understand the relationships between communities and the forests they depend upon. The inventory employs advanced data collection and management tools developed by FAO for supporting national scale forest inventories. Prior to the development of the Land Cover Meta Language (developed by FAO), Land cover change mapping in Bangladesh was problematic. Land cover maps produced by different organizations made it impossible to reconcile meaningful change across both space and time. The Land Cover Meta Language (LCML) has the potential to reduce inconsistency significantly.

FAO currently provides material support to the Greenhouse Gas Inventory. According to the Second National Communication (SNC), the agriculture and land use/land use change sectors emitted 33 percent and 16 percent of the total national GHG emissions respectively, or 49 percent when considered under the banner of AFOLU. FAO support seeks to help Bangladesh improve GHG inventory preparation, develop baselines and scenarios for planning, improve data exchange between government institutions and to operationalize the AFOLU components of the inventory.

Bangladesh is currently in the readiness phase where it develops national strategies or actions plans, policies and measures and capacity to contribute to climate change mitigation through forest-based actions. Bangladesh is under the process of constructing a Forest Reference Level for REDD+ with the aim to assess the effectiveness of REDD+ activities and potentially receive results-based payments.

The way forward

- Processing of field data including QA / QC, field data-processing and analysis
- Carbon stock change and uncertainty assessment
- Historical assessment of land cover changes and GHG refinement as well as development of the first Forest Reference Emissions Level
- Estimate GHG emission, environmental and ecosystem footprint from brick industry to ensure ecofriendly brick industry with reduced GHG emission
- Estimate GHG emission and environmental footprint of rural and urban household energy use through life cycle assessment (LCA), material flow analysis and ecological footprint analysis
- Support the construction and submission of FREL(s)/FRL(s) to the UNFCCC with the aim to receive results-based payments from activities related to reduced emissions from deforestation and forest degradation

FAO resources/tools: Open Foris Collect, Open Foris Calc, Open Foris Geospatial Toolkit, Collect Earth, SEPAL, NFMS web portals

Recommendations for developing a consistent REDD+ reporting framework include:

- establishing needs, in terms of technology and capacities, including institutional arrangements to manage the integration and reporting processes;
- establishing a clear and realistic roadmap setting out the steps to develop an estimation framework for the forest sector (incorporating both REDD+ and GHGI requirements);
- building the technology and capacities required for implementation of the estimation and reporting framework, including adequate:
 - institutional arrangements;
 - data-collection processes;
 - Quality Assurance and Quality Control (see Box 2);
 - archiving systems;
- reporting results that are aligned with and captured within the GHG inventory.

For a summary of country progress on REDD+ reporting, refer to *REDD+ under the UNFCCC – from reference levels to results reporting* (FAO, 2017c). An infographic is available to convey, in an accessible manner, FAO support for countries reporting to the UNFCCC (FAO, 2017a).

Case study 4 FAO-supported activities on the ground in Zambia

Zambia has approximately 50 million hectares of forest, with a high deforestation rate of around 250,000 hectares per year. Drivers of deforestation range from wood fuel, agriculture expansion, mining, timber extraction, bush fires to land and infrastructure development. Deforestation and forest degradation is the highest contributor to Greenhouse Gas (GHG) emissions in developing countries. To tackle the challenge of deforestation and forest degradation Zambia has developed a national strategy. The strategy addresses reducing emissions from deforestation and forest degradation, conservation and enhancement of forest carbon stocks and sustainable management of forests commonly referred to as REDD+.

Zambia's work in the area of MRV for REDD+ has focused on the development of a decentralized National Forest Monitoring System (NFMS). This required extensive in-country capacity-building and infrastructure development. Ten provincial forest monitoring laboratories were established and equipped with tools for forest monitoring such as computers with Geographic Information System (GIS) software, Geographical Positioning System (GPS) units for forest monitoring field activities and printers and plotters for field map production. Technical support has been provided by FAO throughout the process of establishing the NFMS including the production of land cover change maps and especially high-quality forest cover change data.

The field inventory component of the NFMS is known as Integrated Land Use Assessment (ILUA). Currently in its second phase, ILUA is the largest natural resource inventory ever undertaken in Zambia and was implemented concurrently with the UN-REDD readiness programme. The inventory employed FAO's National Forest Monitoring and Assessment (NFMA) methodology. In addition, Open Foris tools continue to be used by the Forestry Department to capture, enter, clean and analyse plot-based forest inventory data. Outputs from the inventory continue to inform both the FREL and the GHGI.

In early 2016 Zambia submitted its Forest Reference Emissions Level to the UNFCCC as part of its commitment to measuring, reporting and verifying its contribution to the mitigation of global climate change. Zambia may also choose to seek results-based payments following the actualization of its REDD+ strategy and Investment Plan. The FREL reference period was from 2006 to 2014 and used a historical average approach without adjustment. The NFMS discussed above contributed both the Activity Data (2000-2010-2014) and the emission factors with CO₂ as the only gas included in the present iteration of the FREL. Zambia currently only includes deforestation activities but will, in the future, take advantage of the step-wise methodology to include both emissions and removals in its FREL.

The way forward

- Support for improving the FREL and including additional activities such as degradation
- Support for MRV activities, especially monitoring those PAMS implemented by the country
- Support quantification of AFOLU components of the GHGI
- Maintain capacity-development activities with a focus on MRV

FAO resources/tools: Open Foris Collect, Open Foris Calc, Open Foris Geospatial Toolkit, Collect Earth, SEPAL, NFMS web portals

Case study 5

FAO-supported activities on the ground in Ecuador

Ecuador registers a great variety of climates and microclimates that make it one of the 17 megadiverse” countries of the planet. Its terrestrial and marine species biodiversity is the greatest in the world. In 2010, 7 098 014.51 hectares were accounted for under conservation or environmental management schemes. In 2017, this figure increased to 8 700 869 hectares, which represent 35.03 percent of the continental territory. This has been the result of various governmental conservation initiatives, notably Socio Bosque. By 2017, 1 607 411 hectares were protected under this scheme, including mangrove and *páramo* ecosystems, a notable rise with respect to 2010.

The Ministry of the Environment estimates that net deforestation by 2016 was 61 112 hectares. In order to reverse forest loss, Ecuador is carrying out a series of initiatives to reduce deforestation as part of good governance of forest resources and to combat climate change. The country is active in REDD+ and in collaboration with FAO and other UN Agencies has been pursuing the fulfilment of the Warsaw Framework Elements. Moreover, Ecuador is one of the first countries to access Green Climate Funds (GCF), which will support efforts to reduce deforestation in the Amazon region through innovative financial mechanisms and best practices (PROAmazonia).

Data collection: Ecuador has engaged key stakeholders to collect data for the national GHGI for the Agriculture and LULUCF sectors. FAO has provided support on data collection, for example the First Forest Evaluation (National Forest Inventory) and the deforestation estimates (periods: 1990-2000-2008-2014) and the establishment of institutional arrangements to manage and share information on Activity Data and emission factors for the Agriculture and LULUCF sectors.

South-South cooperation: Ecuador has shared and gained knowledge through various South-South cooperation initiatives on data collection and GHG inventories for the Agriculture and LULUCF sectors. FAO has worked with Ecuador and is supporting a cooperation network in Latin America and the Caribbean Region (*Red Latinoamericana de Inventarios Nacionales de Gases de Efecto Invernadero – RedINGEI*) for the submission of BURs and NCs. Recently, FAO has facilitated a South-South cooperation exchange between Ecuador and Costa Rica on the NFMS.

National Forest Monitoring System: Ecuador is developing an NFMS that provides data for the estimation and reporting of forest-related emissions and removals, not exclusively for REDD+. FAO has supported the institutional arrangement and assisted throughout with capacity-development activities. Since 2015, FAO has provided technical support for Earth Observation systems, data access, processing and analysis for land monitoring (SEPAL) to implement the NFMS and community forest monitoring.

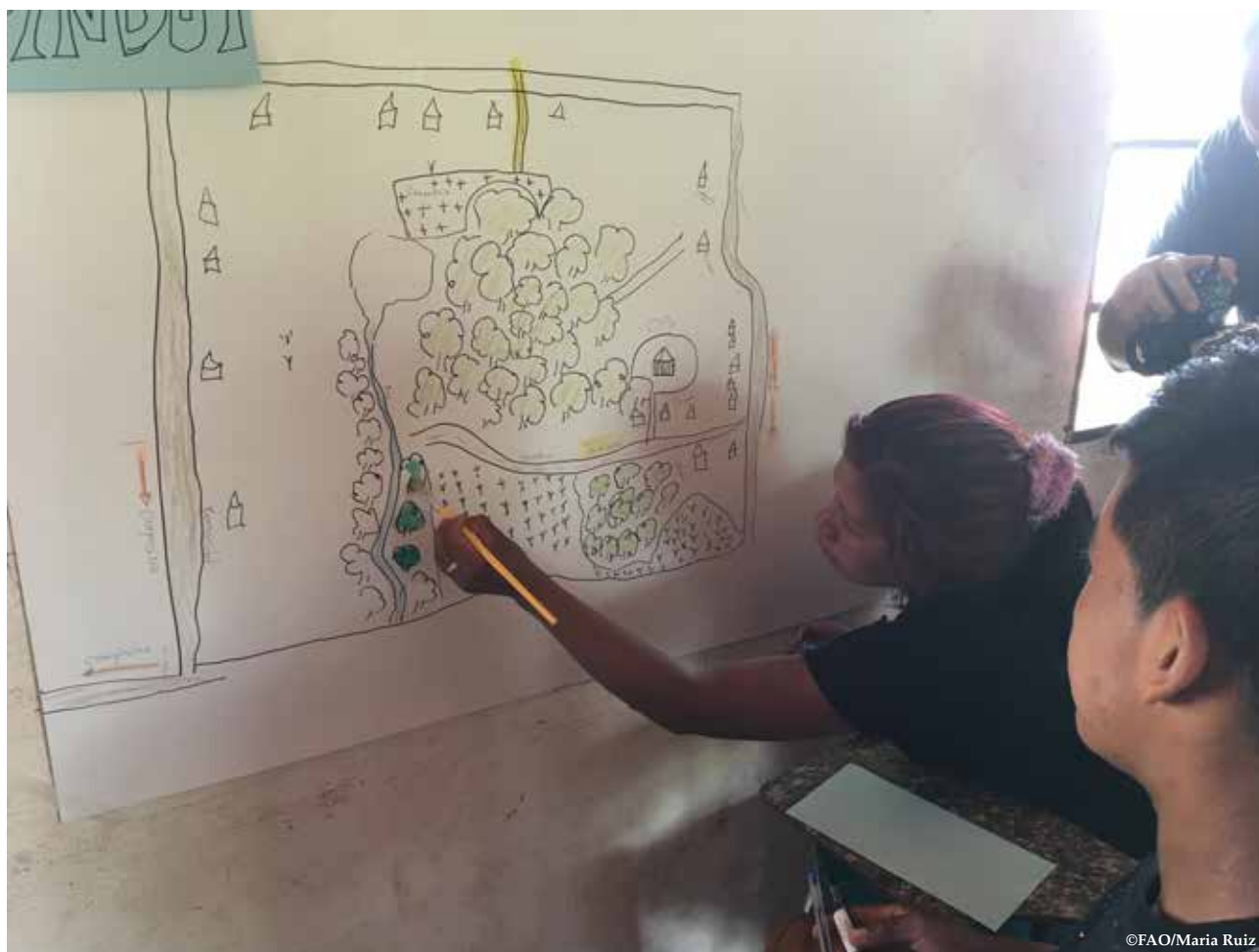
Biennial Update Report and REDD+ reporting: Forest Reference Emission Level for deforestation was submitted in December 2014. Ecuador prepared and submitted its first BUR in September 2016, including the REDD+ technical annex and National Inventory Report (NIR), and has also gone through the ICA process. FAO has provided continuing support to build the national GHGI system and to prepare the national GHGI for the Agriculture and LULUCF sectors, the submission of the FREL and the preparation of the first BUR.

Third National Communication: Ecuador has submitted its Third National Communication to the UNFCCC. An NC, submitted to the UNFCCC every four years, provides information on how countries are addressing climate change. FAO has provided technical support for the national GHGI and quality assurance process for the Agriculture and LULUCF sectors.

The way forward. Ecuador and FAO continue to collaborate and/or support on:

- development of Nationally Determined Contributions (NDCs) for the mitigation and adaptation components in the Agriculture and LULUCF sectors;
- customized SEPAL for Ecuador’s needs to implement the NFMS in order to monitor deforestation, degradation and devise an early warning system;
- development of the second FREL that will include proxies to estimate emission from forest degradation;
- development of funding proposals for the GCF related to results-based payments.

FAO resource/tools: SEPAL, AFOLU Emissions Analysis Tools



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Case study 6

FAO-supported activities on the ground in Colombia

Colombia is one of the world's "megadiverse" countries, hosting close to 14 percent of the planet's biodiversity. The country has around 60 million hectares of natural forest, 31 million hectares of which are on lands that are titled to indigenous peoples and Afro-Colombians. An estimated 1 million hectares of these lands belong to local communities. These forests have generated an important set of cultural, supply, support and regulation ecosystem services, which have contributed to meeting the basic needs of some local populations. However, deforestation in these areas has been increasing in recent years as a consequence of the expansion of the agricultural frontier and praderization for livestock. Of the land deforested between 1990 and 2013, 58 percent was in municipalities with the highest incidence of armed conflict, where high rates of poverty also occur.

The effective implementation of policies or actions to promote the sustainable management of natural forests requires the capacity development of institutions such as the Ministry of Environment and Sustainable Development and the Regional Autonomous Corporations, so that they can fully implement forest management, technical assistance, and control and surveillance tools to promote the legality of the forest chain. Likewise, at community level, strengthening the role of the local population in the governance and management of forest resources depends on a range of activities such as incubating and managing the forestry companies of small producers, partnerships between companies and communities, and a decentralized forest management framework based on the principles of sustainability enshrined in the Constitution.

REDD+ strategy: Colombia has designed and adopted a National Strategy for Reducing Emissions from Deforestation and Forest Degradation (*Bosques Territorios de Vida – Estrategia Integral de Control a la Deforestación y Gestión de los Bosques*), which is part of the country's climate change action together with the Colombian Low Carbon Development Strategy (*Estrategia Colombiana de Desarrollo Bajo en Carbono – ECDBC*). The REDD+ strategy describes five strategic lines to halt deforestation and forest degradation: (i) socio-cultural management of forests and public awareness;

(ii) promotion of a forest economy based on forest goods and services for comprehensive rural development and halting the advance of the agricultural frontier; (iii) cross-sectorial policy action to reduce deforestation and forest degradation; (iv) decision-making based on availability and accessibility of reliable, consistent and robust information pertaining to forest dynamics and threats; and (v) institutional and financial conditions that enable forest management and reduce deforestation and forest degradation. FAO has provided technical support to design and implement the REDD+ strategy within the framework of the UN-REDD programme.

National Forest Monitoring System: Colombia launched an NFSM in 2012 and has put in place and/or implemented a Forest and Carbon Monitoring System (*Sistema de Monitoreo de Bosques y Carbono – SMBYC*), which includes an SLMS that has generated the first official national maps of forest cover and forest-cover change and the National Forest Inventory (NFI), implemented from 2015, which includes a country-wide assessment of forests. An online portal, open to the public, provides access to key information from the maps and the NFI. The SMBYC makes it possible to: (i) identify and report periodically on the surface of natural forest; (ii) generate methodologies for the annual quantification of national deforestation; (iii) generate quarterly early warning for deforestation; (iv) characterize, model and simulate the causes and agents of deforestation and degradation; and (v) monitor carbon stocks in forests and GHG emissions. FAO has provided support for the design and implementation of the forest degradation monitoring methodology, data collection, and the management and processing of the NFI, as well as the construction of the approach to community-based monitoring. FAO has also supported the institutional arrangement and, throughout the appraisal process of Decree 1655, the organization and operation of the NFMS with technical and legal advice. Use of the REDD+ Compass tool within the UN-REDD programme to build a document entitled *Measurement / Monitoring, Reporting and Verification System (M/MRV) in Colombia: Progress and roadmap for its consolidation* was also facilitated by FAO.

South-South cooperation: Colombia shared and gained knowledge through the South-South cooperation work plan on forest monitoring from the Mesoamerican Strategy for Environmental Sustainability (*Estrategia Mesoamericana de Sustentabilidad Ambiental – EMSA*). FAO has worked with Colombia and the other EMSA countries (Belize, Colombia, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama and the Dominican Republic) to support cooperation between Mesoamerican countries.

Biennial Update Report (BUR) and REDD+ reporting: Forest Reference Emission Level (FREL) for deforestation in the Colombian Amazon Biome for results-based payments for REDD+ was submitted in December 2014. Preparation of the FREL has benefited from data collected through the NFMS. Colombia prepared and submitted its first BUR, including the REDD+ technical annex, in March 2016, and has already gone through the ICA process under the UNFCCC. FAO has provided continuous support for the submission of the FREL, preparation of the national GHGI for the AFOLU sector, and the first BUR.

Third National Communication: Colombia has submitted its Third National Communication to the UNFCCC. Consistency and improvements between submissions (BUR and NC) to the UNFCCC have characterized this process. FAO has provided technical support on the national GHGI and quality assurance for the AFOLU sector, as well as on the risk and vulnerability analysis component.

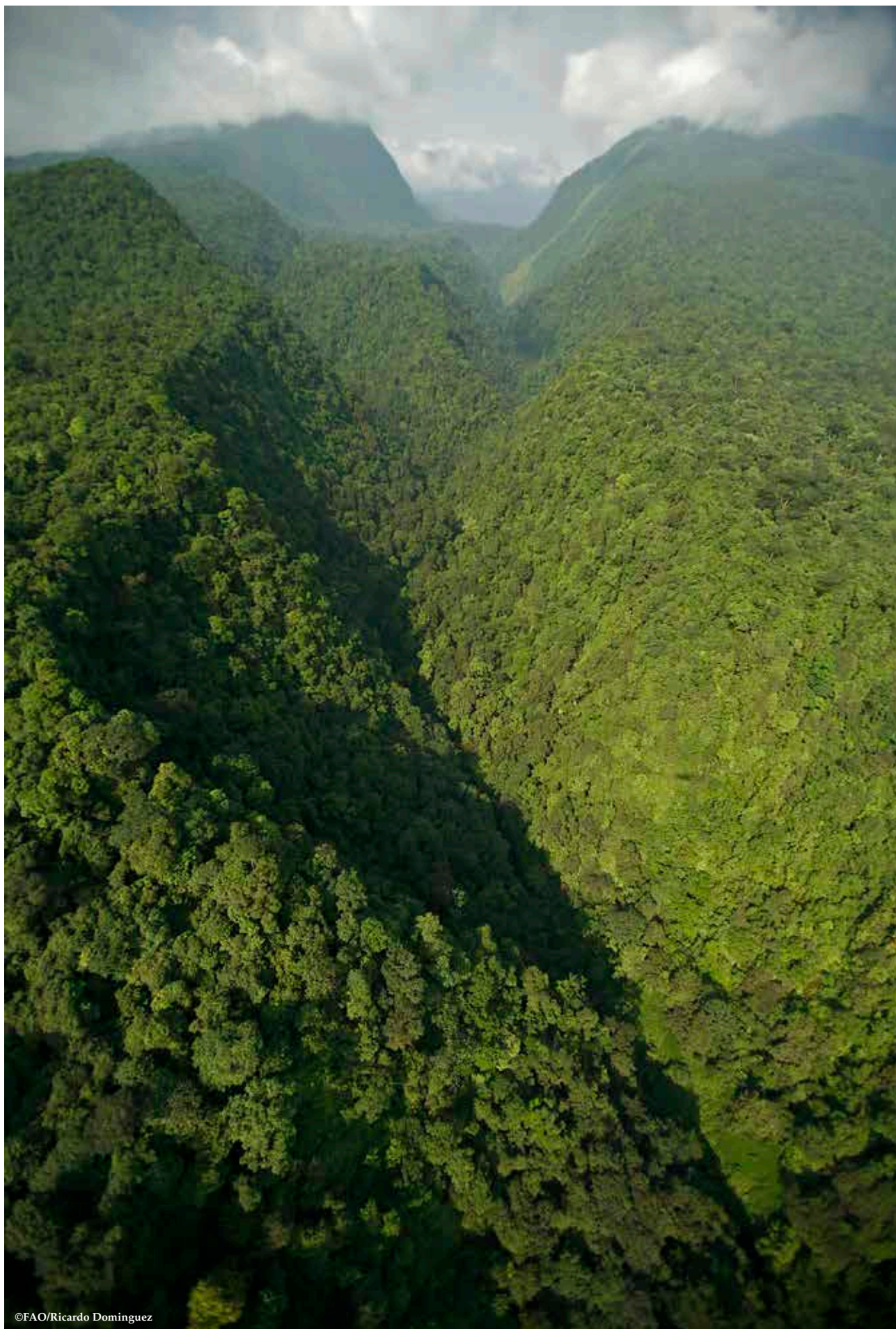
The way forward. Colombia and FAO continue to collaborate on:

- forest governance through the implementation of the forest community approach for an integral control strategy to deforestation and forest management;
- updating the FREL for deforestation at national level;
- approaches for monitoring forest restoration through existing freely available remote-sensing data and products, including potential customization of SEPAL.

FAO resources/tools: Open Foris, SEPAL, REDD+ Compass



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5. Conclusion

FAO has been providing support to member countries on national forest monitoring for decades. Best practices and lessons learned are summarized in FAO's *Voluntary guidelines on national forest monitoring* (VGNFM), which provide principles, elements and best practices for the establishment and implementation of a multipurpose National Forest Monitoring System (NFMS). In the context of results-based payment for REDD+, countries are required to establish an operational NFMS capable of meeting MRV requirements, as set out in UNFCCC decisions. FAO continues to support technical and functional capacities³⁴ for developing and operating NFMS through a focus on SLMS, NFI and REDD+ reporting and the other elements included in the VGNFM.

Following the adoption of the historic Paris Agreement in December 2015, transparency and the mechanism through which this transparency is enabled will become the backbone of the Paris Agreement. At its core, FAO's national forest monitoring country-level capacity-development work is designed to enhance transparency and promote inclusive government-owned national REDD+ processes aimed at achieving broader benefits of improved forest governance. In working on SLMS, NFI and REDD+ reporting, the priority is government ownership and keeping up momentum in scientific excellence. Establishing a solid technical and functional foundation will lead to a sustainable NFMS for a broad range of national and international forest-related reporting requirements, which can continually improve through a stepwise development plan matched to countries' aims, capabilities and resources.

Whether establishing or improving an NFMS in a stepwise manner, it is useful to develop implementation plans/roadmaps that represent national aims and objectives, current state of preparations, technical and functional capacity and knowledge gaps that remain to be resolved to achieve a sustainable, multifunctional system.

³⁴ Technical capacities include the ability to work with data and carry out calculations. Functional capacities include system-related aspects, such as design decisions and institutional arrangements.



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6. Bibliography

- FAO. 2013. *National forest monitoring and assessment – manual for integrated field data collection*. Version 2.3. National Forest Monitoring and Assessment Working Paper NFMA 37/E. Rome.
- FAO. 2016. *Map accuracy assessment and area estimation: a practical guide*. National Forest Monitoring and Assessment Working Paper. Rome.
- FAO. 2017a. *The work of FAO to enhance national capacities to report on climate change*. Infographic booklet. Rome.
- FAO. 2017b. *National forest monitoring guiding framework*. FAO Internal Working Paper. Rome.
- FAO. 2017c. *REDD+ under the UNFCCC – from reference levels to results reporting*. Working Paper. Rome.
- FAO. 2017d. *Voluntary guidelines on national forest monitoring*. Rome.
- GOFC-GOLD. 2016. *A sourcebook of methods and procedures for monitoring and reporting anthropogenic greenhouse gas emissions and removals associated with deforestation, gains and losses of carbon stocks in forests remaining forests, and forestation*. GOFC-GOLD Report version COP22-1, Wageningen University, The Netherlands. GOFC-GOLD Land Cover Project Office.
- GFOI. 2016. *Integration of remote-sensing and ground-based observations for estimation of emissions and removals of greenhouse gases in forests: methods and guidance from the Global Forest Observations Initiative*, Edition 2.0. Rome, FAO.
- Gullison, R.E., Frumhoff, P.C., Canadell, J.G., Field, C.B., Nepstad, D.C., Hayhoe, K., Avissar, R., Curran, L.M., Friedlingstein, P., Jones, C.D. & Nobre, C. 2007. Tropical forests and climate policy. *Science* 316: 985–986.
- Houghton, R.A. 2005. *Tropical deforestation as a source of greenhouse gas emissions in tropical deforestation and climate change*. P. Moutinho and S. Schwartzman (eds), 13–21. Belém, Pará, Brazil, Amazon Institute for Environmental Research.
- IPCC. 2000. *Good practice guidance and uncertainty management in national greenhouse gas inventories*. Hayama, Japan, IPCC/OECD/IEA/IGES.
- IPCC. 2003. *Good practice guidance for land use, land-use change and forestry*. Hayama, Japan, IPCC/IGES.
- IPCC. 2006. *Guidelines for national greenhouse gas inventories*. Vol. 4. *Agriculture, forestry and other land use*. Japan, IGES.
- IPCC. 2007. *Fourth assessment report of the Intergovernmental Panel on Climate Change*. Cambridge, UK, and New York, Cambridge University Press.
- Open Foris. Free open-source software tools. Rome, FAO (available at <http://www.openforis.org>).
- SEPAL. System for Earth Observations, data access, processing & analysis for land monitoring. Rome, FAO (available at <https://sepal.io>).
- UNFCCC. 1995. *The United Nations Framework Convention on Climate Change*. FCCC/INFORMAL/84. Bonn, Germany.

UNFCCC. 1997. The Kyoto Protocol. Bonn, Germany, United Nations Framework Convention on Climate Change.

UNFCCC. 2004. The UNFCCC Guidelines 2004 for the preparation of National Communications by Parties included in Annex I of the Convention, Part I: Reporting guidelines on annual inventories. Document UNFCCC/SBSTA/2004/8. Bonn, Germany, United Nations Framework Convention on Climate Change.

UNFCCC. 2007a. Decision 1/13. Bali Action Plan. Bonn, Germany, United Nations Framework Convention on Climate Change (available at <http://unfccc.int/resource/docs/2007/cop13/eng/06a01.pdf>).

UNFCCC. 2007b. Decision 2/13. Reducing emissions from deforestation in developing countries: approaches to stimulate action. Bonn, Germany, United Nations Framework Convention on Climate Change (available at <http://unfccc.int/resource/docs/2007/cop13/eng/06a01.pdf>).

UNFCCC. 2009. Decision 4/CP.15. Methodological guidance for activities relating to reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries. Bonn, Germany, United Nations Framework Convention on Climate Change (available at <http://unfccc.int/resource/docs/2009/cop15/eng/11a01.pdf>).

UNFCCC. 2010. Decision 1/CP.16. Cancún Agreements. Bonn, Germany, United Nations Framework Convention on Climate Change (available at <http://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf>).

UNFCCC. 2011. *Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention*. Bonn, Germany, United Nations Framework Convention on Climate Change.

UNFCCC. 2014. *Handbook on measurement, reporting and verification for developing countries*. Bonn, Germany, United Nations Framework Convention on Climate Change (available at https://unfccc.int/files/national_reports/annex_i_natcom/application/pdf/non-annex_i_mrv_handbook.pdf). Paris.

UNFCCC. 2015. The Paris Agreement (available at http://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf).

UN-REDD. 2013. *National forest monitoring systems: monitoring and measurement, reporting and verification (M&MRV) in the context of REDD+ activities*. Rome, FAO.

UN-REDD. 2014. *Emerging approaches to forest reference emission levels and/or forest reference levels for REDD+*. Rome, FAO.

UN-REDD. 2015. *Technical considerations for forest reference emission level and/or forest reference level construction for REDD+ under the UNFCCC*. Rome, FAO.

UN-REDD. 2016. *Towards a common understanding of REDD+ under the UNFCCC: a UN-REDD programme document to foster a common approach of REDD+ implementation*. UN-REDD Technical Resource Series 3. Rome, FAO.

UN-REDD. 2017a. *Comparative analysis of the UNFCCC REDD+ related decisions and other multilateral and bilateral requirements to access results-based payments / results-based finance for REDD+ results-based actions*. UN-REDD Technical Resource Series 5.

UN-REDD. 2017b. *Towards a common understanding of REDD+ under the UNFCCC*. UN-REDD Technical Resource Series 3.

World Bank. 2004. *Sustaining forests: a development strategy*. Washington, DC.

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