TECHNICAL SERIES

43

TECHNICAL GUIDE ON THE QUANTIFICATION OF CARBON BENEFITS IN ITTO PROJECTS

JANUARY 2015

INTERNATIONAL TROPICAL TIMBER ORGANIZATION

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TECHNICAL GUIDE ON THE QUANTIFICATION OF CARBON BENEFITS IN ITTO PROJECTS

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ITTO TECHNICAL SERIES #43

INTERNATIONAL TROPICAL TIMBER ORGANIZATION

Technical guide on the quantification of carbon benefits in ITTO projects

Preferred citation: Robledo Abad, C. 2014. *Technical guide on the quantification of carbon benefits in ITTO projects*. ITTO Technical Series No. 43. International Tropical Timber Organization, Yokohama, Japan.

The International Tropical Timber Organization (ITTO) is an intergovernmental organization promoting the conservation and sustainable management, use and trade of tropical forest resources. Its members represent the bulk of the world's tropical forests and of the global tropical timber trade. ITTO develops internationally agreed policy documents to promote sustainable forest management and forest conservation and assists tropical member countries to adapt such policies to local circumstances and to implement them in the field through projects. In addition, ITTO collects, analyzes and disseminates data on the production and trade of tropical timber and funds projects and other actions aimed at developing industries at both the community and industrial scales. Since it became operational in 1987, ITTO has funded more than 1000 projects, pre-projects and activities valued at more than US$400 million. All projects are funded by voluntary contributions, the major donors being the governments of Japan, Switzerland, the United States of America, Norway and the European Union.

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ISBN 978-4-86507-016-3

Front-cover photo: Local beneficiaries in an ITTO project stand in a field of newly planted teak seedlings in Papua New Guinea. ITTO projects may use this guide to monitor the carbon benefits of their activities with a view to demonstrating successful experiences at the community or forest management unit level in 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. *Photo: H.O. Ma, ITTO*

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FOREWORD

REDD+ offers an important opportunity for investment in emission reductions and carbon sequestration in tropical countries as part of the mitigation of climate change. Meeting REDD+ requirements will not be simple, however. To fulfil the expectations of REDD+, a critical requirement is to establish a robust measuring, reporting and verification system.

Since it began operation in 1987, ITTO has been helping to build capacity in sustainable forest management (SFM) in the tropics. To increase the complementarity of ITTO projects and other international REDD+ initiatives, ITTO launched its Thematic Programme on Reducing Deforestation and Forest Degradation and Enhancing Environmental Services in Tropical Forests (REDDES) in 2009, and REDDES projects are now underway in many ITTO member countries to help put policies into practice by promoting REDD+-related activities. Among other things, REDDES aims to build capacity at the local level for measuring, assessing and reporting on the carbon benefits of field projects.

This technical guide on the quantification of carbon benefits in ITTO projects is an output of ITTO Project RED-PA 069/11 Rev.1 (F), which was financed through REDDES. The aim of the guide is to support forest managers in monitoring and reporting on the carbon benefits of ITTO projects. Although directed primarily at the managers of ITTO projects, it is likely to also help other forest managers in understanding the scientific, technical and social aspects of climate-change mitigation through forestry.

In line with the Intergovernmental Panel on Climate Change's *Good Practice Guidelines for Land Use, Land Use Change and Forestry*, which recommends monitoring carbon benefits as a function of land or activity area and emission factors per activity, this technical guide provides step-by-step advice on the actions that should be taken to include carbon benefits and climate-change mitigation in forest-related projects. The monitoring of carbon benefits should be planned in a way that is complementary to other monitoring activities.

I extend my great appreciation to Dr Carmenza Robledo Abed for her dedication in preparing this guide. I hope and expect that the guide will assist forest managers as they incorporate climate-change mitigation as a management objective in their forests and in their efforts to monitor and report on the carbon benefits arising from ITTO co-funded activities.

Emmanuel Ze Meka
Executive Director
ITTO

ACKNOWLEDGEMENTS

The author thanks reviewers in five ITTO member countries (Colombia, India, Mexico, New Zealand and the Philippines) and the many international experts who provided comments on this document, including Joachim Sell, Patricia Tobon and Thelma Krug; FAO's Susan Braatz, Serena Fortuna, Leslie Lipper, Mette Løyche Wilkie (now with UNEP), Eduardo Mansur, Marco Piazza and Simmone Rose; The Gold Standard's Moriz Vohrer; and the CVS Association's Summer Montacute. The author also thanks Caitlin Connelly and Alastair Sarre for their support in editing the document and expresses her gratitude to the ITTO Secretariat and HELVETAS Swiss Intercooperation for facilitating the project.

ACRONYMS AND ABBREVIATIONS

ACR	American Carbon Registry
AFOLU	agriculture, forestry and other land uses
AGB	aboveground biomass
A/R	afforestation and reforestation
A/R CDM	afforestation and reforestation project activities under the CDM
BEF	biomass expansion factor
BGB	belowground biomass
C	carbon
CAR	Climate Action Reserve (California, USA)
CCAR	California Climate Action Registry (USA)
CCBA	Climate, Community and Biodiversity Alliance
CCB Standard	Climate, Community and Biodiversity Standard
CCX	Chicago Climate Exchange (USA)
CDM	Clean Development Mechanism
CH_4	methane
cm	centimetre(s)
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COP	Conference of the Parties
DNA	designated national authority
ENCOFOR	Environment and Community-based Framework for Designing Afforestation, Reforestation and Revegetation Projects in the CDM
ERT	Emission reduction ton
Ex-ACT	Ex-ante Appraisal Carbon-balance Tool
FAO	Food and Agriculture Organization of the United Nations
FCPF	Forest Carbon Partnership Facility
FMU	forest management unit
GEF	Global Environment Facility
GHG	greenhouse gas
Gt	gigatonne(s)
GWP	global warming potential
HWP	harvested wood product
IFM	improved forest management
IPCC	Intergovernmental Panel on Climate Change
ITTA	International Tropical Timber Agreement
ITTO	International Tropical Timber Organization
JNR	Jurisdictional and Nested REDD+ (VCS)
LiDAR	light detection and ranging
mm	millimetre(s)

MRV	measurement (or monitoring), reporting and verification
Mt	megatonne(s)
MtC	megatonne(s) carbon
NAMA	nationally appropriate mitigation action
N	nitrogen
N_2O	nitrous oxide
Pg	petagram(s)
PoA	programme of activity
PBCCh	Platform for the Generation and Trading of Forest Carbon Credits (Chile)
REDD	reducing emissions from deforestation and forest degradation
REDDES	Thematic Programme on Reducing Deforestation and Forest Degradation and Enhancing Environmental Services in Tropical Forests
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+SES	REDD+ Social and Environmental Standards
REL	forest reference emission level
RIL	reduced-impact logging
RL	forest reference level
sCreen	Fast-track Estimation of Carbon Benefits from Forestry Activities
SFM	sustainable forest management
SOC	soil organic carbon
TARAM	Tool for Afforestation and Reforestation Approved Methodologies
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UN-REDD Programme	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation
US$	United states dollar(s)
VCS	Verified Carbon Standard

EXECUTIVE SUMMARY

The aim of this guide is to provide basic knowledge and techniques on the quantification of carbon benefits in forest-related projects. The guide targets forest managers who want to: calculate the potential carbon benefits of their projects; determine which existing climate-change mitigation framework to use; and understand the specific requirements and challenges of the various frameworks and accounting mechanisms. The guide also sets out a method for the voluntary monitoring and reporting of carbon benefits arising from ITTO projects. It provides added value to existing technical guidance on accounting for carbon benefits because it is the first guide to offer a comparison of existing accounting mechanisms. The guide is a tool for understanding the options available for given activities at the forest management unit (FMU) level and not an assessment of those mechanisms and their methods or procedures. The objective is to enable forest managers to select the best options according to their specific circumstances.

Carbon benefits from forestry activities

There are three major ways of obtaining carbon benefits in forestry activities: 1) reductions in greenhouse-gas emissions; 2) carbon sequestration/carbon enhancement; and 3) carbon substitution. Various forest management activities can provide these carbon benefits, such as forest conservation; sustainable forest management; forest plantation establishment; agroforestry; silvopastoral systems; and forest restoration, including the rehabilitation of secondary forests. Wood and non-wood forest products can be used as substitutes for more carbon-intensive materials. Changes in forest management practices (e.g. extending rotation periods) can also provide carbon benefits. Tropical forests have large carbon stocks that can be maintained and increased, providing major carbon benefits as well as other positive environmental and social impacts (Table ES1).

Three main greenhouse gases need to be considered when accounting for carbon benefits in the forest sector: carbon dioxide (CO_2), nitrous oxide (N_20) and methane (CH_4). To maintain consistency in estimating and measuring carbon benefits, it is standard practice to convert all emissions to carbon dioxide equivalent (CO_2e) values. Specific formulas and default values are available for making these conversions.

Carbon benefits result when the carbon stock in forest carbon pools increases or is maintained. There are five carbon pools in the forest: aboveground biomass, belowground biomass, deadwood, litter, and soil organic matter. Timber production means a reduction in carbon stocks in the forest and will be discounted. Because harvested wood products (HWPs) can become long-term sinks, however, they

Table ES1: Potential impacts on carbon stocks of various forestry activities

Forestry activity	Mitigation activity	Carbon benefit (according to decisions and ongoing discussion in the UNFCCC)	Relation to land-use change if no project takes place (i.e. relation to "baseline/reference")
Conservation, sustainable forest management (avoided deforestation, reduced degradation)	Maintain a forest area and long-term carbon density in areas under pressure	Greenhouse-gas emission reductions	Avoiding change from forest to non-forest Avoiding degradation
Afforestation/reforestation	Increase forest area and carbon stocks	Carbon sequestration/ carbon enhancement	Non-forest to forest
Restoration	Increase site-level carbon density		Forest to forest
Agroforestry and silvopastoral systems	Increase landscape-scale carbon stocks		Non-forest to forest
Biofuel plantations (wood and non-wood products)	Increase input for biofuel production and substitution through harvested wood products, when biofuel production does not increase greenhouse-gas forest emissions	Creating the potential for substitution	Non-forest to forest

are also recognized as a carbon pool—but outside the forest. There are currently no agreed methods for quantifying HWP carbon benefits in developing countries. Forestry activities can also produce inputs for bioenergy, with a potential carbon benefit. The quantification of this carbon benefit should consider greenhouse-gas emissions and sinks in bioenergy production as well as in the replaced energy system (e.g. fossil fuels).

Carbon benefits are normally estimated at the beginning of an intervention or in the planning phase (ex-ante estimation) and measured regularly during the course of implementation (measurement over time). To facilitate both estimation and measurement, it is good practice to stratify the intervention area into homogeneous areas and to use a conservative approach in calculating carbon benefits. Stratification may not be necessary, however, when a forestry intervention is very small.

Carbon benefits should be permanent—that is, the aim should be to avoid the re-emission of the benefits to the atmosphere. Interventions in one area should not promote a displacement of emissions to another (forested) area (i.e. "leakage" should be avoided).

Possible mitigation frameworks

This guide differentiates between three mitigation frameworks: 1) the United Nations Framework Convention on Climate Change (UNFCCC); 2) regulated markets; and 3) the voluntary market. The UNFCCC considers carbon benefits from forest ecosystems in three mechanisms: REDD+, afforestation and reforestation project activities under the Clean Development Mechanism (A/R CDM), and nationally appropriate mitigation actions (NAMAs).

1. **REDD+** refers to a negotiation item within the UNFCCC as well as to a series of ongoing processes, programmes and initiatives looking at climate-change mitigation options in the forest sector. At present, there is no binding agreement on, or including, REDD+. However the UNFCCC Conference of the Parties has agreed to a set of decisions regulating REDD+. These include modalities for ex-ante estimations (forest reference levels or forest reference emission levels) and for measurement, reporting and verification and safeguards, and they also request funding for activities. Although there are open questions on the future role of REDD+, the current situation provides an opportunity for exploring useful approaches and mechanisms for forestry activities as a way of mitigating climate change and promoting sustainable development.
2. The **A/R CDM** refers to project activities on afforestation and reforestation in the CDM and the possibility of establishing a programme of activities at the national level. Modalities and procedures for the A/R CDM were agreed in 2003, and several approved methodologies are available.
3. **NAMAs**—Chile, Dominica and Mali have started processes for creating NAMAs considering forestry activities.

Two regulated markets that could be of interest to ITTO producer member countries are the California Climate Action Registry and the Climate Action Reserve. Both are regulated in the United States.

The guide presents standards for participation in the voluntary market, where transactions are "over the counter". These standards are self-regulated but open to international scrutiny.

Considerations at the forest management unit level

This guide proposes a step-wise approach for considering carbon benefits at the FMU level (Figure ES1):

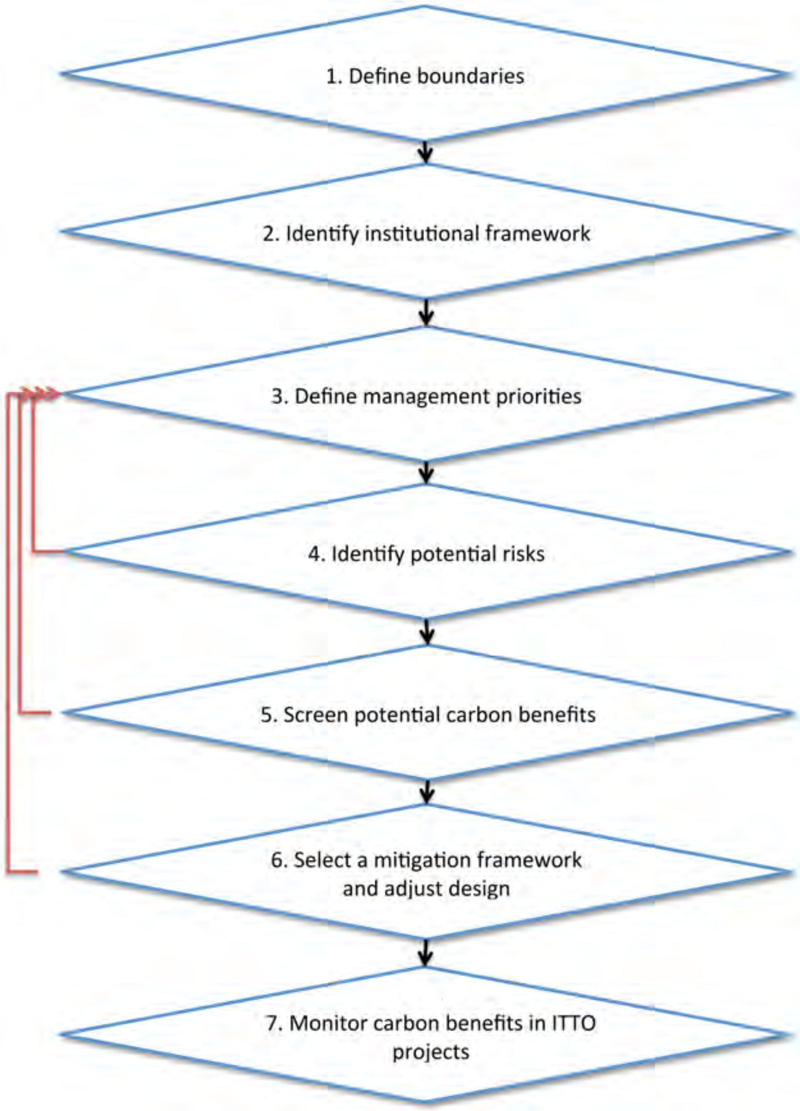
1. Define boundaries
2. Identify the institutional framework
3. Define management priorities
4. Identify potential risks
5. Screen potential carbon benefits
6. Select mitigation framework and adjust design
7. Monitor carbon benefits in ITTO projects.

For each of the first six steps, the guide addresses three questions:

1. Why is this step necessary?
2. How do I undertake this step?
3. What happens if there is a significant change?

Step 1: Define boundaries. This step considers both geographical and temporal boundaries. Geographical boundaries respond to the question of "where" the activity will be implemented, and temporal boundaries respond to the question

Figure ES1: Step-wise approach, from activity design to the monitoring of carbon benefits



Note: red lines show possible feedbacks between steps.

of "when" the intervention will take place. The answers to both questions will have an impact on the quantification of the intervention's carbon benefits. Changes to boundaries over time will affect carbon benefits and must be documented.

Step 2: Identify the institutional framework. In this guide, "institutional framework" comprises the rules and regulations applying to different social actors that are relevant to the current and future management of a given area of forestland. Social actors include forest users as well as regulatory bodies and investors in the public and private sectors and civil society. The interaction between social actors has a great influence on how forestland is used. The guide explains how to characterize the social actors and institutional agreements relevant to an intervention.

Step 3: Define the management priorities. Management priorities form the basis of the forest management plan. If the highest priority is to maximize carbon benefits, planting/harvesting activities should be geared to ensuring this, but this may affect other management priorities. ITTO has produced several guidelines that can assist in setting forest management priorities.

Step 4: Identify potential risks. The identification of risks provides information on the feasibility of management practices over time. If a project is liable for the carbon benefits in an FMU, it is responsible for keeping those benefits secure. Risks can affect the permanence of carbon benefits and therefore need to be managed. Categories of potential risk are: political and regulatory; social; economic and financial; and natural disturbances and hazards.

Step 5: Screen potential carbon benefits. Screening is aimed at obtaining preliminary estimates of the potential carbon benefits of a forestry project or activity. It should be doable with information contained in the forest management plan and using existing default values for estimating carbon benefits. The three recommended steps in screening potential carbon benefits are: 1) selecting the most important carbon pools; 2) defining the strata; and 3) selecting the most appropriate screening tool.

Step 6: Select the mitigation framework and adjust design. The mitigation framework defines which activities are eligible, the regulations for carbon accounting and monitoring requirements, and the available carbon markets or payment schemes. To realize the carbon potential of an intervention it is important, therefore, to select the most appropriate framework. To facilitate the selection process and the quantification of carbon benefits, the guide presents the main principles and the available methodologies and tools of the following mitigation frameworks:

- UNFCCC
  - REDD+, including the processes employed by the Forest Carbon Partnership Facility and the UN-REDD Programme
  - Afforestation and reforestation project activities under the CDM
- Regulated markets
  - California Climate Action Registry
  - Climate Action Reserve
- Voluntary carbon standards
  - American Carbon Registry
  - Plan Vivo
  - The Gold Standard
  - Verified Carbon Standard
- Voluntary quality standards
  - Climate, Community and Biodiversity Standards
  - REDD+ Social and Environmental Standards.

Table ES2: Summary of the main challenges for monitoring carbon benefits in SFM

Challenges for monitoring the carbon benefits of SFM	Strategies currently used	Remaining challenges
Clarifying forest status (e.g. the stage of degradation), which is necessary for defining boundaries and strata	Remote sensing is a good option for differentiating forest from non-forest but is less useful for determining the state of degradation	Estimating the state of degradation, which is necessary for accurate stratification
Generating appropriate aboveground biomass equations or quantification for different sites; estimating the degradation stage	Use radar and optical remote sensing technology	Radar remote sensing can acquire data irrespective of haze and the persistently cloudy weather conditions common in the humid tropics, but the signal of all available radar sensors tends to saturate at a lower value than the actual aboveground biomass volumes of tropical rainforests and there are also errors in mountain areas
	Use LiDAR sensors to overcome sensor saturation	Large-scale applications are not feasible due to narrow swath and high costs
Estimating aboveground biomass growth after harvesting (under differing regimes)	Ongoing research projects are aimed at developing the necessary models and testing aboveground biomass estimation techniques, combined with field inventories	
Quantifying carbon benefits in carbon pools other than aboveground biomass	Field inventories and ongoing research	Reducing the cost of field inventories for non-aboveground biomass carbon pools (in remote areas)

Guidance on the voluntary monitoring of carbon benefits in ITTO projects

Step 7: Monitoring carbon benefits in ITTO projects. This section clarifies the steps that ITTO project managers may take in monitoring the carbon benefits of projects when no mitigation framework has been used (if the ITTO project participates in an established mitigation framework, carbon benefits may be reported on the basis of the monitoring requirements of that framework). The guide details "how" to do this monitoring and "who" is responsible for it. Information is also provided on how to establish the land/activity area, the emission factors, how to deal with uncertainties, how to establish and quantify leakage, and how to involve stakeholders in monitoring activities. An annex provides a detailed format for the voluntary monitoring and reporting on the carbon benefits of ITTO projects.

Although it is recognized that sustainable forest management (SFM) generates carbon benefits, it is only starting to be included as an activity in mitigation frameworks. This section documents the opportunities for SFM, as well as the challenges involved in monitoring the carbon benefits of SFM (Table ES2).

In promoting the carbon benefits of an FMU, it is important to clarify who owns those benefits. This is a requirement for the sale of carbon certificates, which are becoming important in REDD+ negotiations. The clarification of the ownership of carbon benefits may be voluntary or required, depending on the mitigation framework. It should be in line with land-tenure and land-use regulations and customary rights and claims.

Guidance on carbon accounting in other intergovernmental organizations

To promote consistency among intergovernmental organizations and avoid the duplication of work at the level of forest managers, guidance for accounting carbon benefits developed by intergovernmental organizations other than ITTO is briefly described.

1 INTRODUCTION

This technical guide is the second output of ITTO Project RED-PA 069/11 Rev.1 (F): *Quantifying carbon benefits of ITTO projects*, which was financed through ITTO's Thematic Programme on Reducing Deforestation and Forest Degradation and Enhancing Environmental Services in Tropical Forests (REDDES) in 2011. The guide is a response to the need to support forest managers[1] in:

- increasing their knowledge on the scientific, technical and social aspects of climate-change mitigation and forestry;
- their efforts to include climate-change mitigation as a management objective;
- understanding the possibilities for obtaining carbon finance for forestry activities; and
- monitoring and reporting carbon benefits from ITTO co-funded activities.

The guide is structured as follows:

- Chapter 2 sets out the scope and context of the guide.
- Chapter 3 presents the main concepts related to estimating, measuring and monitoring carbon benefits in forestry activities. It includes an explanation of the ex-ante estimation and ex-post quantification of carbon benefits, as well as clarification of the concepts of stratification, permanence, leakage, uncertainties and data availability.
- Chapter 4 presents a general taxonomy of the mitigation frameworks, including those of the United Nations Framework Convention on Climate Change (UNFCCC), other regulated markets and the "voluntary market".
- Chapter 5 presents a roadmap of steps to be taken at the level of the forest management unit (FMU) to include carbon benefits and climate-change mitigation in project activities. It contains the general requirements for each climate-change mitigation framework at the FMU level, as well as a compilation of the approved carbon accounting methodologies by each mitigation framework and carbon standard. It further provides guidance for ITTO project managers interested in participating in any of these frameworks.
- Chapter 6 provides specific guidance on the voluntary monitoring and reporting of the carbon benefits generated by ITTO projects.
- Chapter 7 presents the efforts of other multilateral organizations towards integrating carbon accounting into their projects.
- Annexes provide descriptions of the tools available for the mitigation frameworks and a possible format for the voluntary reporting of the carbon benefits generated by ITTO projects.

This guide is intended as a living document that should be updated over time according to developments in the UNFCCC and the voluntary carbon markets.

1 In this guide, forest managers are defined as persons or organizations who decide on the management activities to be undertaken at a given site and who are also involved in the implementation of those activities.

2 SCOPE OF THE GUIDE

Many publications provide guidance on monitoring carbon benefits from forestry activities. These include: Baker et al. (2010); Diaz and Delaney (2011); FAO (2013); GOFC-GOLD (2011); Harris et al. (2012); Herold and Johns (2007); Herold and Skutsch (2011); Hodgman et al. (2012); MacDicken (1997); Muraya and Baraka (2010); Pearson et al. (2005a, 2005b, 2007, 2012); Petrokofsky et al. (2012); Ravindranath and Ostwald (2007); Rombold (2003); UN-REDD Programme (2013a); Walker et al. (2012); Watson (2009); and Zhang et al. (2012).[2]

The Intergovernmental Panel on Climate Change (IPCC) also provides guidance. The *Good Practice Guidance for Land Use, Land-Use Change and Forestry* (IPCC 2003) provides direction on carbon accounting at the national and project levels, as well as a series of default regional formulas and values.[3] The IPCC has put out additional guidance in its *Guidelines for National Greenhouse Gas Inventories* (IPCC 2006), which deals with the quantification of greenhouse-gas (GHG) emissions and sinks in agriculture, forestry and other land uses (AFOLU).

Numerous other organizations have prepared guidelines for quantifying carbon benefits, such as the Global Environment Facility (GEF), the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP) and the UNEP–Risoe Center, the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation (UN-REDD Programme), and the Food and Agriculture Organization of the United Nations (FAO). The joint guidelines of UNDP and GEF for integrating estimates of carbon benefits into GEF projects (Pearson et al. 2005a) provide detailed guidance on the quantification of carbon benefits and can be used in any ongoing forestry project.[4] In 2007, the GEF and other multilateral organizations, including UNDP and the World Bank, started a project costing in excess of US$10 million aimed at providing a cost-effective, user-friendly and scientifically rigorous methodology for modelling, measuring and monitoring carbon and GHG mitigation benefits in projects dealing with natural resources in all climate zones and land-use systems. Other organizations, such as FAO and UNEP, have produced guidelines on climate-change mitigation

The guide seeks to address a range of important questions.

General questions:

- What are the carbon benefits of forestry activities? (Chapter 3)
- How can these benefits be measured? (Chapter 3)
- What existing frameworks are relevant to forestry activities? (Chapter 4)

Questions related to carbon benefits in specific interventions:

- How should a forest manager interested in carbon benefits proceed? (Chapter 5)
- Are the potential carbon benefits significant? (Chapter 5)
- How can the major risks and corresponding strategies be identified? (Chapter 5)
- Which climate-change mitigation framework best fits particular circumstances, and have national decisions changed the options? (Chapter 5)
  - Is REDD+ an option?
  - What about the CDM market?
  - Should another regulated market be used?
  - Should the voluntary market be used?
- How do you select a methodology that fits your circumstances? (Chapter 5)
- What are the implications in terms of data collection? (Chapter 5)
- What methods and tools are available for monitoring carbon benefits according to the different mitigation frameworks? (Chapter 5)
- Which stakeholders should be included, and how? (Chapter 5)
- Who owns the carbon benefits? (Chapter 5)
- Are there specific considerations for monitoring the carbon benefits in sustainable forest management? (Chapter 5)
- How can the carbon benefits in ITTO projects be monitored and reported if the project is not participating in a mitigation framework? (Chapter 6)
- Which other intergovernmental organizations request the monitoring of carbon benefits? (Chapter 7).

2 Guidelines for evaluating the social impacts of forestry activities aimed at mitigating climate change (e.g. by Forest Trends, the Climate, Community and Biodiversity Alliance and the Rainforest Alliance) are discussed in Chapter 5. The main focus of this guide, however, is on technical aspects.

3 The *IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry* is available in Arabic, Chinese, English, French, Russian and Spanish at: www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html.

4 The GEF guidebook on integrating estimates of carbon benefits into GEF projects can be downloaded at: www.winrock.org/ecosystems/files/GEF_Guidebook.pdf.

and the opportunities and challenges this poses for forestry activities (see Chapter 7).

The current guide considers and builds on this existing body of work. It aims to simplify decisions for using climate-change mitigation mechanisms within the UNFCCC, other regulated markets, and voluntary markets. It targets forest managers at the FMU level who want to: calculate their potential carbon benefits; determine which existing mechanism to use; and understand the specific requirements and challenges of the various mechanisms and methodologies. The guide also sets out a method for the voluntary monitoring and reporting of carbon benefits arising from ITTO projects.

Thus, this guide provides added value to existing technical guidelines for accounting for carbon benefits because it is the first guide to offer a comparison of existing accounting mechanisms. The guide is not an assessment of those mechanisms and their methods or procedures, but rather a tool to help understand the options available for given activities at the FMU level. The objective is to enable forest managers to select the best option according to their specific circumstances.

3 CARBON BENEFITS IN FOREST ACTIVITIES: AN OVERVIEW

Tropical forests are landscapes in change. On one side are major social and economical drivers of forest degradation and conversion to agriculture and other land uses; on the other side is increasing awareness of the importance of a sustainable supply of forest goods and environmental services. Forest managers are called on to use forests sustainably and in ways that generate sufficient economic returns and environmental benefits. The mechanisms aimed at mitigating climate change can serve as tools to help achieve this.

For a forest ecosystem to help mitigate climate change, its carbon stock must either remain steady or increase. In many forests, climate-change mitigation is unlikely to be the only forest management objective; thus, a forest's carbon benefits should be seen as complementary to other management objectives. This chapter presents the basic elements for estimating carbon benefits during the planning and implementation phases of a given forestry activity.

3.1 Forestry activities: potential carbon benefits

There are three main ways in which forestry activities can help mitigate climate change:

1. *carbon substitution*—producing forest products as substitutes for emission-intensive materials;
2. *carbon sequestration/carbon stock enhancement*: promoting carbon sequestration through forest growth or by increasing forest density; and
3. *GHG emission reduction*—reducing GHG emissions from forests by reducing deforestation and forest degradation.

These three ways are not mutually exclusive; indeed, at a landscape scale they can be complementary, not only in mitigating climate change but also in generating socioeconomic and environmental co-benefits. However, the co-benefits and tradeoffs are site-specific and depend on the size of the intervention, the governance arrangement and local circumstances. Thus, an analysis of the complementarity of climate-change mitigation approaches and the co-benefits and tradeoffs should be undertaken in light of the specificities of a given project.

As a general principle, the use of forestry activities as a means of mitigating climate change should be based on (national) development priorities. For the purposes of this guide, the three main forest-based climate-change mitigation options are seen as potential "carbon benefits" of forest management activities in the tropics.

3.1.1 Carbon substitution

Carbon substitution takes place when one material is replaced by another, less carbon-intensive material. For example, wood products can be used in construction as a less carbon-intensive material than steel, and forest based bioenergy can be used as a replacement for fossil fuels. Quantifying carbon substitution is challenging for three reasons:

1. The total substitution effect can be quantified only if carbon accounting is available for both the substitute material and the substituted material. This information is required to answer two questions: What has been replaced? What emissions were generated in the production of these materials?
2. Uncertainties exist about the lifespan of some replacement materials (i.e. How long will the substitution effect last?).
3. The quantification of GHG emissions for some substitute products (e.g. biofuel) is highly contested because of uncertainties about emissions in the production phase as well as the potential for indirect emissions (e.g. from the conversion of natural forests for biofuel plantations).

3.1.2 Carbon sequestration and/or carbon stock enhancement

Carbon sequestration and the enhancement of forest carbon stocks can be achieved by increasing the absorption of carbon (via photosynthesis) in vegetation and soil, for example by increasing forest area and/or forest density through management practices such as plantation establishment and agroforestry, the use of silvopastoral systems, and the rehabilitation or restoration of degraded forest. Because trees have a much longer lifespan than agricultural crops, they act as long-term reservoirs, potentially “locking up” carbon for decades, even centuries, in trees and soil. Therefore, activities such as forest restoration and forest plantation establishment can contribute substantially to climate-change mitigation.

The potential for forest-based carbon sequestration and carbon enhancement can be significant in the tropics but challenging to achieve (Hodgman et al. 2012). There is considerable variation in the potential for carbon sequestration in forestry activities (mainly through plantations and agroforestry): Sathaye et al. (2006), for example, estimated the range at 18–94 megatonnes (Mt) of carbon dioxide (CO_2) equivalent (usually denoted as CO_2e). A lack of availability of land, water and other resources, socioeconomic constraints, and a lack of clarity on land and carbon tenure are other potential challenges that need to be overcome to maximize the use of forest-based carbon sequestration in some tropical countries.

3.1.3 Greenhouse gas emission reductions[5]

The burning of fossil fuels is the largest source of GHG emissions worldwide (IPCC 2007; IPCC 2014a). The second most important source is the land-use sector—primarily tropical deforestation, forest degradation and forest fires (IPCC 2007; IPCC 2014a)—which accounts for about 25% of annual greenhouse emissions worldwide (IPCC 2014a). In addition to their impacts on climate, deforestation and ecosystem degradation are among the most significant environmental problems faced by developing countries because of their potentially long-term negative impacts on biodiversity, economic opportunities and social equity.

Forestry activities aimed at reducing or avoiding deforestation and forest degradation can have a potential carbon benefit if they result in a reduction in GHG emissions. Changes in management can further reduce GHG emissions.

In its most recent assessment report, the IPCC discussed the following forestry activities: reducing deforestation; afforestation/reforestation; forest management; and forest restoration (Bustamante et al. 2014; Smith et al. 2014). It also discussed activities in “integrated systems”, including agroforestry and mixed-biomass production systems. All these activities are relevant to ITTO and may be components of ITTO projects. Table 1 summarizes the main forest management activities and their relation to carbon benefits as well as the mitigation activities, as presented in the IPCC’s fourth assessment report (IPCC 2007). Minor changes in forest management at the FMU level

Table 1: Potential impacts on carbon stocks of various forestry activities

Forestry activity	Mitigation activity	Carbon benefit (according to decisions and ongoing discussion in the UNFCCC)	Relation to land-use change if no project takes place (i.e. relation to “baseline/reference”)
Conservation, sustainable forest management (avoided deforestation, reduced degradation)	Maintain a forest area and long-term carbon density in areas under pressure	Greenhouse-gas emission reductions	Avoiding change from forest to non-forest Avoiding degradation
Afforestation/reforestation	Increase forest area and carbon stocks	Carbon sequestration/carbon enhancement	Non-forest to forest
Restoration	Increase site-level carbon density		Forest to forest
Agroforestry and silvopastoral systems	Increase landscape-scale carbon stocks		Non-forest to forest
Biofuel plantations (wood and non-wood products)	Increase input for biofuel production and substitution through harvested wood products, when biofuel production does not increase forest greenhouse-gas emissions	Creating the potential for substitution	Non-forest to forest

Sources: Adapted from IPCC (2007, 2014a).

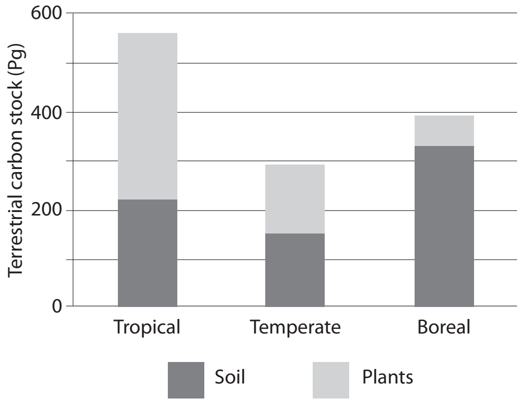
5 Some authors refer to forestry options for reducing GHG emissions as “carbon conservation”.

can have important impacts on carbon stocks as well. For example, extending the rotation period, reducing forest damage through reduced-impact logging, reducing fertilizer applications, and improving forest fire management can all generate carbon benefits.

To understand the potential size of carbon benefits in forestry activities it is useful to quantify the current carbon stocks in tropical forests. Tropical forests worldwide contain approximately 540 petagrams (Pg) of carbon, the major part of it (340 Pg) in living plants and most of the remainder in the soil. In comparison, boreal forests contain less than 400 Pg of carbon, most of it (338 Pg) in the soil (Figure 1)[6], indicating broad differences in the carbon dynamics of the two biomes (Price et al. 2012).

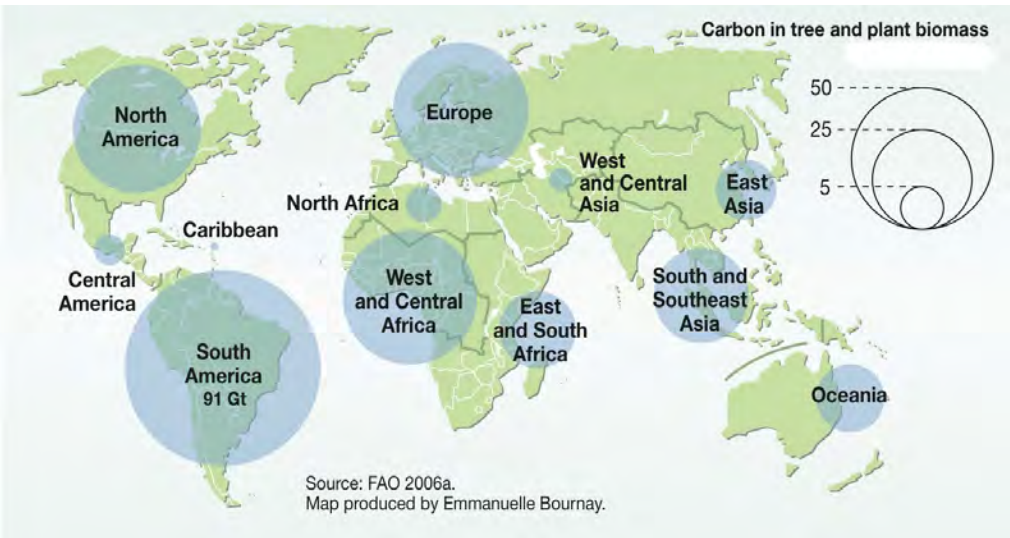
In the tropics there are important variations in carbon stocks among and within regions (Table 2 and Figure 2). On a local scale, factors such as soil fertility, precipitation and disturbance regimes can influence the amount of biomass and carbon (Cid-Liccardi et al. 2012; Gibbs et al. 2007; Olander et al. 2008).

Figure 1: Distribution of world forest carbon stock, by biome



Source: Price et al. (2012).

Figure 2: Distribution of carbon in tree and plant biomass



Source: www.grida.no/graphicslib/detail/forest-carbon-stock-per-region_1760. Used with permission.7

6 1 petagram (Pg) = 1 gigatonne (Gt).

7 Graphic designed by P. Rekacewicz, with C. Marin, A. Stienne, G. Frigieri, R. Pravettoni, L. Margueritte and M. Lecoquierre. Uploaded on 25 February 2012 by Grid-Arendal.

Table 2: Carbon stock ranges in tropical forests

Forest type	Region	MtC/ha
Rainforest	Neotropics (Central and South America)	120–400
	Africa	130–510
	Asia–Pacific	120–680*
Montane forest	Neotropics (Central and South America)	60–230
	Africa	40–190
	Asia–Pacific	50–360
Seasonal forest	Neotropics (Central and South America)	210
	Africa	140
	Asia–Pacific	130

** Peat swamp forests in the Asia–Pacific region may contain > 1000 MtC/ha.*

Sources: Cid-Liccardi et al. (2012); deFries et al. (2002); IPCC (2006); Houghton (2003, 2005).

Summary

There are three major options for obtaining carbon benefits in forestry activities: carbon substitution; carbon sequestration/carbon enhancement; and reductions in greenhouse-gas emissions. Various forest management activities can provide these carbon benefits, such as forest conservation; sustainable forest management; forest plantation establishment; agroforestry; silvopastoral systems; and forest restoration, including the rehabilitation of secondary forests. Wood and non-wood forest products can be used as substitutes for more carbon-intensive materials. Changes in forest management practices (e.g. extending rotation periods) can also provide carbon benefits. Tropical forests have large carbon stocks that can be maintained and increased, providing major carbon benefits as well as other positive environmental and social impacts.

3.2 Carbon accounting: what is to be estimated, measured and monitored?

Forests emit three main GHGs: carbon dioxide, methane (CH_4) and nitrous oxide (N_2O); to a lesser extent they may also emit carbon monoxide (CO). To maintain consistency in estimating and measuring carbon benefits, it is standard practice to convert all emissions to CO_2e values.

Various metrics can be used to quantify the contribution of GHGs to climate change. Up to 2013, the most common of these was "global warming potential" (GWP)[8] (IPCC 2013), but IPCC (2013)[9] also mentions "global temperature change potential". This guide focuses on GWP because most ITTO producer member countries and most approved methodologies use this metric. Methane, carbon dioxide and nitrous oxide have different warming potentials; that is, they interact in different ways with the atmosphere and thus have different impacts on climate change over time. The conversion of a given volume of these GHGs to CO_2e values is done using default values for their GWPs and the following formula:

mass CO_2e = (mass of GHG) * (GWP)

Table 3 shows the GWPs of the three main forestry-relevant GHGs. Normally, the values used in calculations are the 100-year values (marked in red in the table) (IPCC 1996).[10] Other values may be used, however, such as those given in IPCC (2006) and IPCC (2013), according to national circumstances; the key thing is to clearly document the methodology.

Carbon values are converted to CO_2e values using the following formula:

(mass) CO_2e = (mass) C * 44/12[11]

For example, the mass CO_2e of 15 tonnes of carbon becomes:

15 * 3.67 = 55.05 tonnes CO_2e.

Table 3: Default values for global warming potential of forestry-relevant greenhouse gases

Greenhouse gas	Lifetime	Global warming potential time horizon			Source[a]
		20 years	100 years	500 years	
Carbon dioxide	Complex	1	1	n.a.	IPCC (2013)
		1	1	1	IPCC (2007)
		1	1	1	IPCC (2001)
		1	1	1	IPCC (1996)
Nitrous oxide	121	264	265	n.a.	IPCC (2013)
	114	289	298	153	IPCC (2007)
	114	275	296	156	IPCC (2001)
	120	280	310	170	IPCC (1996)
Methane	12.4	84	28	n.a.	IPCC (2013)
	12	72	25	7.6	IPCC (2007)
	12	62	23	7	IPCC (2001)
	14	56	21	6.5	IPCC (1996)

a Sources of the default values in Table 3: IPCC (2013) (Fifth Assessment Report, Working Group I, Chapter 8, Appendix 8.A); IPCC(2007) (Fourth Assessment Report, Working Group I, Chapter 2); IPCC (2001) (Third Assessment Report, Working Group I, Chapter 6); IPCC (1996) (Second Assessment Report, Working Group I, Chapter 2).

8 GWP accounts for the radioactive efficiencies of the various substances and their lifetimes in the atmosphere and gives values relative to those for the reference gas, carbon dioxide (IPCC 2013).

9 This refers to the work of Working Group I–Science of the IPCC in its Fifth Assessment Report.

10 The UNFCCC COP has agreed to use these values. However, future agreements may ask for adjustments.

11 44/12 = 3.6666666 (≈3.67).

Summary

Three main greenhouse gases (GHGs) need to be considered when accounting for carbon benefits in the forest sector: carbon dioxide, nitrous oxide and methane. These GHGs need to be converted to carbon dioxide equivalent (CO2e) values. Data on carbon benefits are given either in mass carbon (e.g. tonnes carbon) or mass carbon dioxide (e.g. tonnes carbon dioxide). It is necessary to be consistent and to be sure that all data are converted to CO2e. Specific formulas and default values are available for making these conversions.

3.2.1 Carbon pools, harvested wood products and bioenergy resources

This section looks at issues related to where carbon benefits occur. It explains the potential carbon benefits within the forest ("forest carbon pools"), and those that may occur outside the forest.

3.2.2 Carbon benefits within the forest

The IPCC defines five carbon pools (or reservoirs) within forests: aboveground biomass (AGB); belowground biomass (BGB); dead wood; litter; and soil organic carbon. Changes in carbon stocks in the forest take place through increases or decreases in these pools (Figure 3 and Table 4).[12]

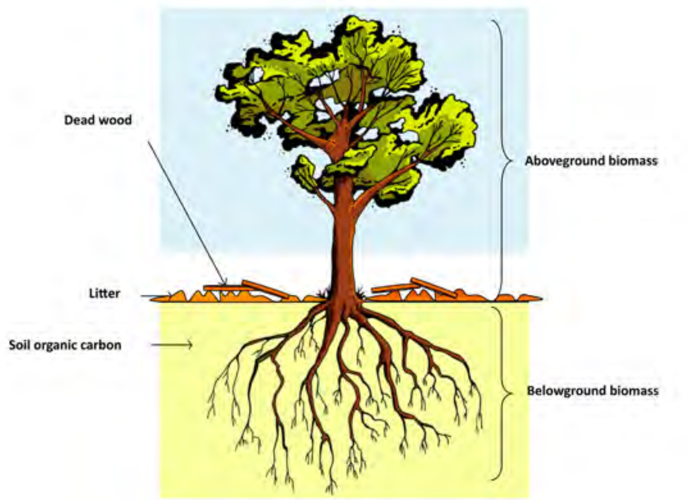
As far as possible, all carbon pools should be included in calculations. The IPCC and UNFCCC indicate that a pool should only be excluded "whenever the carbon stock changes in the pool are not significant". Approved methodologies exist for accounting for the various carbon pools according to specific applicability conditions (Chapter 5 provides more information on specific methodologies).

In addition to stock changes in these five forest carbon pools, emissions in the forest sector may also occur as a result of the use of harvesting machinery and during the transportation of harvested forest goods.

3.2.3 Carbon benefits outside the forest

Harvested wood products. Harvested wood products (HWPs) constitute a carbon pool (or reservoir) outside the forest. IPCC (2006) defines HWPs as "all wood material (including bark) that leaves harvest sites". The harvesting of timber products reduces carbon stocks in the forest's living biomass, and this loss is accounted for as a reduction in the potential *in situ* carbon benefit. If, however, the harvested wood is used in construction or for other non-destructive purposes, it may constitute a long-term carbon sink; it may also be used as a substitute for other materials with higher carbon intensity. As indicated by the IPCC, the carbon benefits of HWPs decline over time as the products are discarded.

Figure 3: Forest carbon pools



Source: Robledo and Blaser (2008).

Forest products as bioenergy source. Wood and non-wood forest products can be used in the production of bioenergy. Potential bioenergy resources in forestry include wood residues and the outputs of bioenergy plantations and dedicated tree/forest crops (e.g. palm oil or jatropha). The carbon benefit associated with bioenergy use is in carbon substitution. The quantification of carbon benefits arising from substitution involves calculating the difference in GHG emissions and sinks between the substitute and substituted materials. For example, if jatropha replaces a fossil fuel, the carbon benefit would be the difference between the net GHG emissions of the fossil fuel and those caused by the use of jatropha. The production of biofuels can be energy-intensive, and bioenergy cannot be considered carbon neutral, although it is based on a

12 The GEF guidelines for integrating estimates of carbon benefits refer to seven pools and differ from this guide in two main ways: 1) they include harvested wood products; and 2) they divide aboveground biomass into two pools: aboveground trees and aboveground non-trees.

Table 4: Definitions of carbon pools

Pool		
Living biomass	Aboveground biomass	Includes all biomass of living vegetation, both woody and herbaceous, above the soil, including stems, stumps, branches, bark, seeds and foliage. Note: In cases where the forest understorey is a relatively small component of the aboveground biomass carbon pool, it is acceptable for the methodologies and associated data used in some tiers (Box 1) to exclude it, provided the tiers are used in a consistent manner throughout the inventory time series.
	Belowground biomass	Includes all biomass of live roots. Fine roots of less than (suggested) 2 mm diameter are often excluded because these often cannot be distinguished empirically from soil organic matter or litter.
Dead organic matter	Dead wood	Includes all non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Dead wood comprises wood lying on the surface, dead roots, and stumps larger than or equal to 10 cm in diameter (or the diameter specified by the country).
	Litter	Includes all non-living biomass with a size greater than the limit for soil organic matter (suggested at 2 mm) and less than the minimum diameter chosen for dead wood (e.g. 10 cm), lying dead, in various states of decomposition, above or within the mineral or organic soil. This includes the litter layer as usually defined in soil typologies. Live fine roots above the mineral or organic soil (of less than the minimum diameter limit chosen for belowground biomass) are included in litter where they cannot be distinguished from it empirically.
Soils	Soil organic matter[a]	Includes organic carbon in mineral soils to a specified depth chosen by a country and applied consistently through the time series.[b] Live and dead fine roots and dead organic matter within the soil that are less than the minimum diameter limit (suggested at 2 mm) for roots and dead organic matter are included with soil organic matter where they cannot be distinguished from it empirically. The default for soil depth is 30 cm.

[a] Includes organic material (living and non-living) within the soil matrix, operationally defined as a specific size fraction (e.g. all matter passing through a 2 mm sieve). Soil carbon stock estimates may also include soil inorganic carbon if using a Tier 3 method. Carbon dioxide emissions from liming and urea applications to soils are estimated as fluxes using a Tier 1 or Tier 2 method. See Box 1 for clarification on tiers.

[b] Carbon stocks in organic soils are not explicitly computed using Tier 1 or Tier 2 methods (which estimate only annual carbon flux in organic soils), but carbon stocks in organic soils can be estimated using a Tier 3 method. The definition of organic soils for classification purposes is provided in Chapter 3 of IPCC (2006). See Box 1 for clarification on tiers.

Source: IPCC (2006) (Volume 4).

renewable material. When using forest products as a bioenergy source, sustainability aspects—such as impacts on food production and land competition at the local level—should also be considered; otherwise, the carbon benefits derived from the use of bioenergy may be lost due to the displacement of destructive activities such as deforestation (i.e. “leakage”).

3.2.4 Ex-ante estimation of expected carbon benefits

The ex-ante estimation of expected carbon benefits is the expected difference between the CO_2e impact of an intervention and what would happen without intervention. Normally, an ex-ante estimate is made during the planning phase of a project. It can be calculated by comparing the expected carbon stocks or GHG emissions (figures 4–6). The scenario (projection over time) showing what would have happened without intervention is commonly called “business as usual”.

Figure 4 shows a typical curve of the expected changes in carbon stocks from activities aimed at promoting sequestration or enhancing carbon stocks (e.g. through plantations). Typically, the carbon stocks will be lower in the absence of an intervention. Figure 5 shows the expected changes in carbon stocks from activities aimed at reducing GHG emissions (e.g. through forest conservation). In this case, carbon stocks will be reduced dramatically without intervention (e.g. due to deforestation or forest degradation). Carbon stocks are therefore higher in the "intervention" scenario. Figure 6 shows the difference in GHG emissions between scenarios with and without intervention. Typically, one expects to have fewer GHG emissions with an intervention (e.g. conservation) than without it (e.g. continuation of deforestation).

Figure 4: Carbon sequestration/carbon enhancement

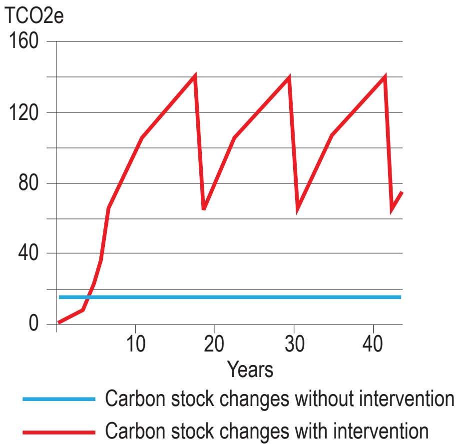
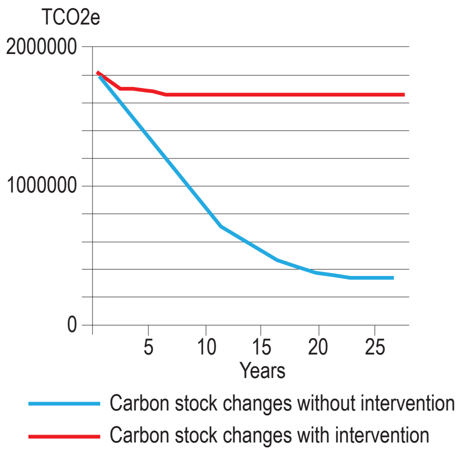
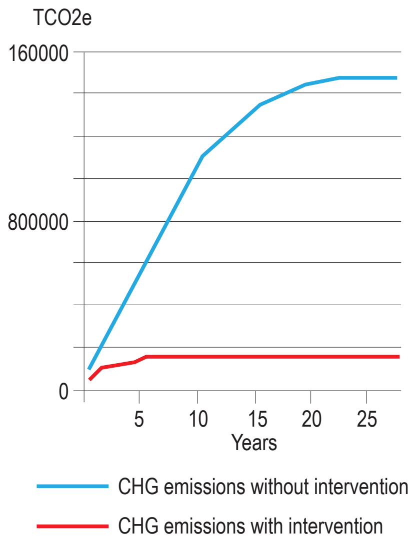


Figure 5: Change in carbon stock, with and without intervention



Preparing an ex-ante estimate requires a robust understanding of past and future land-use trends in the designated area as well as of the project's proposed management activities. Historical trends can be extrapolated only if no new developments are expected—that is, when the future context is likely to be similar to that of the past. If the context is expected to change in a significant way, such as through a new forest policy, this will affect future

Figure 6: Difference in GHG emissions, with and without intervention



changes in carbon stocks and GHG emissions, even without intervention. Such future changes need to be reflected in the ex-ante estimation of carbon benefits.

The regulation of the modalities, procedures and methods available for conducting ex-ante estimations depends on the climate-change mitigation framework employed. For projects under the Clean Development Mechanism (CDM), the ex-ante estimate is called the "baseline", while under REDD+[13] it is called either the reference emission level or the reference level. (Chapter 4 describes the climate-change mitigation frameworks and mechanisms, and Chapter 5 discusses specific modalities and procedures.)

3.2.5 Measuring and monitoring changes in carbon stocks

Monitoring changes in carbon stocks involves the measurement of progress in accumulating carbon in carbon pools or reducing GHG emissions over the length of a project or forestry activity. Regular monitoring ensures an accurate account of progress and can help identify potential difficulties and options for increasing benefits. Monitoring, therefore, is aimed both at the ongoing quantification of carbon benefits and at facilitating management adjustments.

13 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.

Four categories of methods for measuring forest biomass and estimating carbon are currently in use:

1) forest inventory (biomass) and corresponding allometric equations;
2) remote sensing (relationship between biomass and land cover);
3) eddy covariance (direct measurement of carbon dioxide release and uptake); and
4) the inverse method (relationship among biomass, carbon dioxide flux and carbon dioxide atmospheric transport).

These methods vary in their accuracy and the resolution at which data can be obtained. Each has its advantages and disadvantages, and appropriate circumstances exist for the use of each in measuring carbon dioxide flux and carbon storage at various temporal and spatial scales of evaluation and measurement (Zhang et al. 2012). A combination of the first two approaches—forest inventory and remote sensing—is most commonly used to measure changes in carbon stocks over time in activities in developing countries. Eddy covariance and the inverse method are used infrequently in developing countries for various reasons: eddy covariance is advanced in terms of accuracy and resolution and is normally used for measurement in small areas (e.g. 1 hectare), but it has some systematic restrictions; and the inverse method is used at the continental or global scales (Zhang et al. 2012). A major challenge in the use of any of these methods is obtaining high confidence intervals, because large sets of data are necessary for this.

3.2.6 Stratification

The IPCC defines stratification as the division of an area into subpopulations (or strata) according to specific criteria, so that each stratum can be taken as a relatively homogenous unit (IPCC 2003).

The stratification of (project) areas can cost-effectively increase the accuracy and precision of measurements and monitoring. The size and spatial distribution of a project does not influence this step—whether the land is in a single large, contiguous block or many small parcels, it can be stratified in the same manner. In general, stratification decreases the costs of measuring and monitoring because it reduces the sampling effort required to achieve a given level of confidence. The stratification should be carried out using criteria that are related directly to the variables to be estimated, measured and monitored—that is, carbon stocks in the various forest carbon pools.

The following criteria are commonly used for undertaking the stratification: land use; vegetation type; age; slope and topography; drainage; and proximity to roads or settlements (IPCC 2003; Pearson et al. 2005b).

According to IPCC (2003), there is a tradeoff between the number of strata and the required sampling intensity. The goal is to balance the number of strata against the total number of plots needed to adequately sample each stratum.

3.2.7 Permanence, leakage and conservativeness

This section discusses two major challenges—permanence and leakage—in estimating, measuring and monitoring carbon benefits, and the use of conservativeness as a way of reducing overestimates of carbon benefits.

Permanence relates to the time that carbon remains in the biosphere. For various reasons, such as fire and pest outbreaks, carbon can be released prematurely to the atmosphere, reversing mitigation benefits. The stocks in forest carbon pools could be released at any time, making emission reductions and sequestration effects "non-permanent". The IPCC has clarified that a short-term reduction in emissions or increase in a carbon sink has a positive short-term impact in mitigating climate change. However, it is important to promote an effect on the atmosphere that is as permanent as possible.

Leakage and emissions displacement are concepts around the potential for unintended consequences—GHG emissions caused by an intervention beyond the boundaries of the intervention area. In the CDM, leakage is defined as "the increase in GHG emissions by sources that occurs outside the boundary of a given area [in afforestation and reforestation—A/R—project activities under the CDM—known collectively as A/R CDM—in the project area] which is measurable and attributable to the particular activities envisaged" (UNFCCC Decision 5/CMP.1). A great difficulty in dealing with this definition is that it refers to emissions outside the intervention area but not does provide specific guidance on how to define "outside". It is challenging, therefore, to create consistent and coherent rules for attributing emissions outside a project intervention area to the intervention itself.

Conservativeness is seen as good practice in reducing the risk of overestimating carbon benefits. Where accounting relies on assumptions, values and procedures with high uncertainties, the most conservative option in the biological range should be chosen so as not to overestimate carbon sinks or underestimate GHG sources. Conservative carbon estimates can also be achieved through the omission of carbon pools, as long as those pools are not net emitters (Watson 2009).

3.2.8 Availability of data

Accurate estimates of changes in the forest carbon pools require large amounts of data. To the extent possible, both data and algorithms should be based on measurements made in the intervention area. This is not always possible, however, and the IPCC has developed a three-tier system for data to facilitate comparable carbon accounting (Box 1). As good practice, combining the use of activity data (area assessment) with emission factors and carbon stock numbers is encouraged.

3.2.9 Uncertainty

The IPCC good-practice guidance for land use, land-use change and forestry (IPCC 2003) includes two definitions of uncertainty relevant to the forest sector:

1) a statistical definition—"a parameter, associated with the result of a measurement that characterizes the dispersion of the value that could be reasonably attributed to the measured quantity (e.g. the sample variance or coefficient of variation)" (page G.21); and
2) an inventory definition—"a general and imprecise term, which refers to the lack of certainty (in inventory components) resulting from any causal factor such as unidentified sources of sinks, lack of transparency, etc.)" (page G.21).

Petrokofsky et al. (2012) identified four sources of uncertainty associated with biomass estimates of tropical forests:

1) inaccurate measurements of variables, including instrument and calibration errors;
2) incorrect allometric models;
3) sampling uncertainty (related to the size of the study sample area and the sampling design); and

poor representativeness of the sampling network.

Thus, the estimation of carbon benefits has uncertainties associated with land/activity area and emissions/sinks factors. IPCC (2003) proposed two possibilities for estimating uncertainties: the simple propagation of errors; and Monte Carlo analysis.

Box 1: IPCC tiers for data availability

Tier 1—global default data. The Tier 1 approach employs the basic method provided in the *IPCC Guidelines* (Workbook) and the default emission factors provided in the *IPCC Guidelines* (Workbook and Reference Manual).

Tier 2—Country/region data. In Tier 2, users employ the same methodological approach as Tier 1 but apply emission factors and activity data defined by the country for the most important land uses/activities. The Tier 2 approach can also apply stock change methodologies based on country-specific data. Country-defined emission factors/activity data are most appropriate for the climate and land-use systems of that country. Tier 2 typically uses higher-resolution activity data to correspond with country-defined coefficients for specific regions and specialized land-use categories.

Tier 3—project data. Tier 3 uses higher-order methods, including models and inventory measurement systems tailored to address national circumstances, repeated over time, driven by high-resolution activity data and 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. Such systems may be geographic information system-based combinations of age class/production data systems, with connections to soil modules and integrating several types of monitoring. Land parcels in which a land-use change occurs can be tracked over time. In most cases, Tier 3 systems have a climate dependency and thus provide source estimates with interannual variability. Models should undergo quality checks, audits and validations.

Source: IPCC (2003).

Summary

Carbon benefits result when carbon stock in forest carbon pools increases or is maintained. There are five carbon pools in the forest: aboveground biomass, belowground biomass, deadwood, litter and soil organic matter. Timber production means a reduction of carbon stocks in the forest and will be discounted. Because harvested wood products (HWPs) can become long-term sinks, however, they are also recognized as a carbon pool (reservoir)—but outside the forest. There are currently no agreed methods for quantifying HWP carbon benefits in developing countries. Forestry activities can also produce inputs for bioenergy, with a potential carbon benefit. The quantification of this carbon benefit should consider greenhouse-gas emissions and sinks in bioenergy production as well as in the replaced energy system (e.g. fossil fuels).

Carbon benefits are normally estimated at the beginning of an intervention or in the planning phase (ex-ante estimation) and measured regularly during the course of implementation (measurement over time). To facilitate both estimation and measurement, it is good practice to stratify the intervention area into homogeneous areas and to use a conservative approach in calculating carbon benefits. Stratification may not be necessary, however, when a forestry intervention is very small.

Carbon benefits should be permanent—that is, the aim should be to avoid the re-emission of the benefits to the atmosphere. Interventions in one area should not promote a displacement of emissions to another (forested) area (i.e. leakage should be avoided).

4 POSSIBLE MITIGATION FRAMEWORKS

This chapter presents a taxonomy of existing climate-change mitigation frameworks that deliver regulations, modalities and procedures. Three mitigation frameworks are differentiated: 1) the UNFCCC; 2) other regulated markets; and 3) the voluntary market.

4.1 UNFCCC

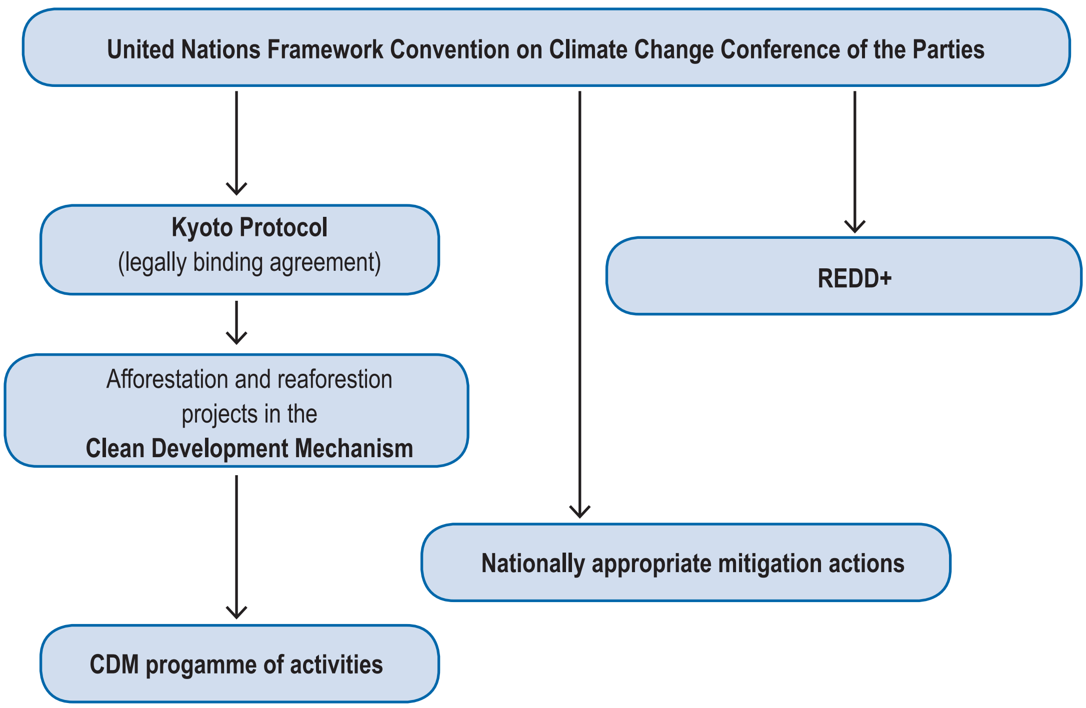
The UNFCCC considers the carbon benefits generated by forest ecosystems in three mechanisms: REDD+, A/R CDM, and nationally appropriate mitigation actions (NAMAs) (Figure 7). The following subsections set out the status of negotiations relevant to these mechanisms and the options available to forestry projects under the UNFCCC, as of December 2013.

4.1.1 REDD+

REDD+ refers to a negotiation item within the UNFCCC as well as to a series of ongoing processes, programmes and initiatives looking at climate-change mitigation options in the forest sector. At present, there is no binding agreement on or including REDD+, but the Conference of the Parties (COP) of the UNFCCC has made a set of decisions regulating REDD+. Although questions remain on the future role of REDD+, the current situation provides an opportunity to explore useful approaches and mechanisms for forestry activities as a means of mitigating climate change and promoting sustainable development.

The notion of "reducing emissions from deforestation in developing countries and approaches to stimulate action" (labelled "REDD") was first introduced into UNFCCC discussions at COP 11 (December 2005) in Montreal. There has been remarkable development since, not only in international discussions but also in efforts to facilitate pilot activities in developing countries. Today, the term REDD+ refers 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". The REDD+ mechanism in the UNFCCC will operate at the national level, and subnational activities are considered to be interim measures (Decision 1 at COP 16, abbreviated to Decision 1/CP.16). Decision 1/CP.16 also agreed

Figure 7: Structure of the UNFCCC mechanisms that consider carbon benefits derived from forestry activities



on a phased approach towards the full-scale implementation of REDD+, comprising the creation of the institutional conditions (phase I, or "readiness"), followed by the implementation of national policies and measures (phase II), evolving finally into the results-based implementation of REDD+, which should be fully measurable, reportable and verifiable (phase III). The latest regulations on REDD+ were delivered during COP 19 in 2013 and collectively are called the "Warsaw Framework for REDD-plus".

There are three main elements to REDD+: carbon accountability; co-benefits and safeguards; and financial issues.

1) **Carbon accounting.** Carbon accounting refers to methodological guidance for the ex-ante estimation and ongoing quantification of climate-change mitigation benefits achieved through human-induced activities in forest ecosystems. In REDD+, terms related to ex-ante estimation are "forest reference emission level" (REL) and "forest reference level" (RL). "Ongoing quantification" refers to the actual measurement and monitoring of mitigation benefits, which should be done regularly during the implementation of activities with the aim of gaining REDD+ benefits. "Ex-post quantification" involves methods and procedures on: how to monitor progress; how to report this progress; and how, when and by whom the verification of mitigation gains should be done. Methods and experiences in ex-post quantification in REDD+ are covered by the term "measurement, reporting and verification" or "monitoring, reporting and verification" (both using the abbreviation MRV).[14] A set of decisions by the UNFCCC COP regulates carbon accounting for REDD+ under the UNFCCC, especially decisions 12/CP17, 11/CP19, 13/CP19 and 14/CP19.

2) **Safeguards.** Although REDD+ started as a climate-change mitigation option, the international community soon realized that REDD+ could have both positive and negative impacts on the living conditions of certain social groups and on biodiversity at various scales (from local to global). This realization is reflected in the inclusion of "safeguards for REDD+ and the consideration of gender", as well as in the inclusion of REDD+ co-benefits as key elements in decisions taken at COP 16 (2010), COP 17 (2011) and COP 19 (2013).

   Paragraph 2 of Appendix I of UNFCCC Decision 1/CP16 established that the following safeguards should be promoted and supported:

   - complementarity or consistency with the objectives of national forest programmes and relevant international conventions and agreements;
   - transparency and effectiveness of national forest governance structures;
   - respect for the knowledge and rights of indigenous peoples and members of local communities;
   - full and effective participation of relevant stakeholders;
   - actions consistent with the conservation of natural forests and biological diversity, ensuring that the actions referred to are not used for the conversion of natural forests, but are instead used to incentivize the protection and conservation of natural forests and their ecosystem services, and to enhance other social and environmental benefits;
   - actions to address the risks of reversals; and
   - actions to reduce displacement of emissions.

   Decision 2/CP17 established guidance on: systems for providing information on the implementation of safeguards; and modalities for RELs and RLs. COP 19 agreed on reporting modalities for safeguards (UNFCCC Decision 12/CP19).

3) **Financial issues.** Securing long-term finance for REDD+ is another key issue. Questions that need to be addressed include: How much will it cost to reduce deforestation and forest degradation? How much will it cost to do the necessary planning, implementation and monitoring of activities? Who should receive this money? Who pays it? What are appropriate sharing mechanisms? How can double-accounting (e.g. in more than one mitigation framework) be avoided?

14 Decision 14/CP19 refers to "measuring, reporting and verifying". For more information see: http://unfccc.int/methods_science/redd/methodological_guidance/items/4123.php.

Such questions are important for Parties to the UNFCCC as well as for civil society and the private sector. Financing issues in REDD+ include, among others, the role of market and non-market mechanisms; monetary and non-monetary incentives; sharing mechanisms; and the costs to be covered by a future REDD+ mechanism. UNFCCC COPs have made several decisions on REDD+ finance (e.g. UNFCCC decisions 1/CP16 and 2/CP17). In 2013, the COP agreed on a work programme on result-based finance to progress towards the full implementation of REDD+ activities (UNFCCC Decision 9/CP19) and proposed an institutional framework for securing and coordinating such financing (UNFCCC decisions 9/CP19 and 10/CP19).

Several actors, including multilateral and bilateral agencies, the private sector and non-Annex I countries, have been active in discussing, funding and testing options for long-term and equitably distributed financing for REDD+ through pilot activities.[15] These activities are known collectively as "early actions", and they comprise a highly heterogeneous group of activities worldwide.

At present, early actions are neither coordinated nor regulated by a central body. Involved agencies and companies can provide a normative framework for specific actions, but they do not have the mandate to deliver an overall REDD+ regulation beyond the requirements and procedures established by the UNFCCC COP. For example, the multilateral bodies working on REDD+ (e.g. the UN-REDD Programme and the Forest Carbon Partnership Facility—FCPF) may include specific MRV requirements, but that does not mean that a future agreement on REDD+ will include the same requirements. The Warsaw Framework for REDD-plus (see below) clearly asked actors participating in REDD+ to better-coordinate their activities and created an information hub for facilitating exchange (UNFCCC Decision 9/CP19).

Table 5 shows the major funds for early REDD+ actions, and Table 6 shows the donors to these funds. In 2009, Parties to the UNFCCC agreed at COP 15 in Copenhagen to establish a new fund, the Green Climate Fund, which will include REDD+ activities. This fund is only now starting operation and is not included in Table 5.

15 For more detailed information see http://unfccc.int/methods_science/redd/redd_finance/items/7376.php.

Table 5: REDD+ funds

Fund	Amount (US$ million)	% of total amount
Amazon Fund	1 033	24.1
Australia's International Forest Carbon Initiative	216	5.0
Congo Basin Forest Fund	165	3.9
Forest Carbon Partnership Facility–Carbon Fund	219	5.1
Forest Carbon Partnership Facility–Readiness Fund	240	5.6
Forest Investment Program	611	14.3
Indonesia Climate Change Trust Fund	21	0.5
Norway's International Climate and Forest Initiative	1 608	37.5
UN-REDD Programme	171	4.0
Total pledges	**4 284**	**100**

Sources: Nakhooda et al. (2011); Schalatek et al. (2012).

The amounts presented in tables 5 and 6 are pledges and not actual deposits by donors; actual deposits are far lower (Nakhooda et al. 2011; Schalatek et al. 2012).

REDD+ financing grew rapidly between 2007 and 2011. However, current financing patterns for climate-change-related activities indicate a shift in donor interest to activities aimed at adaptation and technology transfer.

At UNFCCC COP 19 in Warsaw, Poland, the Parties agreed on the Warsaw Framework for REDD-plus, which comprised the following seven decisions:

1) Decision 9/CP19: Work programme on results-based finance to progress the full implementation of the activities;
2) Decision 10/CP19: Coordination of support for the implementation of activities in relation to mitigation actions in the forest sector by developing countries, including institutional arrangements;
3) Decision 11/CP19: Modalities for national forest monitoring systems;
4) Decision 12/CP19: The timing and frequency of presentations of the summary of information on how all the safeguards referred are being addressed and respected;
5) Decision 13/CP19: Guidelines and procedures for the technical assessment of submissions from Parties on proposed forest reference emission levels and/or forest reference level;

6) Decision 14/CP19: Modalities for measuring, reporting and verifying; and
7) Decision 15/CP19: Addressing the drivers of deforestation and forest degradation.

This framework completes a set of modalities and procedures for facilitating actions in REDD+.

The UNFCCC negotiations are now (in late 2014) at a pivotal stage: a binding agreement on all negotiation items, including REDD+, is expected by the end of 2015. The importance of REDD+ in this agreement remains unclear, however, and it is difficult to predict the future of REDD+ financing.

The FCPF and the UN-REDD Programme (two multilateral funds) are financing activities in many developing countries and developing methodologies and tools for accounting for carbon in REDD+ (see Chapter 5).

Table 6: Donor support for REDD+ (as of end 2012)

Country/region	Amount (US$ million)	% of total
Australia	295.4	6.9
Brazil	4.5	0.1
Canada	46.4	1.1
Denmark	23.9	0.6
Finland	14.7	0.3
France	15.3	0.4
Germany	137.0	3.2
Italy	5.0	0.1
Japan	82.1	1.9
Luxembourg	2.7	0.1
Netherlands	20.3	0.5
Norway	3 068.7	71.6
Regional Europe and Central Asia	26.0	0.6
Spain	22.0	0.5
Sweden	15.3	0.4
Switzerland	19.0	0.4
United Kingdom	289.1	6.7
United States	191.0	4.5
Unknown	5.0	0.1
Total pledges	**4 283.4**	**100.0**

Sources: Nakhooda et al. (2011); Schalatek et al. (2012).

4.1.2 A/R CDM and the programmatic CDM

The CDM is a flexible mechanism under the Kyoto Protocol. It has two objectives: to support industrialized countries in achieving their climate-change mitigation commitments; and to promote sustainable development in developing countries. Under the CDM, emission-reduction projects in developing countries can earn certified emission reduction credits. These credits can be sold on the carbon market for use by industrialized countries to meet part of their emission reduction targets under the Kyoto Protocol. A/R CDM refers to A/R[16] project activities that can be included in the CDM.

By April 2013, A/R CDM had ten approved methodologies for large-scale projects, seven methodologies for small-scale projects, and three consolidated methodologies (UNFCCC 2012). The CDM Board has also developed 13 tools for facilitating the various steps in the process of A/R CDM projects (see Chapter 5). At the end of June 2013, the UNFCCC reported that seven A/R CDM projects had issued certificates totalling 7 302 123 tonnes of CO_2e.[17,18]

Within the CDM there is also the possibility of taking a programmatic approach, with specific “programmes of activity” (PoAs) in given sectors. According to the UNFCCC Secretariat, under a PoA it is possible to register the coordinated implementation of a policy, measure or goal that leads to an emission reduction. Once a PoA is registered, an unlimited number of component project activities can be added without going through the complete CDM project cycle. Such a programmatic approach has many benefits compared with regular CDM project activities, particularly for less-developed countries and regions.[19] These include a reduction in transaction costs and investment risks at the project level; faster approval; and greater access for smaller projects (which wouldn’t make it as stand-alone projects). As of August 2014, however, there were no registered PoAs on forestry.

16 The glossary provides specific definitions of the terms “afforestation” and “reforestation” under the A/R CDM.
17 Excel file on certified emission reductions as of 30 June 2013, downloaded at: http://cdm.unfccc.int/Registry/index.html on 31 July 2013.
18 This corresponds to 0.53% of the CDM certificates.
19 See http://cdm.unfccc.int/ProgrammeOfActivities/index.html.

4.1.3 Forestry NAMAs[20]

At its 16th session, the UNFCCC COP decided to set up a registry to record NAMAs seeking international support, facilitate the matching of finance, technology and capacity-building support with these actions, and recognize other NAMAs. Developing countries can include the forest sector in their NAMAs, and they can also establish NAMAs specifically for this sector. As of April 2013, the following three NAMAs were considering forestry activities:

1) **Chile.** This NAMA aims to advance the implementation of the country's Platform for the Generation and Trading of Forest Carbon Credits (PBCCh). The NAMA includes the development of pilot sites that will be established in different types of forests and lands suitable for forestation; these pilot units will be the first to generate units for trading under the PBCCh. Pilot sites will include improvements in land-titling processes, the identification and implementation of more appropriate forest management techniques, the generation of subnational reference levels and MRV systems, and other issues related to forest carbon projects.

2) **Mali.** This NAMA is aimed at reducing GHG emissions by 12 000 000 tonnes of CO_2e per year through afforestation and reforestation. The Government of Mali is seeking financing for its NAMA.

3) **Dominica.** This NAMA supports the implementation of the Low Carbon Climate Resilient Development Strategy in the agricultural, buildings, energy supply, forestry, industry, waste and transport sectors. The NAMA was submitted to the UNFCCC Secretariat in 2012 and is still in the planning phase.

4.2 OTHER REGULATED MARKETS

To compensate for the lack of national regulations on GHG emissions in the United States, several states in that country have established their own regulations, either alone or in conjunction with others. Although the majority of these schemes look for reductions in GHG emissions in the energy sector, some include forestry activities.

Two schemes in the United States are gaining increasing importance for forestry activities in ITTO producer member countries: the California Climate Action Registry (CCAR) and the Climate Action Reserve (CAR). The CCAR is part of the State of California's effort to address climate change in advance of federal action.

Another regulated market, the Chicago Climate Exchange (CCX), closed activities in December 2010. The CCX, the first cap-and-trade system for GHGs, was launched in the United States in 2003. CCX members made a voluntary but legally binding commitment to meet annual GHG emission reduction targets. Although the CCX has closed, its sister institutions, the European Climate Exchange and the Chicago Climate Futures Exchange, are committed to continuing its activities.

Possibilities for using CAR and CCAR at the FMU level are explained in Chapter 5.

4.3 THE VOLUNTARY MARKET

Besides the UNFCCC and the other regulated markets, transactions of carbon certificates also occur in what is called the "voluntary market". This is not a marketplace itself; it comprises the sum of "over the counter" transactions. Several standards are active in the voluntary market, including the Verified Carbon Standard (VCS), the American Carbon Registry (ACR), the Gold Standards, and Plan Vivo. There are also standards for certifying the co-benefits arising from forestry activities in carbon markets: the Climate, Community and Biodiversity (CCB) Standards and the REDD+ Social and Environmental Standards (REDD+SES). Chapter 5 describes the various standards and their requirements and methods at the FMU level.

20 This section is adapted from the UNFCCC website for NAMAs: https://unfccc.int/cooperation_support/nama/items/7476.php.

Summary

This guide differentiates between three mitigation frameworks: 1) the United Nations Framework Convention on Climate Change (UNFCCC); 2) regulated markets; and 3) the voluntary market. The UNFCCC considers carbon benefits from forest ecosystems in three mechanisms: REDD+; afforestation and reforestation project activities under the Clean Development Mechanism (A/R CDM); and nationally appropriate mitigation actions (NAMAs).

1) REDD+ refers to a negotiation item within the UNFCCC as well as to a series of ongoing processes, programmes and initiatives looking at climate-change mitigation options in the forest sector. At present, there is no binding agreement on, or including, REDD+. However the UNFCCC Conference of the Parties has agreed to a set of decisions regulating REDD+. These include modalities for ex-ante estimations (forest reference levels or forest reference emission levels) and for measurement, reporting and verification and safeguards, and they also request funding for activities. Although there are open questions on the future role of REDD+, the current situation provides an opportunity for exploring useful approaches and mechanisms for forestry activities as a means of mitigating climate change and promoting sustainable development.
2) The A/R CDM refers to project activities on afforestation and reforestation in the CDM and the possibility of establishing a programme of activities at the national level. Modalities and procedures for the A/R CDM were agreed in 2003 and several approved methodologies are available.
3) NAMAs—Chile, Mali and Dominica have started processes for creating NAMAs considering forestry activities.

Two regulated markets that could be of interest to ITTO producer member countries are the California Climate Action Registry and the Climate Action Reserve. Both are regulated in the United States.

The guide presents standards for participation in the voluntary market, where transactions are “over the counter”. These standards are self-regulated but open to international scrutiny.

5 CONSIDERATIONS AT THE FOREST MANAGEMENT UNIT LEVEL

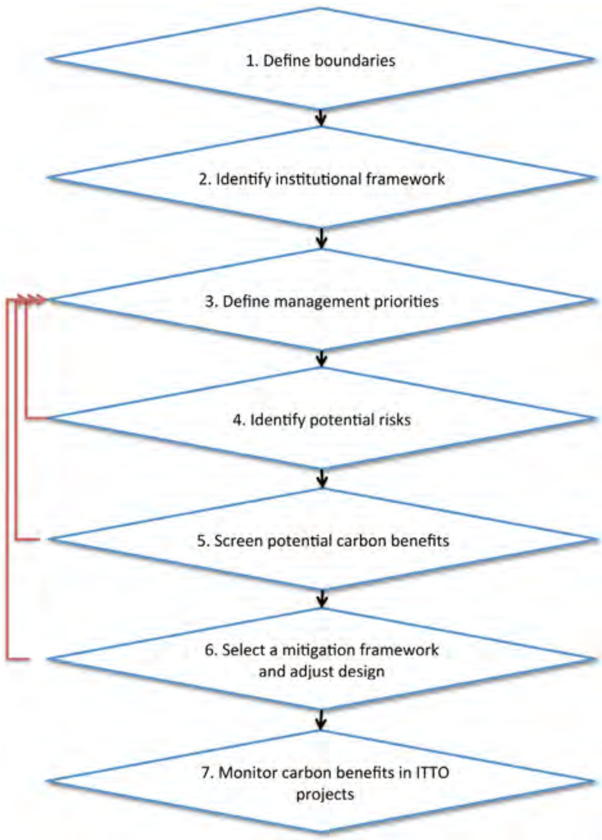
An FMU is a well-defined and demarcated land area, predominantly covered by forests, managed on a long-term basis and having a set of clear objectives specified in a forest management plan. This chapter, which is likely to be useful to forest managers, forest users and other decision-makers at the FMU level, is aimed at supporting carbon-related decisions at the FMU level. It should help in answering the following questions:

- What type of forest management makes sense from a carbon perspective? Is it in line with other management priorities?
- How large are the potential carbon benefits deriving from activities in the forest management plan?
- If the potential carbon benefits seem significant, which framework fits the situation best?
- If the potential carbon benefits do not seem significant, how can the forest management plan be adjusted to increase the carbon benefits?
- How can a project account for carbon benefits if it is not participating in a specific mitigation framework?
- Besides carbon accounting, what else is important if a project wants to maximize carbon benefits over the implementation phase of the forest management plan?

This guide proposes a step-wise approach (see Figure 8) to addressing these questions. At each step (other than step 7), the guide answers three questions:

- Why is this step necessary?
- How is this step undertaken?
- What happens if there is a significant change?

Figure 8: Step-wise approach, from activity design to the monitoring of carbon benefits



Note: *red lines show possible feedbacks.*

In the majority of cases, obtaining carbon benefits is not the only management objective at the FMU level. It is good practice, therefore, to include "maximization of carbon benefits" as an objective and to balance it *vis-à-vis* other management objectives, such as the production of wood and non-wood products and the maintenance of environmental services (such as regulation of the water cycle or biodiversity conservation).

The consideration of carbon benefits should be part of the planning phase of a project, and progress should be monitored regularly during the implementation of the forest management plan. When a forestry activity has already started and adjustment for maximizing carbon benefits is no longer possible, forest managers should focus on monitoring carbon benefits.

Summary

This guide proposes a step-wise approach for considering carbon benefits at the forest management unit level:

1) Define boundaries
2) Identify the institutional framework
3) Define the management priorities
4) Identify potential risks
5) Screen potential carbon benefits
6) Select a mitigation framework and adjust design
7) Monitor carbon benefits in ITTO projects (Chapter 6).

For each of the first six steps, the guide addresses three questions:

1) Why is this step necessary?
2) How do I undertake this step?
3) What happens if there is a significant change?

5.1 STEP 1: DEFINE BOUNDARIES

5.1.1 Why is it important to define boundaries?

Spatial boundaries. Estimates of total carbon benefits require information on the benefits per hectare and the total number of hectares subject to treatment. A unique set of silvicultural practices needs to be tailored to the biophysical and social characteristics of each site to effectively manage forests for carbon (Cid-Liccardi et al. 2012). Thus, the clear definition of project/activity boundaries is important for estimating carbon benefits.

Temporal boundaries. For some mitigation frameworks it is necessary to quantify carbon benefits over a specified period (the length of the period depends on the specific framework). It is important, therefore, to clarify the time over which the current forest managers will retain responsibility for land management.

5.1.2 How are boundaries defined?

Spatial boundaries. Several tools can be used to set boundaries, such as maps, aerial photographs, satellite imagery, geographic information systems and global positioning systems. In some cases it will be necessary to show the legal status of land ownership, and it is important to consider legal status as well as biophysical conditions when setting boundaries. The more accurate the definition of boundaries, the more accurate will be the estimation and monitoring of carbon benefits (Asner 2009).

Temporal boundaries. Forest managers determine the temporal boundaries of their projects or activities after clarifying how long they can ensure the management of a specific area of forestland. Some standards and certification procedures include provisions for a minimum project length. It is good practice to consider adjustments to temporal boundaries after selecting the specific framework for securing carbon benefits (see Step 6 in Chapter 5.6). Note that donors have their own requirements with respect to project and activity length for obtaining carbon benefits. It is good practice to identify potential challenges to the long-term management of forests, as required by most climate-change mitigation frameworks.

5.1.3 What happens if there is a significant change in boundaries?

Boundary changes over time will affect ex-ante estimation and monitoring. If the size of the project area increases, new strata and monitoring plots may be required.

In some mitigation frameworks, boundary changes are not permitted once the activity has started. It is important to strike a balance when defining the size of the intervention area. If the area is too large, it may be difficult to monitor and it could take a long time to obtain full results. If the area is too small, potential carbon benefits might be lost "outside" the area.

Summary

Step 1: Define boundaries. This step considers both geographical and temporal boundaries. Geographical boundaries respond to the question of "where" the activity will be implemented, and temporal boundaries respond to the question of "when" the intervention will take place. The answers to both questions will have an impact on the quantification of the intervention's carbon benefits. Changes to boundaries over time will affect carbon benefits and must be documented.

5.2 STEP 2: IDENTIFY THE INSTITUTIONAL FRAMEWORK

In this guide, "institutional framework" is understood as the rules and regulations relevant to the current and future management of a given area of forestland. It includes the rules and regulations applying to the public sector, the private sector and civil society as well as relevant policies, laws, investment plans, crediting systems, traditional uses and indigenous rights.

5.2.1 Why is it important to identify the institutional framework?

Social actors include forest users as well as regulatory bodies and investors. The interactions of social actors have a huge influence on how an area of forestland is used. For example, deforestation drivers are highly determined by these interactions, and tax regimes and subsidies can have significant impacts on forest plantation establishment. Thus, the set of agreements, policies and regulations that create the normative framework among social actors co-determines the land use.

5.2.2 How can the institutional framework be identified?

Two factors must be characterized when identifying the institutional framework: the social actors; and the institutional agreements and regulations.

Characterizing the social actors.[21] Table 7 provides a template for characterizing relevant social actions; it is completed by defining relevant roles for the forestry activity (x axis) and attributing them to social actors (y axis). It is good practice to use participative methods to create the matrix.[22]

Social actors may be categorized as public sector, private sector or civil society. Actors in the private sector and civil society may be clustered into social groups according to specific variables (e.g. occupation, income level, land tenure or education level) or combinations thereof (Madlener et al. 2006).

Table 7 is an example of a social actors' matrix. One may include as many social actors as there are present, and a given social actor or social group may be assigned to more than one role. Both the social actors and their roles need to be specified according to the circumstances of the project area.

Characterizing institutional agreements. This involves identifying the regulatory framework that sets the agreements and norms for the use of the forest and surrounding land—today and in the future. The regulatory framework includes policies, laws and any type of regulation, formal or informal, and customary rights, at the national, subnational and local levels.

Regulatory frameworks beyond the forest sector (e.g. the laws, norms and regulations in sectors such as agriculture, mining and energy) can constitute drivers of deforestation and forest degradation and must be considered.

The regulatory framework can be analyzed by considering the following questions:

- What can facilitate/promote a driver of deforestation or forest degradation?
- Are there duplications or other contradictions between the regulatory frameworks of different sectors?
- How is land tenure distributed among social actors?
- How are land uses distributed among social actors?
- What is the extent of enforcement of the regulatory framework?
- What are the issues for various social actors (e.g. due to a lack of clarity on land tenure or land use rights)?

It is considered good practice to base the analysis on the following criteria:

- the state of decentralization of the public administration of the natural resources;

21 This section is based on Robledo (2011). Used with permission.
22 Specific participatory methods may be available for particular countries and regions.

Table 7: Example of a social agent matrix

Social actor	Role						
	Regulator	Enforcement	Informal/ illegal user	Concessionaire	Other formal user	Traditional owner	Owner according to statutory law
Public sector							
Local authority							
Regional authority							
National authority							
Private sector							
Company XX							
Bank XY							
Cooperative of users							
Civil society							
Church							
Research institution/ university							
NGOs							

Note: The list of actors and roles will be specific in each case.

Source: Robledo (2011).

- the extent of participative approaches for planning the use of natural resources;
- the state of REDD+ authorities—the existence and enforcement of a REDD+ legal and administrative framework in the public sector; and
- the extent to which land tenure has been clarified.

5.2.3 What happens if there is a significant change in the institutional framework?

If major changes take place in the institutional framework (either in the composition of the social actors or in the institutional agreements), the impact those changes could have on the management activity should be analyzed and, if necessary, the activities should be adjusted. If the project activity is involved in a market-based scheme, the potential impact on contracts of changes to the institutional framework should be assessed.

Summary

Step 2: Identify the institutional framework. In this guide, "institutional framework" comprises the rules and regulations applying to different social actors that are relevant to the current and future management of a given area of forestland. Social actors include forest users as well as regulatory bodies and investors in the public and private sectors and civil society. The interaction between social actors has a great influence on how forestland is used. The guide explains how to characterize the social actors and institutional agreements relevant to an intervention.

5.3 STEP 3: DEFINE THE MANAGEMENT PRIORITIES

5.3.1 Why is it important to define the management priorities?

Management priorities are the basis of the forest management plan. If the highest priority is to maximize carbon benefits, planting/harvesting activities will be geared to ensure this, but this may affect other management priorities. It is good practice to balance management priorities as a way of promoting sustainable forest management (SFM).

5.3.2 How can management priorities be defined?

Numerous sets of guidance are available to assist in planning forestry activities. For example,

Table 8 presents a list of guidelines developed by ITTO (and partners) to assist in planning and implementing SFM.

Table 8: ITTO guidelines relevant to the sustainable management of tropical forests

ITTO guidelines for the establishment and sustainable management of planted tropical forests
ITTO guidelines on fire management in tropical forests
ITTO guidelines for the restoration, management and rehabilitation of degraded and secondary tropical forests
ATO/ITTO principles, criteria and indicators for the sustainable management of African natural tropical forests
Revised ITTO criteria and indicators for the sustainable management of tropical forests
ITTO/IUCN guidelines for the conservation and sustainable use of biodiversity in tropical timber production forests
Guidelines for the sustainable management of natural tropical forests (revised edition)

Note: All these publications are available for download at www.itto.int/policypapers_guidelines.

5.3.3 What happens if there is a significant change in management priorities over time?

Significant changes in management priorities will have implications for carbon benefits. When such changes take place, managers should:

- document and report changes in management priorities;
- clarify corresponding changes in management practices;
- estimate changes in carbon stocks due to the (new) management practices; and
- monitor and report changes in carbon stocks using the formats required by the specific mitigation framework.

Summary

Step 3: Define the management priorities. Management priorities form the basis of the forest management plan. If the highest priority is to maximize carbon benefits, planting/harvesting activities should be geared to ensuring this, but this may affect other management priorities. ITTO has produced several guidelines that can assist in setting forest management priorities.

5.4 STEP 4: IDENTIFY POTENTIAL RISKS

5.4.1 Why is it important to identify potential risks?

The identification of risks provides information on the feasibility of management practices—today and in the future. If a project is liable for the carbon benefits in an FMU, it is responsible for keeping those benefits secure.

5.4.2 How can potential risks be identified?

Forestry activities carry a range of potential risks, including political and regulatory risks, social risks, economic and financial risks, the risk of natural disturbances and hazards, and non-permanence (that is, the risk that the carbon benefits of a project will be lost). Table 9 provides a non-exhaustive list of potential risks in forestry; forest managers can expand this list and assess whether the current and future likelihood of each potential risk is high, medium or low.

5.4.3 What should be done if significant risks are identified now or in the future?

When a significant risk (for today or in the future) is identified, it is good practice to consider taking the following steps:

1) Adjust the management plan to minimize the risk (feedback to Step 3 on defining management priorities).
2) Design risk-management strategies for minimizing the risk and monitor the implementation of these strategies during the course of management activities.
3) Monitor changes to risk factors over time.

Summary

Step 4: Identify potential risks. The identification of risks provides information on the feasibility of management practices over time. If a project is liable for the carbon benefits in a forest management unit, it is responsible for keeping those benefits secure. Risks can affect the permanence of carbon benefits and therefore need to be managed. Categories of potential risk are: political and regulatory; social; economic and financial; and natural disturbances and hazards.

Table 9: Potential risks in forestry activities

Potential risk	Current risk (high, medium, low)	Future risk (high, medium, low)
Political and regulatory risks		
• Approval of adverse policies		
• Lack of clarity on land tenure and/or carbon tenure		
• Political instability		
• Other		
Social risks		
• Lack of technology, capacity or skills in the implementation of the management plan		
• Social instability		
• Social or other conflict, including violence		
• Other		
Economic and financial risks		
• Lack of credit		
• Financial failure		
• Price breakdown		
• Lack of long-term funding		
• Other		
Natural disturbances and hazards		
• Fire		
• Pests		
• Flooding		
• Drought		
• Severe erosion or desertification		
• Landslides		

Sources: Robledo (2011); CCBA (2011); FCPF (2012); Harvey and Pilgrim (2011); Pitman (2011); REDD+SES Initiative (2012a); Richards (2011).

5.5 STEP 5: SCREEN POTENTIAL CARBON BENEFITS

The aim of screening potential carbon benefits is to obtain a preliminary estimate of the potential carbon benefits of a forestry project or activity. Screening should be possible using information in the forest management plan and existing default values for estimating carbon benefits.

5.5.1 Why is it important to screen potential carbon benefits?

Establishing a detailed ex-ante estimate of carbon benefits can be costly as well as time-consuming and data-intensive. If the potential carbon benefits are not significant, there is little reason to undertake a detailed ex-ante estimate.

5.5.2 How can potential carbon benefits be screened?

Three steps are recommended for screening potential carbon benefits: 1) select main pools; 2) define strata; and 3) select screening tool.

Select main pools. All living biomass—that is, aboveground and belowground biomass—should be included. Any other pool that is a significant GHG emitter should also be included. This is particularly important in the case of emissions from organic soils (e.g. forest conversion on peat soils can produce high levels of GHG emissions). If a pool is a zero net emitter, a conservative (and cost-effective) approach would be to omit this pool from the estimations.

Define strata. Stratification is the process of dividing a non-homogeneous project area into subpopulations (or strata) that share important characteristics and are relatively homogeneous (Diaz and Delaney 2011; IPCC 2003). Stratification can increase the accuracy and precision of measurements and reduce monitoring costs. Criteria used for stratification might include the following (IPCC 2003; Pearson et al. 2005a; Pearson et al. 2005b):

- type of vegetation;
- tree species;
- age class;
- slope;

- proximity to settlements, roads or other relevant infrastructure; and
- type of soil.

It is possible that the strata used prior to the project will differ from those used after project implementation. Moreover, it is possible to seek objectives within a single project that result in varying strata. For example, a pre-project may comprise a homogenous non-managed pasture on a plain. Under the project, a fast-growing plantation is to be installed in one half of the area and an agroforestry system is to be created in the other half, increasing the heterogeneity of the area and leading to a change in the stratification.

Select an existing screening tool. Several tools and simplified methods exist for screening the potential carbon benefits of forestry activities (Table 10).

Tools aimed at producing detailed ex-ante quantifications of potential carbon benefits are also available for the various mitigation frameworks. The use of these tools, however, requires greater investments of time, data and capacities (Annex 1 provides information on some of these tools).

Screening tools should help in clarifying whether a project's mitigation potential is large enough to justify further investment.

5.5.3 What should be done if there is significant carbon potential?

If the potential carbon benefits are significant, it is worth considering the inclusion of the project in a mitigation framework. Bear in mind that using any of the mitigation frameworks will create costs for the project associated with obtaining information, fulfilling requirements for acceptance (validation and, if required, registration), monitoring, verification and, in some cases, certification. Costs vary significantly between frameworks and also between standards. It is good practice to undertake a cost–benefit assessment of the potential carbon benefits.

Table 10: Existing carbon screening tools (in no specific order)

sCreen	
Description	sCreen (Fast-track Estimation of Carbon Benefits from Forestry Activities) is a set of methods for estimating carbon benefits from any forestry activity, including sustainable forest management, forest conservation, forest rehabilitation/restoration, forest plantations and agroforestry. The development of sCreen was initiated under ITTO Project RED-PA 069/11 Rev.1 (F)
Pools considered	Aboveground biomass and belowground biomass
Availability	Contact the ITTO Secretariat at itto@itto.int for more information
ENCOFOR	
Description	ENCOFOR (Environment and Community-based Framework for Designing Afforestation, Reforestation and Revegetation Projects in the CDM) aims to maximize synergies between carbon sequestration and benefits for the local environment and stakeholders. ENCOFOR comprises several tools, including a carbon accounting module for the pre-feasibility stage. This integrates the quantitative analyses needed to prepare a project idea note, including relatively simple assessments of the baseline and with-project scenarios
Pools considered	Aboveground biomass, belowground biomass, litter, deadwood, soil and harvested wood products. This tool focuses on plantations and agroforestry and silvopastoral systems
Availability	www.joanneum.at/encofor/tools/tool_demonstration/prefeasibility.htm
Ex-ACT	
Description	Ex-ACT (Ex-ante Appraisal Carbon-balance Tool) aims to provide ex-ante estimates of the impact of agricultural and forestry development projects on GHG emissions and carbon sequestration, indicating its effects on the carbon balance. Ex-ACT has been tested in agricultural development projects and investment programmes. Ongoing tests in forestry projects are underway, as well as value-chain analyses
Pools considered	Aboveground biomass, belowground biomass, litter, dead wood and soil
Availability	www.fao.org/tc/exact/en
REDD+ feasibility tool	
Description	This Excel-based tool was developed for use by project developers to help quickly and accurately assess a proposed site/region's potential for REDD+ development; it includes a detailed financial feasibility breakdown
Pools considered	Aboveground biomass and belowground biomass
Availability	www.conservation.org/global/carbon_fund/publications/pages/publications.aspx

If the potential carbon benefits are assessed as low, it is worth considering whether it is possible and desirable to adjust the management priorities; if so, the carbon potential may be screened again. The purpose of simple carbon screening tools is to enable forest managers to maximize the benefits of their forestry practices and the sustainable management of the resource.

Summary

Step 5: Screen potential carbon benefits. Screening is aimed at obtaining preliminary estimates of the potential carbon benefits of a forestry project or activity. It should be doable with information contained in the forest management plan and using existing default values for estimating carbon benefits. The three recommended steps in screening potential carbon benefits are: 1) selecting the most important carbon pools; 2) defining the strata; and 3) selecting the most appropriate screening tool.

5.6 STEP 6: SELECT A MITIGATION FRAMEWORK AND ADJUST DESIGN

5.6.1 Why is it important to select a mitigation framework and to adjust the project design?

There are several reasons for putting thought into selecting the mitigation framework:

- There are differences between frameworks in which activities are eligible.
- Some frameworks have specific approved methodologies for ex-ante estimation as well as for the monitoring and quantification of ex-post benefits.
- Some frameworks have specific regulations on third-party validation, verification and/or certification.
- Requirements for carbon tenure may differ between frameworks.
- Benefits and compensation schemes, as well as corresponding conditions, may differ between frameworks (for example, not all mitigation frameworks offer direct payments).
- The requirements for documenting processes and changes may differ.
- Formats may differ.
- Country contact points and country requirements may differ.

5.6.2 How does one select a mitigation framework?

First, clarify the purpose of accounting for carbon benefits (Figure 9).

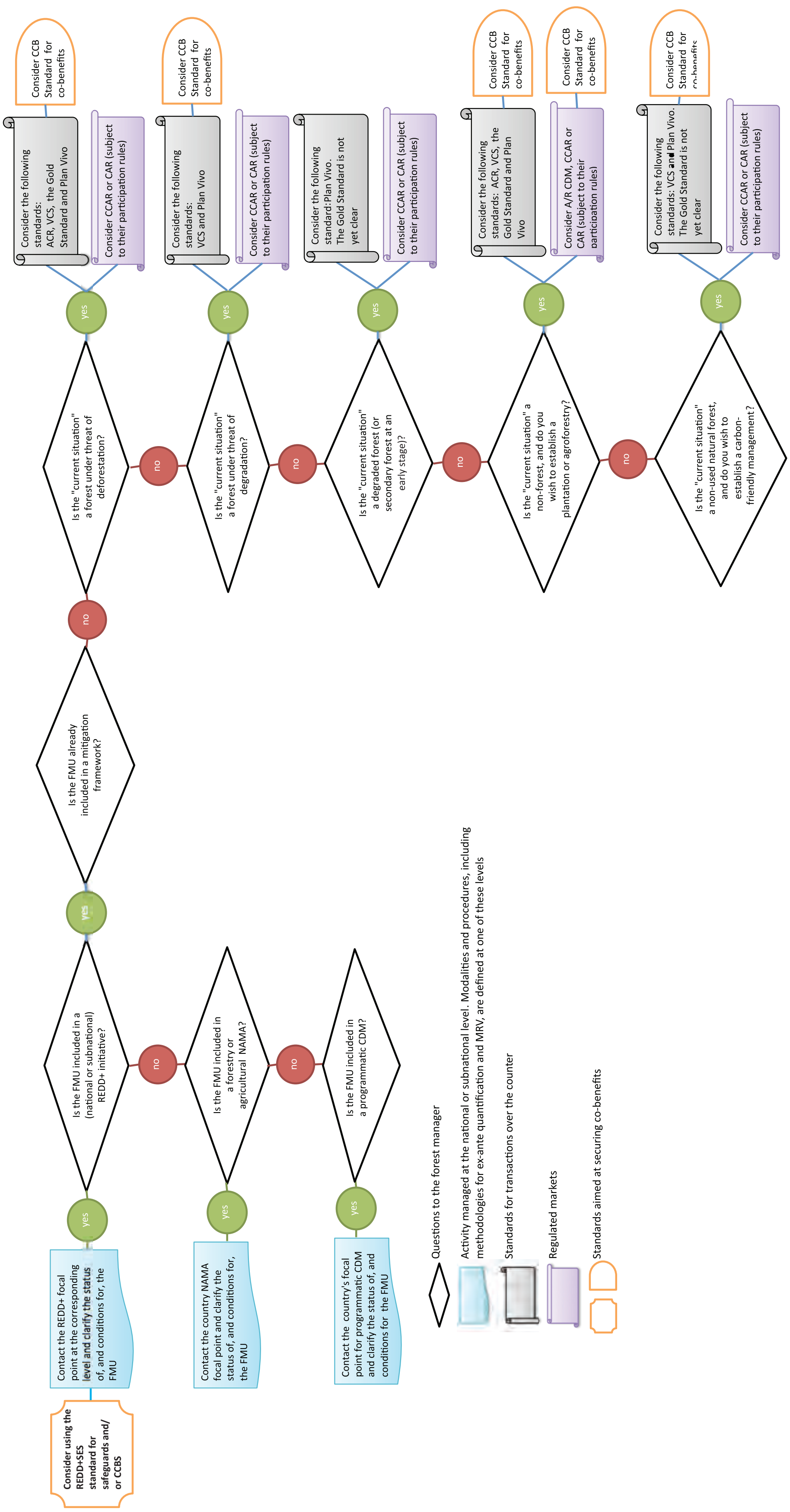
If project proponents are interested in participating in any of the mitigation frameworks presented in Chapter 4, they should select the most appropriate framework for their circumstances. Decision tree 2 (Figure 10) will help in making this decision.

Below is a summary of the requirements and approved methodologies for each mitigation framework; Annex 1 presents the existing tools for these mitigation frameworks.[23]

Figure 9: Decision tree 1—purpose of carbon accounting

23 Information as per the end of July 2013.

Figure 10: Decision tree 2–selecting a mitigation framework at the FMU level



5.6.3 UNFCCC

REDD+. The REDD+ mechanism is still under negotiation in the UNFCCC, and a series of pilot activities called "early actions" is ongoing. Several developing countries, multilateral organizations and other stakeholders are participating in these initiatives aimed at gaining experience in and knowledge of REDD+-related issues.

According to UNFCCC Decision 1/CP16, REDD+ will be based at the country level; if appropriate, a subnational level may be used as an interim measure. Developing countries have been asked to develop REDD+ strategies as a basis for their activities. For this reason, forest managers at the FMU level wishing to participate in the REDD+ mechanism under the UNFCCC should contact the relevant focal point at the national level. Guidance on methodologies, modalities and procedures for integrating the FMU level into REDD+ mechanisms are defined at the country level.

The following sections present experiences in ongoing initiatives on REDD+ to define three main elements: RELs and RLs; MRV; and safeguards.[24]

Forest Carbon Partnership Facility. The FCPF is a global partnership of governments, businesses, civil society and indigenous peoples focused on reducing emissions from deforestation and forest degradation; conserving forest carbon stocks; the sustainable management of forests; and the enhancement of forest carbon stocks in developing countries (i.e. the activities commonly referred to collectively as REDD+). The FCPF assists developing countries in their efforts to plan and implement REDD+ strategies by adding value to standing forests.[25,26]

A compilation of strategic guidance on emerging best practices in the field was developed with Forest Trends and other partners.[27] It comprises the following nine volumes:

1) Step-by-step overview
2) REDD guidance: technical project design
3) A/R guidance: technical project design
4) Carbon stock assessment guidance: inventory and monitoring procedures
5) Community engagement guidance: good practice for forest carbon projects
6) Legal guidance: legal and contractual aspects of forest carbon projects
7) Business guidance: forest carbon marketing and finance
8) Social impacts guidance: key assessment issues for forest carbon projects
9) Biodiversity impacts guidance: key assessment issues for forest carbon projects.

Volume 4 ("Carbon stock assessment guidance inventory and monitoring procedures"[28]) (Diaz and Delaney 2011) deals with forest inventories and carbon accounting in the field and is therefore relevant to the work discussed in this guide.

The FCPF also provides guidance on safeguards. The publication *Common Approach to Environmental and Social Safeguards for Multiple Delivery Partners* (FCPF 2012) sets out the FCPF's requests to developing countries that participate in the fund's financing schemes regarding REDD+ safeguards. The FCPF also provides guidance on REDD+ technical issues at the national level. This includes the FCPF Program-level Monitoring and Evaluation Framework (especially the country-level activities).[29]

UN-REDD Programme. The UN-REDD Programme was launched in 2008 and builds on the convening role and technical expertise of FAO, UNDP and UNEP. The UN-REDD Programme supports nationally led REDD+ processes and promotes the informed and meaningful involvement of all stakeholders. In particular, it supports the involvement of indigenous peoples and

24 Information in these subsections is based on the experiences reported by countries, NGOs and research organizations to the REDD+ Platform of the UNFCCC (http://unfccc.int/methods/redd/redd_web_platform/items/4531.php) as well as on information from relevant multilateral funds (as documented).

25 For more information on the FCPF see: www.forestcarbonpartnership.org.

26 By end of July 2013, the following countries had status as participants in the FCPF: Argentina, Bolivia, Cameroon, Cambodia, Central African Republic, Chile, Colombia, Democratic Republic of the Congo, Republic of the Congo, Costa Rica, El Salvador, Ethiopia, Gabon, Ghana, Guatemala, Guyana, Honduras, Indonesia, Kenya, Lao People's Democratic Republic, Liberia, Madagascar, Mexico, Mozambique, Nepal, Nicaragua, Panama, Papua New Guinea, Paraguay, Peru, Suriname, Thailand, Uganda, United Republic of Tanzania, Vanuatu and Viet Nam.

27 See www.forestcarbonpartnership.org/building-forest-carbon-projects-new-set-guidance-documents-forest-trends.

28 See: www.forest-trends.org/publication_details.php?publicationID=2862.

29 From the UN-REDD Programme webpage, accessed June 2013. Available at: www.forestcarbonpartnership.org/fmt-notes-guidelines-templates.

other forest-dependent communities in national and international REDD+ implementation.[30] Figure 11 shows the countries in which the UN-REDD Programme is active.

For the UN-REDD Programme, monitoring systems that enable the credible measurement, reporting and verification of REDD+ activities are critical for the successful implementation of any REDD+ mechanism. Consequently, the UN-REDD Programme is supporting countries to develop cost-effective, robust, compatible national monitoring and MRV systems, providing tools, methodologies, training and knowledge-sharing to help countries strengthen their technical and institutional capacity in developing and implementing effective MRV systems. The UN-REDD Programme's activities in MRV include:

- *Carbon MRV*—the focus of the work is on GHG emissions monitoring, RELs, forest inventories and remote sensing.
- *Monitoring safeguards*—the UN-REDD Programme supports countries in building systems to provide information on safeguards and how safeguards can be implemented and respected in the implementation of REDD+.
- *Governance*—the monitoring of governance focuses on the performance of a country's capacity and governance.
- *Multiple benefits and potential risks*—the monitoring of multiple benefits identifies the additional benefits that REDD+ can harness, in addition to carbon (including livelihood improvement and the protection of biodiversity and watersheds).

The UN-REDD Programme recently produced a guidance document on monitoring, measurement, reporting and verification in the context of REDD+ activities (UN-REDD Programme 2013a), focusing on national-level reporting needs and options for national forest monitoring systems. The UN-REDD Programme also supports countries in developing their country-level approaches for fulfilling requirements on REDD+ safeguards and their corresponding information systems (Peskett and Todd 2013). This work is in line with the Social and Environmental Principles and Criteria, which include the following principles (UN-REDD Programme 2012)[31]:

- Apply norms of democratic governance, as reflected in national commitments and multilateral agreements.

Figure 11: Countries participating in the UN-REDD Programme

Source: www.un-redd.org.

30 See: www.un-redd.org/Events/tabid/104448/Default.aspx.

31 The document includes definitions and/or clarifications of relevant terms such as degradation and conservation.

- Respect and protect stakeholder rights in accordance with international obligations.
- Promote sustainable livelihoods and poverty reduction.
- Contribute to low-carbon, climate-resilient sustainable development policy, consistent with national development strategies, national forest programmes, and commitments made under international conventions and agreements.
- Protect natural forest from degradation and/or conversion.
- Maintain and enhance the multiple functions of forests, including the conservation of biodiversity and the provision of ecosystem services.
- Avoid or minimize adverse impacts on non-forest ecosystem services and biodiversity.

The UN-REDD Programme has designed a corresponding tool for assessing social and environmental risks (see Annex 1 for more information on this tool).

Clean Development Mechanism and Programmatic CDM. The following conditions and information are relevant to all A/R methodologies and are applicable in addition to the conditions listed in the methodology summaries (UNFCCC 2012):

- Forest cover on land eligible for project activities must have been below the forest threshold, as determined by the host country. This needs to be proven (e.g. by the use of satellite imagery or participatory rural appraisal).
- No tree vegetation is expected to emerge without human intervention to form a forest on the project land.
- The project start date must be 1 January 2000 or later.
- In the absence of the project activity, carbon stocks in the carbon pools not considered in the project activity are expected to decrease or increase less relative to the project scenario.

A/R CDM project activities result in temporary certified emission reductions and long-term certified emission reductions.

Project managers should check the requirements for an A/R CDM project activity in their specific countries. Each developing country involved in the A/R CDM (i.e. the "host country") has a focal point called the designated national authority (DNA). This authority is responsible for setting the forest definition for A/R CDM in the country as well as approval requirements (see Annex 2 for a list of DNAs in ITTO producer member countries).

The A/R CDM distinguishes between three methodologies:

1) consolidated methodologies;

2) methodologies for large-scale projects; and

3) methodologies for small-scale projects.

Table 11 presents the three A/R CDM consolidated methodologies, Table 12 shows the approved methodologies for large-scale A/R CDM projects, and Table 13 lists the seven approved methodologies for small-scale A/R CDM projects.

Table 11: A/R CDM consolidated methodologies

Number	A/R CDM consolidated methodology
AR-AMC0001	Afforestation and reforestation of degraded land. See: https://cdm.unfccc.int/methodologies/DB/X4VOLW3Y7IJCH9WXSBXBC2Q0JKG9UZ
AR-ACM0002	Afforestation or reforestation of degraded land without displacement of pre-project activities. See: https://cdm.unfccc.int/methodologies/DB/OOH5AKLQDUYW6N3STD3LDH7EL9THD1
AR-ACM0003	Afforestation and reforestation of lands except wetlands. See: https://cdm.unfccc.int/methodologies/DB/WB63WYT7LKF8N6V0A3YXXXI8GCP2J3

Source: https://cdm.unfccc.int/methodologies/index.html.

Table 12: A/R CDM methodologies for large-scale projects

Number	A/R CDM methodology for large-scale projects
AR-AM0002	Restoration of degraded lands through afforestation/reforestation. This methodology has been replaced by the consolidated methodology AR-ACM0003
AR-AM0004	Reforestation or afforestation of land currently under agricultural use. This methodology has been replaced by the consolidated methodology AR-ACM0003
AR_AM0005	Afforestation and reforestation project activities implemented for industrial and/or commercial uses. This methodology has been replaced by the consolidated methodology AR-ACM0003
AR-AM0007	Afforestation and reforestation of land currently under agricultural or pastoral use. This methodology has been replaced by the consolidated methodology AR-ACM0003
AR-AM0009	Afforestation or reforestation on degraded land allowing for silvopastoral activities. This methodology has been replaced by the consolidated methodology AR-ACM0003
AR-AM0010	Afforestation and reforestation project activities implemented on unmanaged grassland in reserve/protected areas. This methodology has been replaced by the consolidated methodology AR-ACM0003
AR-AM0011	Afforestation and reforestation of land subject to polyculture farming. This methodology has been replaced by the consolidated methodology AR-ACM0003
AR-AM 0012	Afforestation or reforestation of degraded or abandoned agricultural lands. This methodology has been replaced by the consolidated methodology AR-ACM0003
AR-AM0013	Afforestation and reforestation of lands other than wetlands. This methodology has been replaced by the consolidated methodology AR-ACM0003
AR-AM0014	Afforestation and reforestation of degraded mangrove habitats. See more at: https://cdm.unfccc.int/methodologies/DB/MYKQ6SF4NBIOQ77A5V7RFZ602N39GQ

Note: *The listed webpages present the specific methodologies and all needed tools. Many of these methodologies have been replaced by consolidated methodologies (as clarified for each methodology). Annex 1 provides the consolidated methodologies.*

Source: https://cdm.unfccc.int/methodologies/index.html.

Table 13: A/R CDM methodologies for small-scale projects

Number	A/R CDM methodology for small-scale projects
AR-AMS0001	Small-scale A/R CDM project activities implemented on grasslands or croplands with limited displacement of pre-project activities.[a] This methodology is no longer active and has been incorporated in AR-AMS0007
AR-AMS0002	Small-scale afforestation and reforestation project activities under the CDM implemented on settlements.[b] This methodology is no longer active and has been incorporated in AR-AMS0007 AR-AMS0003: Small-scale A/R CDM project activities implemented on wetlands. See more at: https://cdm.unfccc.int/methodologies/DB/8LLTGVPG1SMMB1AMGSU0ZEYVO9P45P
AR-AMS0004	Small-scale agroforestry–afforestation and reforestation project activities under the CDM[c]. This methodology is no longer active and has been incorporated in AR-AMS0007
AR-AMS0005	Small-scale afforestation and reforestation project activities under the CDM implemented on land having low inherent potential to support living biomass.[d] This methodology is no longer active and has been incorporated in AR-AMS0007
AR-AMS0006	Small-scale silvopastoral afforestation and reforestation project activities under the CDM.[e] This methodology is no longer active and has been incorporated to AR-AMS0007
AR-AMS0007	Small-scale A/R CDM project activities implemented on lands other than wetlands. See more at: https://cdm.unfccc.int/methodologies/DB/M9KFJT0OMGFD2M07PGAA3E7XIGSI7T

a At its 68th meeting, the CDM Board revised methodology AR-AMS0007, which incorporates methodology AR-AM001, and agreed to withdraw methodology AR-AMS0001, effective 20 March 2013.
b At its 68th meeting, the CDM Board revised methodology AR-AMS0007, which incorporates methodology AR-AM001, and agreed to withdraw methodology AR-AMS0002, effective 20 March 2013.
c At its 68th meeting, the CDM Board revised methodology AR-AMS0007, which incorporates methodology AR-AM001, and agreed to withdraw methodology AR-AMS0004, effective 20 March 2013.
d At its 68th meeting, the CDM Board revised methodology AR-AMS0007, which incorporates methodology AR-AM001, and agreed to withdraw methodology AR-AMS0005, effective 20 March 2013.
e At its 68th meeting, the CDM Board revised methodology AR-AMS0007, which incorporates methodology AR-AM001, and agreed to withdraw methodology AR-AMS0006, effective 20 March 2013.

Source: https://cdm.unfccc.int/methodologies/index.html.

5.6.4 Other regulated markets

California Climate Action Registry and the Climate Action Reserve. CCAR was part of the State of California's efforts to address climate change in advance of federal action.[32] One aspect of the land-use focus of the CCAR was forests in California and forests controlled by Californian entities (Haskett 2011). The CCAR's parent organization, the CAR, operates the premier carbon offset registry in the North American carbon market. The CAR built on the CCAR's knowledge and expertise in GHG accounting and developed a regulatory-quality programme for quantifying GHG emission reductions in offset projects.[33]

The CCAR includes a forest project reporting level (i.e. for FMUs) for three types of activities:

1) conservation-based forest management;
2) reforestation projects; and
3) conservation projects.

In its forest protocol, CAR presents eligibility rules and requirements, rules for the assessment of GHG emissions, the quantification approach and strategy for ensuring permanence, and modalities for monitoring and verification (CAR 2012a). CAR has also prepared detailed guidelines for carbon quantification, including algorithms and default data (CAR 2012b). Participants in the CAR should use this guidance.

5.6.5 Voluntary carbon standards[34]

American Carbon Registry®.[35] The ACR is a non-profit US carbon market standard and registry and the first private voluntary GHG registry in the United States; it has issued over 37 million carbon offsets. ACR has three standards: the ACR Standard, the Forest Carbon Project Standard, and the ACR Nested REDD+ Standard. Table 14 lists the ACR methodologies.

The ACR provides an electronic registry system by which members can transparently register offset projects as well as transfer and retire serialized project-based verified emission reductions (VERs), branded as emission reduction tons (ERTs).

Plan Vivo.[36, 37] The Plan Vivo Standard is a certification framework for projects supporting rural smallholders and community groups to implement improved natural resource management using payments for ecosystem services (Plan Vivo Foundation 2013). Quantifying and monitoring climate services (in tonnes CO_2e) enables projects to generate Plan Vivo certificates, which can be used to generate funding for project activities and payments for ecosystem services, for example through the voluntary carbon market or other ecosystem-services markets. The Plan Vivo Standard can also be used in other funding schemes, such as bilateral cooperation projects (Plan Vivo Foundation 2012a, 2013).

Project interventions may include any improved land management activity that can generate quantifiable climate services and benefit the livelihoods of participants and local-level ecosystems. Eligible activities for generating Plan Vivo certificates are afforestation and agroforestry, forest conservation, restoration, and avoided deforestation. Activities are undertaken by smallholders and community groups on their own land and designed with the full participation of local communities. The projects follow a "whole landscape" approach. The standard includes requirements on, among others, the eligibility of projects; coordination and management; participatory design; the quantification and monitoring of climate services; and risk management (Plan Vivo Foundation 2012a, 2013). Projects can be small or large, and can scale up over time. Procedures are designed to facilitate a "programme of activities" model of expansion (Plan Vivo Foundation 2012a).

32 The CCAR, a programme of the CAR, closed in December 2010. It served as a voluntary GHG registry to protect and promote early actions to reduce GHG emissions by organizations. The California Registry is transitioning its members to the Climate Registry, a nonprofit GHG emissions registry for North America that provides organizations with tools and resources to help them calculate, verify, report and manage their GHG emissions in a publicly transparent and credible way (see www.climateregistry.org).

33 See www.climateactionreserve.org.

34 Methodologies and tools under the standards presented in this section continue to evolve. Thus, it is highly recommended that, when needed, users obtain the most updated versions at the websites given in the text.

35 Information on the ACR was obtained at http://americancarbonregistry.org/aboutus.

36 For more information on the Plan Vivo Standard see: www.planvivo.org/governance-of-the-standard.

37 A new version of the Plan Vivo Standard for Community Payments for Ecosystem Services was published in 2013. For updates see: www.planvivo.org/governance-of-the-standard.

Table 14: Methods available at the American Carbon Registry

<table>
<tr><th>Name</th><th>Short description</th></tr>
<tr><td>Afforestation and reforestation of degraded lands</td><td>The methodology was initially developed from CDM-approved consolidated A/R baseline and monitoring methodology AR-ACM0001 version 5.0.0. Guidance on accounting for harvested wood products was drawn from a methodology for “improved forest management through extension of rotation age”, developed by Winrock International; this was incorporated by TREES Forest Carbon Consulting, reviewed and approved by the American Carbon Registry’s (ACR’s) independent Agriculture, Forestry and Other Land Use Technical Committee, and published in March 2011. Available at: http://americancarbonregistry.org/carbon-accounting/carbon-accounting/afforestation-and-reforestation-of-degraded-lands.</td></tr>
<tr><td>Reducing emissions from deforestation and degradation (REDD)—avoiding planned deforestation</td><td>REDD is an eligible project activity under the ACR Forest Carbon Project Standard, defined as the reduction in greenhouse-gas (GHG) emissions from the avoided conversion of forest to non-forest use or avoided degradation of forests remaining as forests.

This methodology is applicable only to the REDD subcategory “avoiding planned deforestation”. Separate ACR methodologies address other types of REDD, such as avoiding unplanned deforestation and avoiding forest degradation through fuelwood and charcoal production. The methodology references the separate ACR Tool for Estimation of Stocks in Carbon Pools and Emissions from Emissions Sources.

Projects using this methodology must comply with all requirements of the ACR Forest Carbon Project Standard; submit a GHG Project Plan for certification by ACR; and secure independent validation of the GHG Project Plan and verification of GHG assertions by an ACR-approved third-party verifier. Available at: http://americancarbonregistry.org/carbon-accounting/carbon-accounting/redd-2013-avoiding-planned-deforestation</td></tr>
<tr><td>REDD methodology modules</td><td>The REDD modules are applicable to projects that reduce emissions from planned deforestation, unplanned deforestation, and degradation through non-renewable fuelwood collection and charcoal production. The modular approach is an effort to streamline methodology development and use. The REDD modules may be used on their own for project-level REDD activities or combined with the ACR’s forthcoming nested REDD+ requirements to register project-level activities nested within a jurisdictional accounting framework.

A framework module, REDD-MF, establishes the overall functionality of the methodology. Included in REDD-MF are:
three baseline modules—
BL-PL “Estimation of baseline carbon stock changes and GHG emissions from planned deforestation”
BL-UP “Estimation of baseline carbon stock changes and GHG emissions from unplanned deforestation”
BL-DFW “Estimation of baseline emission from forest degradation caused by extraction of wood for fuel”;
four leakage modules—
LK-ASP “Estimation of emissions from activity-shifting for avoided planned deforestation”
LK-ASU “Estimation of emissions from activity-shifting for avoided unplanned deforestation”
LK-ME “Estimation of emissions from market effects”
LK-DFW “Estimation of emissions from displacement of fuelwood extraction”;
M-MON “Methods for monitoring of greenhouse gas emissions and removals”; and
two miscellaneous modules:
X -STR “Methods for stratification of the project area”
X-UNC “Estimation of uncertainty for REDD project activities”.
More information on these modules is available at: http://americancarbonregistry.org/carbon-accounting/carbon-accounting/redd-methodology-modules-1. The methodology includes four tools (see Annex 1).</td></tr>
</table>

Source: http://americancarbonregistry.org/aboutus.

The following eight principles guide the Plan Vivo Standard (Plan Vivo Foundation 2012a, 2013):

1) Projects directly engage and benefit smallholders and community groups.
2) Projects generate ecosystem-service benefits and maintain or enhance biodiversity.
3) Projects are managed with transparency and accountability, the engagement of relevant stakeholders, and in compliance with the law.
4) Projects demonstrate community ownership, with communities participating meaningfully through the design and implementation of "plan vivos" (land management plans) that address local needs and priorities.
5) Projects generate real and additional ecosystem services that are demonstrated with credible quantification and monitoring.
6) Projects manage risks effectively throughout their design and implementation.
7) Projects demonstrate positive livelihood and socioeconomic impacts.
8) Projects share benefits equitably and transact ecosystem-services benefits through clear agreements with performance-based incentives.

Plan Vivo provides corresponding detailed requirements for each of these principles (Plan Vivo Foundation 2012a, 2012b). Plan Vivo has an eligibility checklist that helps in clarifying if an FMU activity fits into the standard.

Plan Vivo projects need to be designed using an "approved approach", which is a protocol methodology or tool that has been approved by the Plan Vivo Foundation to assess or quantify elements of Plan Vivo projects (Plan Vivo Foundation 2012b). Such tools and methods are aimed at measuring carbon pools and emission sources, quantifying climate services, assessing and monitoring leakage, assessing risks, and identifying appropriate buffer levels. Table 15 presents Plan Vivo's approved approach; Annex 1 lists other Plan Vivo tools.

The Gold Standard.[38] The Gold Standard is a "compliance grade" standard also operating in the voluntary market. Its credits can only be assessed by United Nations-accredited auditors and, unlike other standards, the Gold Standard also conducts additional in-house reviews of audit reports. This double-checking process is aimed at ensuring that carbon reductions are real, measurable, additional and permanent and that sustainable development benefits are assured. Gold Standard credits are numbered and transparently listed in a central registry that provides direct access to all project and audit documentation. The following seven principles are mandatory for the Gold Standard (The Gold Standard 2013a):

1) The activity shall comply with the UNDP Millenium Development Goals Carbon Safeguards principles.
2) The activity shall enhance sustainable development.
3) The activity shall involve all relevant stakeholders.
4) The GHG emission reductions and sequestration shall be real.
5) The activity shall comply with all relevant laws *and* the Gold Standard principles.
6) The activity shall be transparent.
7) The activity's compliance and progress shall be monitored, reported and independently verified.

The Gold Standard Foundation recently expanded its scope to include the land-use and forest sectors. In forestry, the Gold Standard will initially focus on A/R and improved forest management (IFM). By August 2014, the Gold Standard Land Use & Forestry Framework and the A/R requirements had been approved. The information provided here is based on the most recent public version, updated with the approved version (The Gold Standard 2013a, 2013b, 2013c). The IFM requirements were expected to be available by the end of 2014.

In addition to those pertaining to information, the A/R requirements include the following topics: sustainability; additionality; methodology for accounting carbon benefits; carbon performance; a description of the project cycle; and provisions for non-compliance. Section 5—methodology—includes algorithms, default values and procedures for calculating GHG emissions from the forest carbon pools as well as other emissions (e.g. from the combustion of fossil fuels in transportation) and indicates how to estimate the baseline and calculate potential leakage.

38 Information obtained at www.goldstandard.org/luf and from cited documents.

Table 15: Plan Vivo approved approaches and methodologies

Baseline/carbon modelling methodologies			
Title	**Location**	**Developer**	**Status**
Assessment of net carbon benefit for Emiti Nibwo Bulora project	United Republic of Tanzania	Vi Agroforestry	Approved May 2010
Assessment of net carbon benefit of Clinton Hunter Development Initiative Malawi land-use activities	Malawi	Clinton Hunter Development Initiative	Approved Dec 2011
Afforestation/reforestation			
Reforesting traditional home gardens using the analogue forestry concept in tropical wet zones	Sri Lanka	Conservation Carbon Company and Rainforest Rescue International	Under review
Woodlots (mixed native)	United Republic of Tanzania	Vi Agroforestry	Approved May 2010
Woodlots (mixed miombo species)	Mozambique	Envirotrade	Approved
Woodlots (mixed native/naturalized species)	Malawi	Clinton Hunter Development Initiative	Approved Dec 2011
Homestead planting (mixed fruit and non-fruit)	Mozambique	Envirotrade	Approved
Sole species woodlots (Maesopsis emini)	Uganda	Ecotrust	Approved 2007
Mixed native species woodlots	Uganda	Ecotrust	Approved 2007
Mixed native species plantations	Nicaragua	Taking Root	Approved March 2011
Agroforestry			
Dispersed interplanting	United Republic of Tanzania	Vi Agroforestry	Approved May 2010
Fruit orchard, mixed (mango, lemon, avocado, jackfruit)	United Republic of Tanzania	Vi Agroforestry	Approved May 2010
Boundary planting	United Republic of Tanzania	Vi Agroforestry	Approved May 2010
Dispersed systematic interplanting	Malawi	Clinton Hunter Development Initiative	Approved Dec 2011
Citrus orchard	Malawi		Approved Dec 2011
Boundary planting	Malawi		Approved Dec 2011
Mango orchard	Malawi		Approved Dec 2011
Fruit orchard, mango (Mangifera Indica)	Mozambique	Envirotrade	Approved
Dispersed interplanting (Faidherbia albida)	Mozambique	Envirotrade	Approved
Boundary planting	Mozambique	Envirotrade	Approved
Fruit orchard, cashew (Anacardium occidentale)	Mozambique	Envirotrade	Approved
Sub-tropical improved fallow (pine oak)	Mexico	AMBIO	Approved 2007
Subtropical live fence	Mexico	AMBIO	Approved 2007
Tropical shade coffee	Mexico	AMBIO	Approved 2007
Tropical improved fallow	Mexico	AMBIO	Approved 2007
Tropical live fence	Mexico	AMBIO	Approved 2007
Tropical taungya system	Mexico	AMBIO	Approved
Forest restoration, conservation, avoided deforestation			
Forest management and conservation (tropical lowland humid forest)	Mexico	AMBIO	Approved 2007
Subtropical forest restoration	Mexico	AMBIO	Approved 2007
Conservation of miombo woodland in Mozambique	Mozambique	Envirotrade	Review underway

Note: As of July 2013. The methodologies can be obtained at: www.planvivo.org/tools-and-resources/plan-vivo-technical-library.
Source: www.planvivo.org.[1]

The Gold Standard foresees various stages in a process that includes a pre-feasibility assessment and a regular certification process. The Gold Standard and the Forest Stewardship Council are partnering, and it will be possible for projects to obtain dual certification. The Gold Standard accepts other approved methodologies and tools, such as those of the A/R CDM (see Annex 1 for these methodologies and tools).

Verified Carbon Standard.[39] The VCS operates a GHG crediting programme in the voluntary carbon market. A VCS programme is a mechanism for certifying emission reductions and/or carbon sequestration. The VCS relies on four basic quality assurance elements: the integration of best practices; robust GHG accounting methodologies; independent auditing of all projects; and a transparent registry.

The VCS issues credits to project developers using their own methodologies (Shoch et al. 2013). As of August 2013, the VCS had more than 70 registered projects in AFOLU and around 15 in REDD+. It also had 15 approved methodologies for AFOLU, nine of them at the FMU level (Table 16), and six new methodologies were under development (Table 17) (see Annex 1 for information on VCS tools and modules). The VCS developed the Jurisdictional and Nested REDD+ (JNR) framework for accounting and crediting REDD+ programmes implemented at either the national or subnational scale. The framework also establishes a clear pathway for existing and new subnational jurisdictional activities and projects to be integrated (or "nested") within broader (higher-level) jurisdictional REDD+ programmes.[40]

Voluntary quality standards. This guide differentiates between carbon standards and quality standards. The carbon standards presented above count carbon benefits, while quality standards look at the socioeconomic and/or environmental co-benefits of forestry activities aimed at obtaining carbon benefits. This guide presents two quality standards—the CCB standards, and RES+SES.

The **CCB Standards** are aimed at evaluating land-based carbon mitigation projects from the early stages of development through implementation. The CCB Standards don't look at accounting for the carbon benefits but rather at the integration of best-practice and multiple-benefit approaches into project design and implementation. The CCB Standards assist in:

- identifying projects that simultaneously address climate change, support local communities and conserve biodiversity;
- promoting excellence and innovation in project design and implementation; and
- mitigating risk for investors and offset buyers and increasing funding opportunities for project developers.

The CCB Standards can be applied to any land-based carbon project, including activities that reduce emissions from REDD+, agricultural land management, and the avoided degradation of non-forest ecosystems. The CCB Standards do not lead to the delivery of quantified emission reductions certificates (so they should be used in combination with a carbon accounting standard, such as those of the CDM or the VCS). Consequently, the CCB Standards don't provide a set of methodologies for ex-ante carbon estimation or for ex-post carbon quantification. Carbon accounting is done according to the provisions of the specific mitigation framework selected. Relevant information for the CCB Standards is then included in the project design document. Specific templates and guidance is available for combining the CCB Standards with the VCS.[41]

The CCB Standards must be used in a two-step process involving validation and verification. CCB Standards could be considered in an FMU interested in certifying its social and biodiversity co-benefits with the aim of obtaining carbon benefits (CCBA 2008, 2010). The CCB Standards seek to ensure that projects fulfil a set of criteria (shown in Table 18, as of 2013).

The Climate, Community and Biodiversity Alliance (CCBA)'s manual for assessing the social and biodiversity impacts of REDD+ projects (CCBA 2011) has three main components:

1) core guidance for project proponents, which explains the rationale and theory of change behind the assessment approach as well as the seven stages of their application (CCBA 2011);

39 See: www.v-c-s.org/methodologies/what-methodology. All information presented here on VCS methodologies was obtained directly from VCS.
40 For more information see: www.v-c-s.org/JNRI.
41 For the VCS + CCB project description template and guidance on the project development process, see: www.climate-standards.org/documents.

Table 16: VCS approved methodologies

	Approved methodologies	
VM0003	Methodology for improved forest management through extension of rotation age, version 1.2	This methodology quantifies the greenhouse-gas (GHG) emission reductions and removals generated by extending the rotation age of a forest or patch of forest before harvesting. By extending the age at which trees are cut, projects increase the average carbon stock on the land and remove more carbon dioxide from the atmosphere. This methodology is applicable to managed forests where clearcutting or patch-cutting practices are implemented in the baseline. www.v-c-s.org/methodologies/VM0003
VM0005	Methodology for conversion of low-productive forest to high-productive forest, version 1.2	This methodology quantifies the GHG emission reductions and removals generated by avoiding the re-logging and/or by the rehabilitation of previously logged forest. Rehabilitation is achieved by implementing silvicultural techniques to increase forest density, such as the cutting of climbers and vines, liberation thinning, and enrichment planting. This methodology is applicable to logged or degraded natural evergreen tropical rainforest. It was revised on 23 July 2013 to address baseline scenario requirements for accounting for GHG emissions released from harvested wood products and on 24 August 2011 to update equations for estimating wood product carbon stocks. www.v-c-s.org/methodologies/VM0005
VM0006	Methodology for carbon accounting for mosaic and landscape-scale REDD projects, version 2.1	This methodology quantifies the GHG emission reductions and removals generated by avoiding unplanned deforestation and forest degradation in a mosaic configuration. Deforestation and forest degradation can be reduced by strengthening land-tenure status; developing sustainable forest and land-use management plans; patrolling forests and forest boundaries to protect them; capacity building; preventing fire; and introducing fuel-efficient woodstoves. This methodology is applicable to forest that would be deforested in the absence of the project activity. Deforestation and degradation in the baseline could be caused by: the conversion of forest to cropland or grazing land for small-scale farming; the conversion of forestland to settlements; the logging of timber for commercial sale; the logging of timber for local and domestic use; fuelwood collection or charcoal production; or forest fires. www.v-c-s.org/methodologies/VM0006
VM0007	REDD methodology modules (REDD-MF), version 1.4	This methodology provides a set of modules for various components of a methodology for reducing emissions from deforestation and forest degradation. The modules, when used together, quantify GHG emission reductions and removals by avoiding unplanned and planned deforestation and forest degradation. The methodology is applicable to forestlands that would be deforested or degraded in the absence of the project activity. The methodology includes a module for activities to reduce emissions from forest degradation caused by the extraction of wood for fuel. No modules are included for activities to reduce emissions from forest degradation caused by the illegal harvesting of trees for timber; such a module may be included in the future. www.v-c-s.org/methodologies/VM0007
VM0009	Methodology for avoided ecosystem conversion, version 3.0	This methodology, which was pioneered by Wildlife Works, provides a means for quantifying net GHG emission reductions and removals from project activities that prevent the conversion of forest to non-forest and of native grasslands and shrublands to non-native states. Version 3.0 differentiates between eight baseline types based on the type of ecosystem, the proximate agent of conversion, the drivers of conversion, whether the specific agent of conversion can be identified, and the progression of conversion. A single project may include one or more baseline types. www.v-c-s.org/methodologies/VM0009
VM0010	Methodology for improved forest management: conversion from logged to protected forest, version 1.2	This methodology quantifies the GHG removals generated from preventing logging of an unlogged tropical forest. The baseline scenario for the forest management regime includes selected timber harvest practices. The quantification of GHG emission removals is determined based on a change in land-use practice and an increase in carbon sequestration. This methodology is applicable to unlogged tropical forests. www.v-c-s.org/methodologies/VM0010
VM0011	Methodology for calculating GHG benefits from preventing planned degradation, version 1.0	This methodology quantifies the GHG emission reductions generated by improving forest management and preventing the planned degradation of a forest by stopping selective logging. The methodology accounts for a reduction in GHG emissions as well as an increase in carbon stock. It is applicable to previously logged or intact tropical forests, where selective logging would have occurred in the absence of carbon finance. www.v-c-s.org/methodologies/VM0011
VM0012	Improved forest management in temperate and boreal forests, v1.2	This methodology quantifies the GHG emission reductions generated by improving forest management and preventing logging in temperate and boreal forests. Specifically, the methodology quantifies GHG emission reductions from "logged to protected forest" activities—activities that protect logged or degraded forests from further logging or that protect unlogged forests from future logging. The methodology was revised on 23 July 2013 to address baseline scenario requirements for accounting for GHG emissions released from harvested wood products and on 4 May 2012 to be applicable on publicly owned lands in addition to privately owned (fee simple) forest properties. www.v-c-s.org/methodologies/VM0012
VM0015	Methodology for avoided unplanned deforestation, version 1.1	This methodology estimates GHG emissions from areas where unplanned deforestation is taking place and quantifies the emission reductions achieved by curbing deforestation. The methodology provides a comprehensive set of tools for analyzing both frontier and mosaic deforestation patterns to establish the baseline deforestation rate, monitor emission reductions and assess leakage. www.v-c-s.org/methodologies/VM0015

Table 17: VCS methodologies under development

Baseline and monitoring methodology for the rewetting of drained peatlands used for peat extraction, forestry or agriculture	This methodology outlines procedures for estimating the reduction of net greenhouse-gas (GHG) emissions resulting from project activities that rewet drained peatlands in temperate-climate regions. It allows for the estimation of GHG emissions from drained and rewetted peatlands and also accounts for changes in carbon stocks in selected non-peat carbon pools. The scope of this methodology is essentially limited to project activities designed to rewet peatlands that have been drained for forestry, peat extraction or agriculture where these activities are not or are no longer profitable. Post-rewetting activities are limited to forestry, agriculture, nature conservation/recreation and activities that aim to reduce GHG emissions, or any combination of these. This methodology uses ground vegetation composition and water level as proxies for peatland GHG emissions, known as the "greenhouse gas emission site type" approach
	www.v-c-s.org/rewetting_drained_peatlands_GEST
Avoiding planned deforestation of undrained peat swamp forests	This methodology quantifies the GHG emission reductions and removals generated by activities that avoid the planned deforestation or degradation of peat swamp forest. The methodology also quantifies the GHG emission reductions and removals due to activities that avoid peat conversion and considers the GHG benefit from assisted natural regeneration. This methodology is applicable to tropical forests on peat swamp that are designated for production purposes
	www.v-c-s.org/methodologies/avoiding-planned-deforestation-undrained-peat-swamp-forests
Avoiding degradation through fire management	This methodology calculates emission reductions and removals from avoided forest degradation and can be applied in projects that implement preventative early-dry-season burning activities against a baseline of predominantly late-dry-season burning in miombo woodlands in the Eastern Miombo Ecoregion in Africa. The methodology uses the GapFire Model to calculate emission reductions and removals resulting from the project's fire-management activities. GapFire models the growth and mortality of multiple individual trees under different fire regimes based on an ensemble of canopy-tree-sized woodland patches. It was developed and calibrated to the Eastern Miombo Ecoregion by researchers at the School of GeoSciences, University of Edinburgh. Selective harvesting of trees is allowed in both baseline and project scenarios
	www.v-c-s.org/methodologies/avoiding-degradation-through-fire-management
Rewetting of drained tropical peatlands in Southeast Asia	This methodology applies to project types that reduce GHG emissions from peat oxidation by rewetting previously drained tropical peatlands using technical means (e.g. the establishment of dams in drainage canals). This kind of project will have the following effects on GHG emissions: • a reduction in carbon dioxide emissions due to decreased oxidation of soil organic material; • a reduction in nitrous-oxide emissions in nutrient-rich peatlands (not accounted for by this methodology); • a possible increase in methane emissions (unlikely in the tropics) if the water level after rewetting is maintained near the surface; and • a possible net positive carbon accumulation in peat (not accounted for by this methodology)
	www.v-c-s.org/rewetting_drained_tropical_peatlands_southeast_Asia
Reduced-impact logging practices that reduce carbon emissions methodology	This methodology provides a framework for quantifying GHG emission reductions achieved through reduced-impact logging practices. Practices may entail a range of improved logging and harvest planning practices, such as directional felling, improved log bucking, improved harvest planning via pre-harvest inventories, skid trail planning and/or mono-cable winching, and a reduction in the width of haul roads and size of log landings. This methodology applies a performance method for setting crediting and additionality benchmarks for each emission source category (i.e. felling, skidding and hauling) to a specified area in East Kalimantan, Indonesia
	www.v-c-s.org/methodologies/reduced-impact-logging-practices-reduce-carbon-emissions-ril-c-methodology
Reduced-impact logging practices that reduce carbon emissions performance method module	This module establishes a crediting and additionality benchmark for GHG emission reductions from the implementation of reduced-impact logging practices in a specified area in East Kalimantan, Indonesia. These practices pertain to emissions in four categories: trees felled and abandoned; trees felled and some volume extracted; mortality resulting from skidding damage; and mortality resulting from the clearing of road corridors and log landings
	www.v-c-s.org/methodologies/reduced-impact-logging-practices-reduce-carbon-emissions-ril-c-performance-method

Source http://v-c-s.org.

2) a social impact assessment toolbox (see Annex 1) (Richards 2011); and
3) a biodiversity impact assessment toolbox (see Annex 1) (Pitman 2011).

The **REDD+ Social and Environmental Standards** (REDD+SES)[42] are related to the REDD+ safeguards, which are mandatory under the UNFCCC. Recognizing growing awareness at both the international and national levels of the need for effective social and environmental safeguards, the REDD+SES Initiative aims to define and build support for a higher level of social and environmental performance in REDD+ programmes. The standards are designed for government-led programmes of policies and measures implemented at the national or state, provincial or other subnational scale and are relevant to all forms of fund-based and market-based financing.

A primary role of REDD+SES is to provide a mechanism for the country-led, multistakeholder assessment of REDD+ programme design, implementation and outcomes to enable countries to show how internationally and nationally defined safeguards are being addressed and respected. A country can use REDD+SES to support the monitoring and reporting of safeguards throughout the implementation of a REDD+ programme and to develop a safeguards information system that can respond to UNFCCC guidelines and the reporting needs of donors and others (ProForest 2010).

REDD+SES can be used by governments, NGOs, financing agencies and other stakeholders to support the design and implementation of REDD+ programmes that respect the rights of indigenous peoples and local communities and generate significant social and environmental benefits (REDD+SES Initiative 2012a). As of April 2013, Ecuador, Nepal, Acre state (Brazil) and Central Kalimantan (Indonesia) were using REDD+SES in their three core elements: governance; interpretation; and assessment. Other countries and subnational units starting to use REDD+SES were Guatemala, Liberia, Mexico, the United Republic of Tanzania, the San Martin Region (Peru), and Amazonas state (Brazil).

Table 18: Criteria for CCB Standards

General section	Description
G1: Project goals, design, and long-term viability	The project has clear objectives to generate climate, community and biodiversity benefits and is designed to meet these objectives. Risks are identified and managed to generate and maintain project benefits within and beyond the life of the project
G2: Without-project land-use scenario and additionality	The without-project land-use scenario describes expected land-use changes in the project zone in the absence of project activities. The project impacts on climate, communities and biodiversity are measured against expected conditions for total greenhouse-gas (GHG) emissions, communities and biodiversity associated with the without-project land-use scenario. Project benefits must be additional (i.e. would not have occurred without the project)
G3: Stakeholder engagement	All communities and other stakeholders have adequate information for full and effective participation, which includes effective consultations with all relevant stakeholders and participation, as appropriate, of all those who want to be involved. Feedback and grievance-redress mechanisms are established and functional. Best practices are adopted in worker relations and safety
G4: Management capacity	The project has adequate human and financial resources for effective implementation
G5: Legal status and property rights	The project is based on an internationally accepted legal framework, complies with relevant statutory and customary requirements, and has the necessary approvals from the appropriate state, local and indigenous authorities. The project recognizes, respects and supports rights to lands, territories and resources, including the statutory and customary rights of indigenous peoples and others within communities and other stakeholders. The free, prior and informed consent of relevant property rights-holders has been obtained at every stage of the project. Project activities do not lead to the involuntary removal or relocation of property rights-holders from their lands or territories and do not force them to relocate activities important to their cultures or livelihoods. Any proposed removal or relocation occurs only after obtaining the free, prior and informed consent from the relevant property rights-holders

42 The information presented here was obtained from the REDD+SES website in July 2013 and cited documents. See www.redd-standards.org for updates.

Climate section	
CL1: Without-project climate scenario	Estimates of total GHG emissions in the project area under the without-project land-use scenario are described
CL2: Net positive climate impacts	The project reduces GHG emissions over the project lifetime as a result of project activities within the project area
CL3: Offsite climate impacts	Increased GHG emissions that occur beyond the project area caused by project activities (i.e. leakage) are assessed and mitigated and accounted for in the demonstration of net climate impacts
CL4: Climate-impact monitoring	Climate-impact monitoring assesses changes (within and outside the project area) in project-related carbon pools, project emissions, and non-carbon-dioxide GHG emissions, if appropriate, resulting from project activities
GL1: Climate-change adaptation benefits (optional)	The project provides significant support to assist communities and/or biodiversity in adapting to the impacts of climate change. Strategies to help local communities and biodiversity adapt to climate change are identified and implemented
Community section	
CM1: Without-project scenario for communities	Original well-being conditions for communities and expected changes under the without-project scenario are described
CM2: Net positive community impacts	The project generates net positive impacts on the well-being of communities over the project lifetime. The project maintains or enhances the high conservation values in the project zone that are of importance to the well-being of communities
CM3: Other stakeholder impacts	Project activities at least "do no harm" to the well-being of other stakeholders
CM4: Community-impact monitoring	Community-impact monitoring assesses changes in the well-being of community groups and other stakeholders resulting from the project activities
GL2: Exceptional community benefits (optional)	The project is smallholder/community-led and implemented on land that they own or manage, and/or is explicitly pro-poor in terms of targeting benefits to globally poorer communities. The project delivers equitable well-being benefits to smallholders/community members, including short-term and long-term benefits and enhancement of security and empowerment of smallholders/community members. Appropriate institutional and governance arrangements have been used to enable the full and effective participation of smallholders/community members in the decision-making, implementation and management of the project and in doing so has managed risks related to aggregating smallholders/community members at scale. Well-being benefits are shared equitably, not only with smallholders/community members but also among them, ensuring that equitable benefits also flow to more marginalized or vulnerable households and individuals within them
Biodiversity section	
B1: Biodiversity without-project scenario	The original biodiversity conditions in the project zone and expected changes under the without-project scenario are described
B2: Net positive biodiversity impacts	The project generates net positive impacts on biodiversity within the project zone over the project lifetime. The project maintains or enhances any high conservation values present in the project zone of importance in conserving biodiversity. Native species are used unless otherwise justified, and invasive species and genetically modified organisms are not used
B.3 Offsite biodiversity impacts	Negative impacts on biodiversity outside the project zone resulting from project activities are evaluated and mitigated
B.4 Biodiversity-impact monitoring	Biodiversity-impact monitoring assesses the changes in biodiversity resulting from project activities within and outside the project zone
GL.3 Exceptional biodiversity benefits	Projects conserve biodiversity at sites of global significance for biodiversity conservation based on the "key biodiversity area" framework of vulnerability and irreplaceability. Conserving biodiversity at these sites may contribute to meeting country commitments to the Convention on Biological Diversity's Aichi Biodiversity Targets and the priorities identified in national biodiversity strategy and action plans

Source: CCBA (2013).

REDD+SES is aimed at assisting the implementation of REDD+ safeguards as agreed in international processes (REDD+SES Initiative 2012a). It provides support for the development of a (required) safeguard information system. Although REDD+SES can be used at various levels, its application requires the clear definition of the REDD+ programme and is not designed for application in stand-alone projects.

REDD+SES is based on the following seven principles (REDD+SES Initiative 2012a)[43]:

43 Most terms are defined in REDD+SES Initiative (2012a).

1) The REDD+ programme recognizes and respects rights to lands, territories and resources.
2) The benefits of the REDD+ programme are shared equitably among all relevant rights-holders and stakeholders.
3) The REDD+ programme improves the long-term livelihood security and well-being of indigenous peoples and local communities, with special attention to women and the most marginalized and/or vulnerable people.
4) The REDD+ programme contributes to good governance, broader sustainable development and social justice.
5) The REDD+ programme maintains and enhances biodiversity and ecosystem services.
6) All relevant right-holders and stakeholders participate fully and effectively in the REDD+ programme.
7) The REDD+ programme complies with applicable local and national laws and international treaties, conventions and other instruments.

A set of criteria and indicators is provided for these principles (REDD+SES Initiative 2012a), and application involves a ten-step process around three core elements (Table 19).

Table 19: REDD+SES core elements and steps

Core element	Step
Governance	Awareness-raising/capacity building
	Establish facilitation team
	Create standards committee
Interpretation	Develop plan for the REDD+SES process
	Develop draft country-specific indicators
	Organize consultations on indicators
Assessment	Prepare monitoring and assessment plans
	Collect and assess monitoring information
	Organize a stakeholder review of draft assessment report
	Publish the assessment report

Source: REDD+SES Initiative (2012b).

REDD+SES does not provide methodologies for carbon accounting or carbon monitoring.

5.6.6 What happens if there are significant changes in forest management plans?

Including FMU activities in a mitigation framework can imply a series of changes to the forest management plan. It is important to keep a good balance between management priorities, according to the specific circumstances of the FMU or country. Table 20 shows some of the adjustments that may need to be considered.

Table 20: Possible adjustment strategies for including FMU activities in a climate-change mitigation framework

Possible adjustment strategies	Additional considerations
Consider adjusting the management plan at the level of management activities to increase carbon benefits	Estimate the costs and benefits of the new selected activities and compare. Are the new activities still competitive? Are sufficient human and technological skills available for the new activities, or will an increase in capacities be required?
Consider adjusting management priorities to increase carbon benefits	Estimate the costs and benefits of the new selected activities and compare. Are the new activities still competitive? Are sufficient human and technological skills available for other management priorities, or will an increase in capacities be required? Are the new management priorities in line with forest policies and laws? Do other social actors (e.g. forest users and traders of forest products) agree with the new management priorities?
Consider using another mitigation framework	Check the eligibility criteria and other requirements Note: This option might not be available if the FMU is part of an initiative in a mitigation framework (e.g. REDD+) that is agreed at a higher administrative level than the FMU
Consider not applying for any of the mitigation frameworks presented above	If the existing mitigation frameworks are not suitable for the FMU or if the carbon benefits are insignificant, a decision might be taken to not include the project in a mitigation framework. Nevertheless, it is good practice to monitor changes in carbon stocks over time (see below for the voluntary monitoring and reporting of the carbon benefits of ITTO projects) Note: This option might be not possible if the FMU is part of an initiative in a mitigation framework (e.g. REDD+) agreed at a higher administrative level than the FMU

Summary

Step 6: Select the mitigation framework and adjust design. The mitigation framework defines which activities are eligible, the regulations for carbon accounting and monitoring requirements, and the available carbon markets or payment schemes. To realize the carbon potential of an intervention it is important, therefore, to select the most appropriate framework. To facilitate the selection process and the quantification of carbon benefits, the guide presents the main principles and the available methodologies and tools of the mitigation frameworks presented in Chapter 4, namely:

- United Nations Framework Convention on Climate Change
  - REDD+, including the processes employed by the Forest Carbon Partnership Facility and the UN-REDD Programme
  - Afforestation and reforestation project activities under the CDM
- Regulated markets
  - California Climate Action Registry
  - Climate Action Reserve
- Voluntary carbon standards
  - American Carbon Registry
  - Plan Vivo
  - The Gold Standard
  - Verified Carbon Standard
- Voluntary quality standards
  - Climate, Community and Biodiversity Standards
  - REDD+ Social and Environmental Standards.

6 GUIDANCE ON THE VOLUNTARY MONITORING OF CARBON BENEFITS IN ITTO PROJECTS

6.1 STEP 7: MONITOR CARBON BENEFITS IN ITTO PROJECTS

This chapter focuses on Step 7 of the process of making carbon-related decisions (as described in Chapter 5), which specifically concerns the voluntary monitoring and reporting of the carbon benefits obtained from ITTO projects. Step 7 details the approach ITTO project managers may take in monitoring their carbon benefits when none of the mitigation frameworks described in Chapter 4 has been used.[44]

6.1.1 Why it is important to monitor carbon benefits?

The aim of monitoring carbon benefits is to quantify the real and measurable changes in carbon stocks and GHG emissions from other sources over time. Changes in forest carbon stocks are those changes that occur in the five forest carbon pools; GHG emissions can include, for example, emissions from transportation associated with the operation of an FMU.

It is necessary to monitor carbon benefits for:

- the ex-post quantification of carbon benefits;
- making management adjustments over time in order to maximize potential carbon benefits; and
- reporting carbon benefits to investors, project stakeholders and funding organizations.

All mitigation frameworks discussed in Chapter 4 have specific requirements for monitoring carbon benefits. It is possible, however, that carbon benefits will still need to be reported to management, even if the FMU is not participating in a mitigation framework. Because addressing climate change is increasingly important in the context of sustainable development, some multilateral agencies are pushing the monitoring of carbon benefits as a regular activity in bilaterally and multilaterally funded projects.

Several documents provide guidance on monitoring carbon benefits from forestry activities (Baker et al. 2010; Diaz and Delaney 2011; FAO 2013; GOFC-GOLD 2011; Harris et al. 2012; Herold and Skutsch 2011; Hodgman et al. 2012; MacDicken 1997; Herold and Johns 2007; Muraya and Baraka 2010; Pearson et al. 2005a, 2005b, 2012, 2007; Petrokofsky et al. 2012; Ravindranath and Ostwald 2007; Rombold 2003; UN-REDD Programme 2013a; Walker et al. 2012; Watson 2009; Zhang et al. 2012). This guide builds on this existing knowledge and proposes an approach that is in line with existing UNFCCC decisions. In all cases, forest managers should check if there are specific norms regulating the monitoring of carbon benefits in their countries. It is especially important that measurements are consistent with ongoing developments in national forest monitoring systems.

If the results of regular monitoring protocols indicate a carbon benefit significantly below what was expected in the ex-ante screening (e.g. those estimated with sCreen), the following steps can be taken:

- Check if the default values used in the estimation correspond with the measured values during the monitoring. Report significant differences to the source of the default values and correct your estimations.
- Check for management corrections that could be made to improve activity performance.
- Check if the area per activity corresponds with the area planned. If there are significant differences, clarify why these have arisen and make efforts to improve performance.

6.1.2 Rationale

Many ITTO projects involve FMU monitoring activities related to specific management priorities. If so, the monitoring of the carbon benefits should be planned in a way that is complementary to other monitoring activities.

The *IPCC Good Practice Guidelines for Land Use, Land Use Change and Forestry* (IPCC 2003) state

44 If an ITTO project participates in any of the mitigation frameworks described in Chapter 4, carbon benefits may be reported on the basis of the monitoring requirements already used in the particular framework(s).

that carbon benefits should be monitored as a function of land or activity area and emission factors per activity. The clarification of the land/activity area responds to the question: "Where do GHG emissions or sinks happen?" The clarification of emission factors responds to the question: "What GHG emissions or sinks happen in a given area/activity?" (IPCC 2003; UN-REDD Programme 2013a) (Figure 12).

IPCC (2003) defines three approaches for establishing the land area/activity area, as follows:

- *Approach 1—Basic land-use data.* These data apply to the total land-use area within an administrative border (see Table 21 for an example). In the case of an ITTO project, this approach refers to the land/activity area as per the regular statistics used in the project region. The geographical specification is unknown. Data can be subdivided to increase accuracy.
- *Approach 2—Survey of land use and land-use change.* This approach includes information on land-use change and can account for all land-use transitions, but without geographical specification. It "includes more information on changes between categories. The final result of this approach can be presented as a non-spatially explicit land-use matrix" (IPCC 2003) (Table 22).
- *Approach 3—Geographically explicit land-use data.* This approach "requires spatially explicit observations of land and land-use change. The data may be obtained either by sampling or geographically located points, a complete tally (wall-to-wall mapping), or a combination of the two" (IPCC 2003). When using this approach, detailed maps should be obtained allocating land/activity types to special units as grid cells or small polygons in a time series. The final result is a spatially explicit land-use change matrix.

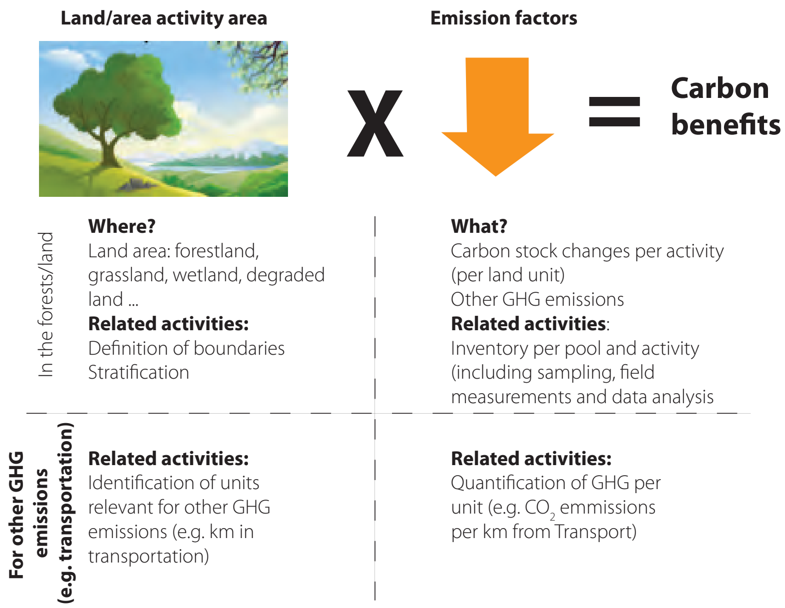
Table 21: Example of Approach 1: available land-use data with complete territorial coverage

Time 1	Time 2	Land-use change between time 1 and time 2
F = 18	F = 19	F = +1
G = 84	G = 82	G = -2
C = 31	C = 29	C = -2
W = 0	W = 0	W = 0
S = 5	S = 8	S = +3
O = 2	O = 2	O = 0
Sum = 140	Sum = 140	Sum = 0

Note: F = forestland; G = grassland; C = cropland; W = wetlands; S = settlements; O = other land. Numbers represent area units (million ha, in this example).

Source: IPCC (2003).

Figure 12: Rationale for monitoring carbon benefits in ITTO projects



Source: Adapted from UN-REDD Programme (2013a). Landscape graphic from www.resourcegraphics.com.

Table 22: Illustrative example of Approach 2 data in a land-use change matrix, with category subdivisions

Initial / Final	Forestland (unmanaged)	Forestland (managed)	Grassland (rough grazing)	Grassland (improved)	Cropland	Wetland	Settlements	Other land	Final area
Forestland (unmanaged)	5								5
Forestland (managed)		10	1	2	1				14
Grassland (rough grazing)		2	56						58
Grassland (improved)			2	22					24
Cropland					29				29
Wetland						0			0
Settlements		1	1		1		5		8
Other land								2	2
Initial area	5	13	60	24	31	0	5	2	140
Net change	0	+1	-2	0	-2	0	+3	0	0

Note: Column and row totals show net changes in land use as presented in Table 2.3.2 of the IPCC Good Practice Guidance (IPCC 2003) but subdivided into national subcategories, as in Table 2.3.3 of the same document. "Initial" indicates the category at a time previous to the date on which the assessment is made and "Final" indicates the category at the date of assessment. Net change (bottom row) is the final area minus the initial area for each of the (sub)categories shown at the head of the corresponding column. Blank cells indicate no land-use change for this transition.

Source: IPCC (2003).

The IPCC proposes three tiers of data sources for the emission factors of activities (Box 1); the higher the approach and tier, the more accurate will be the calculation.

Below, guidance is provided on how to establish the land/activity area and emission factors in ITTO projects when no other mitigation framework is used. The guidance includes a procedure for assessing leakage and, if appropriate, for undertaking the corresponding discounting of the carbon benefits. It takes into account that it will be difficult for some ITTO project activities to fulfil all data requirements, both for Approach 3 and Tier 3.

6.1.3 Establishing land/activity area

For the purposes of monitoring carbon benefits in ITTO projects, it is recommended that maps be created using either Approach 2 or Approach 3 for determining land/activity area. To create these maps, two steps need to be taken (using one of the two approaches):

1) establish the FMU boundaries (as outlined in Step 1 in Chapter 5); and
2) stratify the FMU area (as outlined in Step 5 in Chapter 5).

With the boundaries defined and the area stratified, there should now be detailed geographic information on the size and location of the activity areas. This information can be represented in maps, as geographic coordinates, and in geographic information systems (Asner 2009).

6.1.4 Establishing units for other sources of GHG emissions

In addition to the forest carbon pools, there are several potential sources of GHG emissions in forest projects, such as:

- transportation;
- the operation of equipment; and
- building construction and operation.

If any of these sources could become significant, a measurement unit should be established for potential GHG emissions (e.g. in the case of transportation, the number of kilometres travelled). Even if potential sources are unlikely to become significant, they should still be documented and reported as non-relevant sources to ITTO.

6.1.5 Establishing emission/sink factors

Carbon pools. General guidance on deciding which carbon pools are relevant in a given project is given in Chapter 5 (Step 5). Table 23 shows the recommended pools to be monitored in ITTO projects, by project type.

Bear in mind that three GHGs—carbon dioxide, nitrous oxide and methane—should be considered. Projects that include soil organic carbon should monitor nitrous oxide and methane in addition to carbon dioxide.

Sampling design. In designing a sampling strategy it is necessary to determine the type, form, number and location of plots. There are two basic plot types: temporary and permanent. Both have advantages and disadvantages (Table 24). Permanent plots can be used to monitor tree carbon pools (living biomass). Temporary plots must be used for the other three pools (litter, dead wood and soil organic carbon) because measuring the sample destroys it (this is called "destructive sampling").

According to Pearson et al. (2005a), "the size and shape of the sample plots is a trade-off between accuracy, precision, time and cost for measurement". Single or nested plots can be used, depending on the type of activity in the FMU (e.g. plantation, forest management, conservation or restoration). The decision on whether to use single or nested plots has an impact on the required size of the sample (single plots tend to be larger than nested plots).

Determining the number of required plots is a function of various factors, including the confidence interval, the variance of each carbon pool, and the number of strata. Tools are available to help with this (Box 2). For statistical rigour, plot locations should be determined in a way that does not introduce bias, and all strata in the project area should be sampled. Plot locations can be determined randomly or in a fixed grid over the entire area.

How to proceed? Take the following three steps:

1) Clarify if specific guidance on sampling design is available in the relevant country or region.

2) If no specific guidance is available, select any of the guidelines listed in Box 2, according to specific circumstances (e.g. available/achievable information; budget; and other monitoring priorities).

Table 23: Carbon pools recommended to be measured and monitored, by ITTO project type

Project type	Carbon pools						
	Living biomass			Dead organic matter		Soil organic carbon	Harvested wood products
	Aboveground (tree)	Aboveground (non-tree)	Belowground	Litter	Dead wood		
Afforestation/reforestation	Y	M	Y	M	M	M	Y
Forest management	Y	M	Y	M	Y	M	Y
Conservation	Y	M	Y	M	Y	M	N
Restoration	Y	M	Y	M	M	M	M
Re-vegetation	M	Y	M	M	M	M	M

Note: Letters refer to the need for measuring and monitoring: Y = yes, the change in this pool is likely to be large and should be measured; N = no, the change is likely to be small to none and therefore it is not necessary to measure this pool; M = maybe, the change in this pool may need to be measured, depending on the forest type and/or management intensity of the project.

Sources: Adapted from IPCC (2003); Pearson et al. (2005a).

Table 24: Advantages and disadvantages of temporary and permanent plots

Type of plot	Advantages	Disadvantages
Temporary	Cannot be treated differently and cannot be destroyed by disturbances	Less precise in the estimation of changes in carbon stocks—this can be partially solved by having a higher number of plots, but this increases cost
Permanent	Statistically more efficient in estimating changes in carbon stocks because there is a high covariance between observations at successive sampling events	Because the location is known (and marked), plots might receive "special treatment", potentially introducing bias; can be destroyed by disturbances

Box 2: Guidelines on sampling design

The following publications provide detailed guidance on sampling design:

- Diaz, D. & Delaney, M. (eds.) 2011. *Building forest carbon projects: carbon stock assessment guidance inventory and monitoring procedures*. Available at www.forest-trends.org/publication_details.php?publicationID=2555.
- Ravindranath, N.H. & Ostwald, M. 2007. *Carbon inventory methods: handbook for greenhouse gas inventory, carbon mitigation and roundwood production projects*. Springer.
- Pearson, T., Brown, S. & Birsey, R. 2007. *Measurement guidelines for the sequestration of forest carbon.* Available at: www.nrs.fs.fed.us/pubs/3292.
- A/R methodological tool: "Calculation of the number of sample plots for measurements within A/R CDM project activities" (Version 02). See Annex 1 for details. Available at: http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-03-v2.1.0.pdf/history_view.
- Pearson, T., Brown, S. & Walker, S. 2005b. *Sourcebook for land use, land-use change and forestry projects*. Available at www.winrock.org/ecosystems/tools.asp.
- Winrock sampling calculator. Available at: www.winrock.org/ecosystems/tools.asp.
- Pearson, T.R.H., Brown, S. & Ravindranath, N.H. 2005a. *Integrating carbon benefit estimates into GEF projects.* UNDP and GEF. Available at: www.winrock.org/ecosystems/tools.asp.
- GOFC-GOLD 2011. *A sourcebook of methods and procedures for monitoring and reporting anthropogenic greenhouse gas emissions and removals caused by deforestation, gains and losses of carbon stocks in forests remaining forests, and forestation.* Global Observation of Forest and Land Cover Dynamics.
- IPCC 2003. *Good practice guidance for land use, land-use change and forestry*. Penman, J., Gytarsky, M., Hiraishi, T., Krug, T., Kruger, D., Pipatti, R., Buendia, L., Miwa, K., Ngara, T., Tanabe, K. & Wagner, F. (eds.). Intergovernmental Panel on Climate Change. Institute for Global Environmental Studies, Hayama, Japan.

3) Document the following information:
   - assumptions;
   - methods selected and criteria used for the decision; and
   - tools used.

6.1.6 Field measurements

Field measures depend on the carbon pools selected (see above), and whether there is a default equation (or default value) that relates the measured pool to other pools. For example, there are default values for relating ABG to BGB; in this case, the use of the default values can reduce the need to sample BGB.

In theory, all ABG components (including tree branches and leaves) should be measured because all components contain sequestered carbon that could be emitted into the atmosphere. This would result in a very expensive inventory, however, and an alternative path is to measure tree diameters at breast height and use "biomass expansion factors" (BEFs).[45] The use of BEFs means that the only measurement required for trees (including palms and lianas) is diameter at breast height.

AGB can be measured either as part of a forest inventory or by using emerging techniques such as LiDAR ("light detection and ranging") (Hudak et al. 2012; Kronseder et al. 2012; Sierra et al. 2007). If LiDAR or related techniques are available they should be considered as an option for quantifying AGB.

BGB consists of roots, including fine roots. There are three options for estimating BGB: the use of default values that relate AGB to BGB; the use of regression equations; and destructive sampling. The last option would affect sampling design because it requires the use of temporary plots.

For the deadwood pool, samples of standing dead trees and (coarse) dead wood greater than 10 cm in diameter would need to be measured. Litter, comprising all material on the forest floor, including dead leaves, twigs, dead grasses, branches and wood less than 10 cm in diameter, would need to be sampled and measured.

45 One source of BEFs is IPCC (2003).

According to Ravindranath and Ostwald (2007), several methods are available and in use for estimating soil organic carbon (SOC), ranging from simple laboratory estimations to diffuse reflectance spectroscopy. The wet digestion or titrimetric determination method is the most commonly used method in the field.

Field measurements need to be planned in detail in advance, including the specification of standard operating procedures in the project area. Such detailed planning will help reduce costs and increase the accuracy and transparency of the measurements.

How to proceed? Take the following five steps:

1) Clarify which pools need to be measured.
2) Identify the data requirements for the selected equations for each pool (are these equations based on default values?).
3) Select the specific field measurement techniques (e.g. from Box 3).
4) Prepare standard operating procedures for the project area/FMU.
5) Check the availability of equipment and qualified personnel.

Frequency of measurement. Person et al. (2005a) proposed a straightforward approach for determining the frequency of measurement events related to the accumulation of carbon in the various pools and the type of forestry activity.

Box 3: Available guidance on field measurements

The following publications and websites provide detailed guidance or specific experiences on field measurement:

Walker, S.M., Pearson, T., Casarim, F.M., Harris, N., Petrova, S., Grais, A., Swails, E., Netzer, M., Goslee, K. & Brown, S. 2012. *Standard operating procedures for terrestrial carbon measurement: version 2012*. Available at: www.winrock.org/ecosystems/tools.asp.

Hudak, A.T., Strand, E.K., Vierling, L.A., Byrne, J.C., Eitel, J.U.H., Martinuzzi, S. & Falkowski, M.J. 2012. Quantifying aboveground forest carbon pools and fluxes from repeat LiDAR surveys. *Remote Sensing of Environment* 123: 25–40.

Kronseder, K., Ballhorn, U., Böhm, V. & Siegert, F. 2012. Above ground biomass estimation across forest types at different degradation levels in Central Kalimantan using LiDAR data. *International Journal of Applied Earth Observation and Geoinformation* 18: 37–48.

Diaz, D. & Delaney, M. (eds.) 2011. *Building forest carbon projects: carbon stock assessment guidance inventory and monitoring procedures*. Available at www.forest-trends.org/publication_details.php?publicationID=2555.

Ravindranath, N.H. & Ostwald, M. 2007. *Carbon inventory methods: handbook for greenhouse gas inventory, carbon mitigation and roundwood production projects.* Springer.

Pearson, T., Brown, S. & Birsey, R. 2007. Measurement guidelines for the sequestration of forest carbon. Available at: www.nrs.fs.fed.us/pubs/3292.

Pearson, T., Brown, S. & Walker, S. 2005. *Sourcebook for land use, land-use change and forestry projects.* Available at www.winrock.org/ecosystems/tools.asp.

Pearson, T.R.H., Brown, S. & Ravindranath, N.H. 2005. *Integrating carbon benefit estimates into GEF projects.* UNDP and GEF. Available at: www.winrock.org/ecosystems/tools.asp.

GOFC-GOLD 2011. *A sourcebook of methods and procedures for monitoring and reporting anthropogenic greenhouse gas emissions and removals caused by deforestation, gains and losses of carbon stocks in forests remaining forests, and forestation*. Global Observation of Forest and Land Cover Dynamics. Available at: www.gofcgold.wur.nl.

IPCC 2003. *Good practice guidance for land use, land-use change and forestry.* Penman, J., Gytarsky, M., Hiraishi, T., Krug, T., Kruger, D., Pipatti, R., Buendia, L., Miwa, K., Ngara, T., Tanabe, K. & Wagner, F. (eds). Intergovernmental Panel on Climate Change. Institute for Global Environmental Studies, Hayama, Japan.

A measurement frequency of five years for all carbon pools is specified, with the exception of SOC, which should be measured every ten (or in some circumstances, 20) years.

Nevertheless, because the purpose of this chapter is to provide guidance on reporting carbon benefits in the ITTO project cycle, two field measurement events are recommended:

1) in the last year of implementation of the ITTO project; and
2) during the year of ex-post evaluation (in the same season as the first measurement).

The reason for this frequency is to facilitate reporting on carbon benefits to ITTO.

6.1.7 Emission factors from other sources

To estimate GHG emissions from other sources relevant in an FMU, measurements are either made at the site or default values are used. Measurements can be expensive, so the use of default values appropriate for the FMU is recommended (Box 4). Building construction attributable to FMU activities can have a significant impact on the carbon balance.

6.1.8 Data analysis

In this step, measurements are used for calculating: changes in carbon stocks in the carbon pools selected in the project; and emissions from other sources.

$$\text{Total } MC_{tx} = \Sigma(MC_{ptx} * A_{sa...j}) + \Sigma(MC_{otx} * U_{oa...j})$$

Where:

Total MC_{tx} = total monitored carbon in the FMU at time x for each stratum (CO_2e);

MC_{ptx} = total monitored carbon stocks in the selected pools by time x (CO_2e) (see 6.1.4);

$A_{s1...j}$ = corresponding total land/activity area per stratum a…j (see 6.1.3);

MC_{etx} = total monitored emissions from each other source by time x (CO_2e) (see 6.1.4); and

$U_{oa...j}$) = total units of other sources per each source (e.g. number of litres of petrol consumed) (see 6.1.3).

> *Box 4: Sources of default values for emission factors from other sources*
>
> Several databases of default values for emission factors are available at the national and international levels. See, for example, the factors used in:
>
> - national GHG inventories in the country where the project is implemented (http://unfccc.int/ghg_data/items/3962.php).
> - the UNFCCC data inventory (http://unfccc.int/ghg_data/items/3800.php).
> - internationally accepted databases and other resources (e.g. “ecoinvent”—Althaus, H.-J. & Lehmann, M. (2010). Ökologische Baustoffliste (v2.2e). Empa Abteilung Technologie und Gesellschaft, Dübendorf. Available at: www.empa.ch/baustoffliste).

How to calculate the total changes in carbon stocks in the selected pools. Established equations are available for calculating each carbon pool, especially AGB (e.g. Brown et al. 1989, 1991; Chave et al. 2005; IPCC 2003; Kronseder et al. 2012; Lü et al. 2010; Ngo et al. 2013; Pearson et al. 2005a; Petrokofsky et al. 2012; Ravindranath and Ostwald 2007; Sierra et al. 2007; and Vieilledent et al. 2012).

For each selected pool and following the IPCC tier approach (Box 1), select the equations best suited to the specific situation. That means looking first for equations specific to the region or site (Anwar Siregar 2011; Sierra et al. 2007). If a site-specific equation is unavailable, use country-level equations. If these are unavailable, use default equations, such as those given in IPCC (2003) and Pearson et al. (2005a) (Box 5 provides a list of publications that include default equations). It is also possible to develop specific equations for a site or region, but this is a time-intensive and resource-intensive activity.

Bear in mind that emissions of non-carbon-dioxide gases must be included in the calculations, such as those deriving from the use of fertilizers, draining peat swamps, fire, and the use of certain species (e.g. leguminous species).[46] IPCC (2003) provides methods for estimating these emissions.

46 Leguminous tree species (e.g. *Leucaena lecocephala*) emit nitrous oxide; thus, planting a large area with leguminous tree species will affect the carbon balance of an area, and monitoring nitrous oxide emissions in areas where leguminous are planted becomes very important.

Box 5: Available guidance for data analysis

References providing detailed steps for data analysis, including equations:

- Anwar Siregar, C. 2011. *Develop forest carbon standard and carbon accounting system for small-scale plantation based on local experiences*. Ministry of Forestry (Indonesia), International Tropical Timber Organization. An output of project RED-PD 007/09 Rev.2 (F). Available at: www.itto.int/project_search.
- Berry, N. 2008b. *Carbon modelling for afforestation and reforestation projects*. Edinburgh Centre for Carbon Management, Camco Group, Edinburgh, UK.
- Brown, S., Gillespie, A.J.R. & Lugo, A.E. 1989. Biomass estimation methods for tropical forests with applications to forest inventory data. *Forest Science* 35: 881–902.
- Brown, S., Gillespie, A.J.R. & Lugo, A.E. 1991. Biomass of tropical forests of south and southeast Asia. *Canadian Journal Forest Research* 21: 111–117. DOI:10.1139/x91-015.
- Chave, J., Andalo, C., Brown, S., Cairns, M.A., Chambers, J.Q., Eamus, D., Fölster, H., Fromard, F., Higuchi, N., Kira, T., Lescure, J.-P., Nelson, B.W., Ogawa, H., Puig, H., Riéra, B. & Yamakura, T. 2005. Tree allometry and improved estimation of carbon stocks and balance in tropical forests. *Oecologia* 145: 87–99. DOI:10.1007/s00442-005-0100-x.
- GOFC-GOLD 2011. *A sourcebook of methods and procedures for monitoring and reporting anthropogenic greenhouse gas emissions and removals caused by deforestation, gains and losses of carbon stocks in forests remaining forests, and forestation*. Global Observation of Forest and Land Cover Dynamics. Available at: www.gofcgold.wur.nl.
- IPCC 2003. *Good practice guidance for land use, land-use change and forestry*. Penman, J., Gytarsky, M., Hiraishi, T., Krug, T., Kruger, D., Pipatti, R., Buendia, L., Miwa, K., Ngara, T., Tanabe, K. & Wagner, F. (eds). Intergovernmental Panel on Climate Change. Institute for Global Environmental Studies, Hayama, Japan.
- Lü, X.-T., Yin, J.-X., Jepsen, M.R. & Tang, J.-W. 2010. Ecosystem carbon storage and partitioning in a tropical seasonal forest in southwestern China. *Forest Ecology and Management* 260: 1798–1803.
- Muraya, P. & Baraka, P. 2010. *Supporting data management system: how to set up a structured data management system*. Carbon Benefit Project: Modelling, Measurement and Monitoring. World Agroforestry Centre.
- Ngo, K.M., Turner, B.L., Muller-Landau, H.C., Davies, S.J., Larjavaara, M., Nik Hassan, N.F. bin & Lum, S. 2013. Carbon stocks in primary and secondary tropical forests in Singapore. *Forest Ecology and Management* 296: 81–89.
- Pearson, T., Brown, S., Ravindranath, N.H. 2005. *Integrating carbon benefit estimates into GEF projects*. GEF Guidebook. UNDP and Winrock International.
- Pearson, T., Brown, S. & Walker, S., 2005. *Sourcebook for land use, land-use change and forestry projects*. General Technical Report NRS-18. United States Department of Agriculture Forest Service.
- Ravindranath, N.H. & Ostwald, M. 2007. *Carbon inventory methods: handbook for greenhouse gas inventory, carbon mitigation and roundwood production projects*. Springer.
- Sierra, C.A., del Valle, J.I., Orrego, S.A., Moreno, F.H., Harmon, M.E., Zapata, M., Colorado, G.J., Herrera, M.A., Lara, W., Restrepo, D.E., Berrouet, L.M., Loaiza, L.M. & Benjumea, J.F. 2007. Total carbon stocks in a tropical forest landscape of the Porce region, Colombia. *Forest Ecology and Management* 243: 299–309.
- Vieilledent, G., Vaudry, R., Andriamanohisoa, S.F.D., Rakotonarivo, O.S., Randrianasolo, H.Z., Razafindrabe, H.N., Rakotoarivony, C.B., Ebeling, J. & Rasamoelina, M. 2012. A universal approach to estimate biomass and carbon stock in tropical forests using generic allometric models. *Ecological Applications* 22: 572–583.

6.1.9 Uncertainty

According to IPCC (2003), "estimates of uncertainty need to be developed for all categories in an inventory and for the inventory as a whole". IPCC (2003) includes a section on the key types of uncertainty and provides specific information on how to apply good practice in their treatment. ITTO project managers should therefore be guided by Chapter 5 of IPCC (2003).

6.1.10 Assessment of leakage

The same approach as specified in the sCreen methodology should be used in assessing leakage in ITTO projects.[47] The term leakage is defined in discussions on the modalities and procedures of the Kyoto Protocol.[48] In the context of REDD+, the text of relevant UNFCCC decisions includes "leakage" and "displacement of emissions" without giving specific definitions. For the purpose of estimating carbon benefits in ITTO projects, leakage can be defined as GHG emissions from a given carbon pool that are displaced from the project area as a result of the project. In a project aiming to reduce forest degradation due to illegal logging, for example, if the social groups involved in illegal logging are not included in the management activity, they may continue their illegal activities in other forests. In such a case, the GHG emissions due to illegal logging will continue outside the project area, constituting leakage.

A simplified assessment of potential leakage can be made according to the following procedure:

- Identify activities that cause GHG emissions in the baseline case (e.g. deforestation).
- Identify the social groups involved.
- Clarify if and to what extent these social groups were involved in the implementation of the management activity.
- If the majority of (or all) social groups involved in activities emitting GHGs in the baseline case were also involved in the implementation of the management activity, go to Option 1 (below).
- If some social groups involved in activities emitting GHGs in the baseline case were also involved in the implementation of the project, go to Option 2.
- If no social group involved in activities emitting GHGs in the baseline was involved in management activities, go to Option 3.

Option 1: No or non-significant leakage is expected. In this case there is no need for a reduction in project carbon benefit (0%).

Option 2: Reduce the potential carbon benefit, as estimated using the methodologies presented above, by 30–50%, determining the size of the reduction according to the social groups involved.

Option 3: Reduce the potential carbon benefit, as estimated using the methodologies presented above, by 100%.

6.1.11 The voluntary reporting of carbon benefits to ITTO

ITTO projects are encouraged to regularly report on their carbon benefits; this could be done, at a minimum, in the last year of implementation of the project and during the year of ex-post evaluation. If the ITTO project has more than one phase, the carbon benefits could be reported at the end of the first phase and at the beginning and end of following phases. For those projects that continue implementation after ITTO funding has ceased (e.g. if a plantation has been established), the carbon benefits could be reported every five years.

Two procedures may be followed:

1) If the project is using any of the mitigation frameworks (as described earlier) it should report using the monitoring and reporting protocols of that framework. If the monitoring and reporting dates do not coincide with the end of the project and the year of the ex-post evaluation, the closest monitoring and reporting events of the selected mitigation framework should be used in reporting to ITTO.
2) If none of the mitigation frameworks is used, the following reporting procedure may be used:
   - Calculate the total carbon benefits of the project using the following formula:

     $$CB_{tx} = MC_{tx} - EC_{tx} - L$$

     Where

47 See Robledo (2012). The sCreen methodology was prepared in parallel to this guide and as an output of the same REDDES project (RED-PA 069/11 Rev.1 (F)).

48 In this context, leakage has been defined as an increase in GHGs that occurs outside the boundary of an afforestation or reforestation project activity under the CDM and which is measurable and attributable to the afforestation or reforestation project activity.

CB_{tx} = carbon benefits by year x (CO_2e);

MC_{tx} = monitored changes in carbon stocks and emissions from other sources by year x (see 6.1.4);

EC_{tx} = carbon stock changes expected without intervention by year x (as estimated using a simplified tool such as sCreen); and

L= leakage.

– Document these benefits using the voluntary reporting format (Annex 3).

6.1.12 Participation of stakeholders, including local communities and indigenous peoples, in monitoring activities

The involvement of local stakeholders in monitoring is strongly recommended; it can help increase project acceptance and transparency and thus support the permanence of carbon benefits.

Participatory processes and methods are well-known in ITTO member countries and are not detailed here. It is worth noting, however, that specific guidance on stakeholder involvement in project monitoring is increasingly available, especially for projects aimed at climate-change mitigation (e.g. Blomly and Richards 2011; Larrazzabal et al. 2012; Madlener et al. 2006; Verplanke and Zahabu 2009).

To promote the participation of local stakeholders, the following six steps are recommended:

1) Identify specific monitoring activities suited to a participatory approach.
2) Identify local capacities for step 1.
3) Establish capacity-building demands/needs for participatory monitoring.
4) Conduct capacity building among local stakeholders in advance of any monitoring activity.
5) In collaboration with stakeholders willing to participate in monitoring, establish roles, responsibilities and benefits.
6) Document the agreements made as part of step 5.

6.1.13 Inventory quality assurance/quality control and documentation

IPCC (2003) states: "it is a good practice to implement quality control checks and external expert review of inventory estimates and data. Specific attention should be paid to country-specific estimates of stock change factors and emission factors to ensure that they are based on high quality and verifiable expert opinion". For ITTO projects, these guidelines recommend maintaining careful documentation of all decisions made when undertaking the various steps outlined here and the criteria used in making those decisions. Such documentation increases the transparency and credibility of the monitoring and reporting process.

Summary

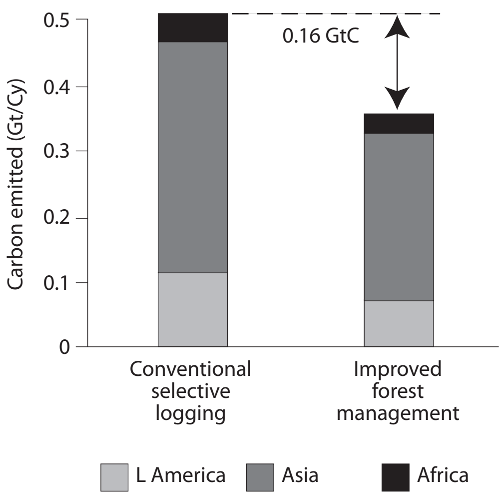
Step 7: Monitoring carbon benefits in ITTO projects. This section clarifies the steps that ITTO project managers may take in monitoring the carbon benefits of projects when no mitigation framework has been used (if the ITTO project participates in an established mitigation framework, carbon benefits may be reported on the basis of the monitoring requirements of that framework). The guide details "how" to do this monitoring and "who" is responsible for it. Information is also provided on how to establish the land/activity area, the emission factors, how to deal with uncertainties, how to establish and quantify leakage, and how to involve stakeholders in monitoring activities. Annex 3 provides a detailed format for the voluntary monitoring and reporting on the carbon benefits of ITTO projects.

6.2 OPPORTUNITIES AND CHALLENGES IN MONITORING THE CARBON BENEFITS OF SFM

There are potential carbon benefits in the implementation of SFM in the tropics. Studies by Putz et al. (2008) and Robledo and Blaser (2008) indicate that these benefits may fall in the range of 0.16 GtC per year (from improving timber practices, calculated using a very conservative approach, see Figure 13) to 0.26 GtC per year (involving all possible management activities). Both studies used the same basic assumption that 350 million hectares of tropical forest are designated as production forest; the potential carbon benefit, therefore, is equivalent to at least 10% of potential emission reductions from deforestation in developing countries.

According to Langner et al. (2012), "in contrast to clear logging, reduced-impact logging (RIL)

Figure 13: Annual reductions in global carbon emissions that would result from the adoption of improved tropical forest management practices



Source: Putz et al. (2008).

mitigates the physical impacts on the ground, to the remaining standing trees, and ecosystem as a whole by using a combination of pre-harvest census, controlled felling, lowered allowable cut, and regulated machinery use. In combination with longer cutting cycles as applied under next-generation ... SFM, RIL also helps to preserve carbon". If a payment or compensation mechanism is in place, carbon benefits can help leverage the economic feasibility of SFM, creating "win–win" outcomes. This could become a realistic avenue towards sustainability in many production forests in the tropics.

What, then, makes SFM challenging for climate-change mitigation? One reason among many is that monitoring the carbon benefits of SFM poses challenges in defining the land/activity area and in estimating and monitoring the emissions and sinks (Table 25).

Estimating AGB is one of the main challenges. Tropical forests are characterized by a high number of species per hectare. Because AGB calculations are based on defining the growth curves of the main vegetation components, accurate estimates require basic equations for many species. Although equations are available for groups of species, the literature is inconsistent and scarce (IPCC 2006, 2003; Pearson et al. 2005a).

Although there has been progress in the development of methods for quantifying carbon and monitoring carbon benefits, major challenges remain. An option is to combine existing technologies and procedures: for example, the use of LiDAR instead of field inventory to calibrate satellite data is a promising option, especially in remote forest areas (Asner 2009). Nevertheless, the cost of monitoring is likely to pose significant difficulties, especially at the project level.

In addition to research projects and national monitoring initiatives, reporting carbon benefits at the FMU level is important for approximating the real and measurable carbon benefits in the field; testing new technologies in the real conditions confronting forest managers; and identifying research gaps. A stepwise approach for improving the monitoring of carbon benefits from SFM at the FMU level is needed. The aim should be to encourage forest managers in their attempts to monitor carbon benefits without creating a financial burden. A stepwise approach should also facilitate permanent improvement in monitoring procedures. On the one hand, therefore, forest managers should have access to flexible guidance on monitoring that allows them to use the best techniques and equations available for their specific sites. On the other, forest managers should report on the methods and measurement techniques used in their monitoring activities in an accurate and transparent manner. The guidance for ITTO projects presented in this chapter is based on these principles.

Summary

Although it is recognized that sustainable forest management (SFM) generates carbon benefits, it is only starting to be included as an activity in mitigation frameworks. This section documents the opportunities for SFM, as well as the challenges involved in monitoring the carbon benefits of SFM.

Table 25: Summary of the main challenges for monitoring carbon benefits in SFM

Challenges for monitoring the carbon benefits of SFM	Strategies currently used	Remaining challenges
Clarifying forest status (e.g. the stage of degradation), which is necessary for defining boundaries and strata	Remote sensing is a good option for differentiating forest from non-forest but is less useful for determining the state of degradation[a,b,g]	Estimating the state of degradation, which is necessary for accurate stratification[c]
Generating appropriate aboveground biomass equations or quantification for different sites; estimating the degradation stage	Use radar and optical remote sensing technology[a]	Radar remote sensing can acquire data irrespective of haze and the persistently cloudy weather conditions common in the humid tropics[4], but the signal of all available radar sensors tends to saturate at a lower value than the actual aboveground biomass volumes of tropical rainforests[c] and there are also errors in mountain areas[e]
	Use LiDAR sensors to overcome sensor saturation	Large-scale applications are not feasible due to narrow swath and high costs[c]
Estimating aboveground biomass growth after harvesting (under differing regimes)	Ongoing research projects are aimed at developing the necessary models and testing aboveground biomass estimation techniques, combined with field inventories[h,i,j,k]	
Quantifying carbon benefits in carbon pools other than aboveground biomass	Field inventories and ongoing research[h,i,j,k,l,m,n,o,p]	Reducing the cost of field inventories for non-aboveground biomass carbon pools (in remote areas)

Sources: a: Saatchi et al. (2011); b: Ramankutty et al. (2007); c: Langner et al. (2012); d: Asner (2009); e: Gibbs et al. (2007); f: Hudak et al. (2012); g: DeFries et al. (2007); h: Hall et al. (2011); i: Le Toan et al. (2011); j: Mitchard et al. (2011); k: Baker et al. (2010); l: Ravindranath and Ostwald (2007); m: Batjes (2011); n: Coles et al. (2010); o: Eliasson et al. (2013); p: Price et al. (2012).

6.3 LEGAL AND CONTRACTUAL CONSIDERATIONS

Summary

In promoting the carbon benefits of a forest management unit, it is important to clarify who owns those benefits. This is a requirement for the sale of carbon certificates, which are becoming important in REDD+ negotiations. The clarification of the ownership of carbon benefits may be voluntary or required, depending on the mitigation framework. It should be in line with land-tenure and land-use regulations and customary rights and claims.

In promoting the carbon benefits of an FMU, it is important to clarify who owns those benefits. This is a requirement for the sale of carbon certificates (for example in the A/R CDM, other regulated markets, and most standards in the voluntary market). The ownership of carbon benefits is also becoming important in REDD+ negotiations (Pierce 2011; Corbera and Schroeder 2011; Ezzine-de-Blas et al. 2011; Hawkins 2011; Kanowski et al. 2011; Markus 2011; McDermott 2012).

The ownership of carbon benefits must be in line with land-tenure and land-use regulations in the project country, as well as with customary rights and—where appropriate—existing land-tenure and land-use claims. Box 6 lists publications with guidance on clarifying legal and contractual issues.

Box 6: Guidance on clarifying legal and contractual issues

The following resources provide guidance that may assist in clarifying legal and contractual issues in FMUs:

- Certified emission reductions sale and purchase agreement (open source). Guidelines and contract template. Available at www.cerspa.com.
- Hawkins, S. 2011. *Legal guidance: legal and contractual aspects of forest carbon projects*. Forest Trends, Washington, DC.

7 GUIDANCE ON CARBON ACCOUNTING IN OTHER INTERGOVERNMENTAL ORGANIZATIONS

7.1 IPCC

The IPCC launched its first special report on issues related to forestry and climate-change mitigation in 2000—the *Special Report on Land Use, Land Use Change and Forestry*[49] (IPCC 2000). This report showed the importance of forestry in mitigating climate change, but questions on methods for accounting for carbon benefits were unanswered. Since then, the IPCC has produced two major documents on carbon accounting: *Good Practice Guidance for Land Use, Land-Use Change and Forestry*"[50] (IPCC 2003), for quantifying carbon benefits at the project level; and the *IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC 2006), for quantifying benefits at the national level. Although there are still knowledge gaps, these two publications provide a robust basis for accounting for the mitigation benefits of forestry activities and are often used to support specific methodologies in all mitigation frameworks.

7.2 GEF[51]

The GEF finances a variety of activities on sustainable land management in developing countries, ranging from reforestation and agroforestry projects to projects that protect wetlands and foster sustainable farming methods. The carbon benefits of these and other non-GEF sustainable land management projects are likely to be considerable, but it has proved difficult to compare the carbon benefits of different land management interventions because of the differing methods that have been used to measure them. Equally, it has been difficult for sustainable land management activities in developing countries to obtain the financial rewards they warrant in emerging carbon markets.

Aware of this situation, in 2009 the GEF launched the GEF Carbon Benefit Project. This project, which is being implemented by UNEP in cooperation with six other organizations, aims to address the need to quantify and predict the carbon content and dynamics of landscapes in the context of global climate change. The project's output is a modular, web-based system that allows users to collate, store, analyze, report and project carbon and total GHG benefits in a standard and comprehensive manner (Annex 1). The test phase of the system began in April 2013, and the full system was launched in late 2013.

7.3 UNDP, UNEP AND THE UNEP–RISOE CENTRE

As part of their efforts to improve capacities in sub-Saharan Africa, UNDP, UNEP and the UNEP–Risoe Centre prepared a report (Watson 2009) establishing principles for accounting for forest carbon aimed at increasing understanding of the forest carbon accounting process. Three forms of carbon accounting are identified: stock accounting; emissions accounting; and emission-reduction accounting. The report presents principles, practices and challenges for carbon accounting in the forest sector.

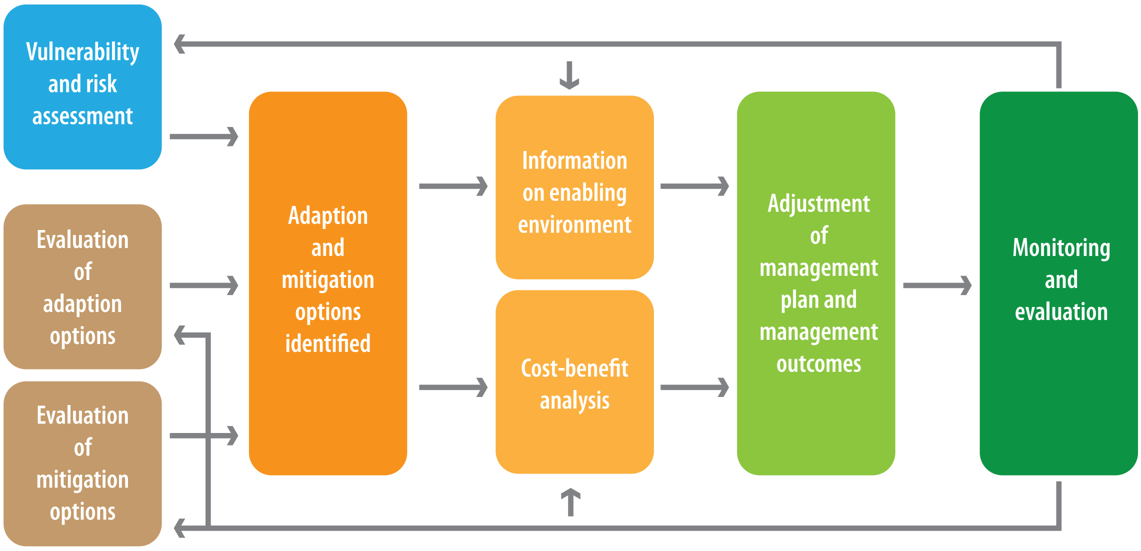
7.4 FAO

In 2010, FAO prepared forest and climate-change guidelines aimed at supporting policymakers in integrating climate-change mitigation and adaptation into forest policies and programmes at the national level (FAO 2011).

In 2013, FAO published a second, complementary set of guidelines aimed at supporting forest managers in their attempts to integrate climate-change mitigation and adaptation into SFM (FAO 2013; Figure 14). According to these guidelines, SFM is consistent with both climate-change adaptation and mitigation and provides a comprehensive framework that can be adapted to changing circumstances. Efforts to advance towards SFM have provided a wealth of knowledge, experience, best-practice guidance, tools, mechanisms and partnerships that can be applied to help meet climate-change challenges and which informs the document. The guidelines aim to assist forest managers in assessing vulnerability, risk, mitigation options, and actions for adaptation, mitigation and monitoring in response to climate

49 See www.ipcc.ch/ipccreports/sres/land_use/index.php?idp=0.
50 See www.ipcc-nggip.iges.or.jp/public/gp.
51 Information obtained from the GEF website and corresponding documents (see: www.unep.org/climatechange/carbon-benefits).

Figure 14: The process of integrating adaptation and mitigation measures into forest management plans



Source: FAO (2013).

change. Recommended actions for climate-change adaptation address impacts on: forest productivity; biodiversity; water availability and quality; fire; pests and diseases; extreme weather events; sea-level rise; and economic, social and institutional considerations. A range of mitigation actions is provided, along with guidance on the additional monitoring and evaluation that may be required in forests in the face of climate change.

Summary

To promote consistency among intergovernmental organizations and avoid the duplication of work at the level of forest managers, guidance for accounting carbon benefits developed by intergovernmental organizations other than ITTO is briefly described.

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GLOSSARY[52]

Abrupt climate change	A large-scale change in the climate system that takes place over a few decades or less, persists (or is anticipated to persist) for at least a few decades, and causes substantial disruptions in human and natural systems
Adaptation	The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate harm or exploit beneficial opportunities. In natural systems, human intervention may facilitate adjustment to expected climate and its effects
Adaptive capacity	The ability of systems, institutions, and humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences
Afforestation	The planting of new forests on lands that historically have not contained forests. Afforestation projects are eligible under a number of schemes, including, among others, Joint Implementation and the Clean Development Mechanism under the Kyoto Protocol, for which particular criteria apply (e.g. proof must be given that the land was not forested for at least 50 years or converted to alternative uses before 31 December 1989) [See IPCC (2000) for a discussion of the term forest and related terms such as afforestation, reforestation and deforestation]
	For the A/R CDM, definition of the Marrakesh Accords: The direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources
Annex I countries	The group of countries included in Annex I (as amended in 1998) to the United Nations Framework Convention on Climate Change, including all the member countries of the Organization for Economic Co-operation and Development in the year 1990 and countries with economies in transition. Under Articles 4.2(a) and 4.2(b) of the Convention, Annex I countries committed themselves specifically to the aim of returning individually or jointly to their 1990 levels of greenhouse-gas emissions by the year 2000. By default, the other countries are referred to as non-Annex I countries. For a list of Annex I countries, see http://unfccc.int
Annex II countries	The group of countries listed in Annex II to the United Nations Framework Convention on Climate Change. Under Article 4 of the Convention, these countries have a special obligation to provide financial resources to meet the agreed full incremental costs of implementing measures mentioned under Article 12, paragraph 1. They are also obliged to provide financial resources, including for the transfer of technology, to meet the agreed incremental costs of implementing measures covered by Article 12, paragraph 1, and agreed between developing country Parties and international entities referred to in Article 11 of the Convention. This group of countries shall also assist countries that are particularly vulnerable to the adverse effects of climate change. For a list of Annex II countries, see http://unfccc.int
Anthropogenic	Resulting from or produced by human beings. Anthropogenic emissions of greenhouse gases, greenhouse-gas precursors and aerosols associated with human activities, including the burning of fossil fuels, deforestation, land-use changes, livestock and fertilization, etc.

52 Sources: IPCC (2014a, 2014b, 2013).

Barrier	Any obstacle to reaching a goal, adaptation or mitigation potential that can be overcome or attenuated by a policy, programme or measure. Barrier removal includes correcting market failures directly or reducing the transaction costs in the public and private sectors by e.g. improving institutional capacity, reducing risk and uncertainty, facilitating market transactions, and enforcing regulatory policies
Baseline	The reference for measurable quantities from which an alternative outcome can be measured, such as a non-intervention scenario used as a reference in the analysis of intervention scenarios
Baseline/reference	The state against which change is measured. In the context of transformation pathways, the term "baseline scenarios" refers to scenarios that are based on the assumption that no mitigation policies or measures will be implemented beyond those that are already in force and/or are legislated or planned to be adopted. Baseline scenarios are not intended to be predictions of the future but rather counterfactual constructions that can serve to highlight the level of emissions that would occur without further policy effort. Typically, baseline scenarios are then compared to mitigation scenarios that are constructed to meet different goals for greenhouse-gas emissions, atmospheric concentrations, or temperature change. The term "baseline scenario" is used interchangeably with "reference scenario" and "no policy scenario". In much of the literature, the term is also synonymous with "business-as-usual scenario", although the latter has fallen out of favour because the notion of business-as-usual in century-long socioeconomic projections is hard to define
Biofuel	A fuel, generally in liquid form, produced from organic matter or combustible oils produced by living or recently living plants. Examples of biofuel include alcohol (bioethanol), black liquor from the paper-manufacturing process, and soybean oil. Biofuels are subdivided into first-generation manufactured biofuel, second-generation biofuel and third-generation biofuel
Biomass	The total mass of living organisms in a given area or volume; dead plant material can be included as dead biomass. In the context of this report, biomass includes products, byproducts and waste of biological origin (plants or animal matter), excluding material embedded in geological formations and transformed to fossil fuels or peat. Traditional biomass refers to the biomass—fuelwood, charcoal, agricultural residues and animal dung—used with traditional technologies such as open fires for cooking, rustic kilns and ovens for small industries. Biomass is divided into traditional biomass and modern biomass
Biome	A major and distinct regional element of the biosphere, typically consisting of several ecosystems (e.g. forests, rivers, ponds and swamps within a region of similar climate). Biomes are characterized by typical communities of plants and animals
Carbon (dioxide) capture and storage	A process consisting of the separation of carbon dioxide from industrial and energy-related sources, transport to a storage location, and long-term isolation from the atmosphere
Carbon cycle	The flow of carbon (in various forms, such as carbon dioxide) through the atmosphere, ocean, terrestrial and marine biosphere and lithosphere. In this report, the reference unit for the global carbon cycle are gigatonnes of carbon (GtC) and PgC (10^{15} g). Carbon is the major chemical constituent of most organic matter and is stored in the following major sinks: organic molecules in the biosphere; carbon dioxide in the atmosphere; organic matter in the soils; the lithosphere; and the oceans

Carbon dioxide	A naturally occurring gas and also a byproduct of burning fossil fuels from fossil carbon deposits, such as oil, gas and coal, of burning biomass and of land-use changes and other industrial processes. It is the principal anthropogenic greenhouse gas that affects the earth's radiative balance and the reference gas against which other greenhouse gases are measured; it therefore has a global warming potential of 1
Carbon dioxide fertilization	The enhancement of the growth of plants as a result of increased atmospheric carbon dioxide concentration. Depending on their mechanism of photosynthesis, certain types of plants are more sensitive to changes in the concentration of atmospheric carbon dioxide
Carbon intensity	The amount of emissions of carbon dioxide released per unit of another variable such as gross domestic product, output energy use or transport
Carbon leakage	Phenomenon whereby a reduction in greenhouse-gas emissions (relative to a baseline) in a jurisdiction/sector associated with the implementation of mitigation policy is offset to some degree by an increase outside the jurisdiction/sector through induced changes in consumption, production, prices, land use or trade across the jurisdictions/sectors. Leakage can occur at a number of levels—e.g. project, state, province, nation, or world
Carbon sequestration	The uptake (i.e. the addition of a substance of concern to a reservoir) of carbon-containing substances, particularly carbon dioxide, in terrestrial or marine reservoirs. Biological sequestration includes the direct removal of carbon dioxide from the atmosphere through land-use change, afforestation, reforestation, revegetation, carbon storage in landfills, and practices that enhance soil carbon in agriculture (e.g. cropland and grazing-land management)
Climate change	A change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. The United Nations Framework Convention on Climate Change defines climate change as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" (Article 1). The Convention thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes
Deforestation	The conversion of forest to non-forest. Deforestation is one of the major sources of greenhouse-gas emissions. Under Article 3.3 of the Kyoto Protocol, "the net changes in greenhouse gas emissions by sources and removals by sinks resulting from direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990, measured as verifiable changes in carbon stocks in each commitment period, shall be used to meet the commitments under this Article of each Party included in Annex I". For a discussion of the term forest and related terms such as afforestation, reforestation and deforestation, see IPCC (2000) and IPCC (2003)

Ecosystem	A functional unit consisting of living organisms, their non-living environment, and the interactions within and between them. The components included in a given ecosystem and its spatial boundaries depend on the purpose for which the ecosystem is defined: in some cases they are relatively sharp, while in others they are diffuse. Ecosystem boundaries can change over time. Ecosystems are nested within other ecosystems, and their scale can range from very small to the entire biosphere. In the current era, most ecosystems either contain people as key organisms or are influenced by the effects of human activities in their environment
Ecosystem services	See Environmental services
Emission factor	1) The rate of emission per unit of activity, output or input (e.g. a particular fossil fuel power plant has a carbon dioxide emission factor of 0.765 kg/kWh generated) (IPCC 2007) 2) The emissions released per unit of activity (IPCC 2014). See also Carbon intensity
Environmental services (also called ecosystem services, and the two terms are used interchangeably in this document)	The benefits people obtain from forest ecosystems. They include provisioning services, such as food and water; regulating services, such as the regulation of floods, droughts, land degradation and disease; supporting services, such as soil formation and nutrient cycling; and cultural services, such as recreational, spiritual, religious and other nonmaterial benefits. Forest environmental services perform a range of functions, such as: moderating weather extremes and their impacts; dispersing seeds; mitigating drought and floods; cycling and moving nutrients; protecting stream and river channels and coastal shores from erosion; detoxifying and decomposing wastes; controlling agricultural pests; maintaining biodiversity; generating and preserving soils and renewing their fertility; contributing to climate stability; purifying air and water; and pollinating crops and natural vegetation. Tropical forests provide all these services and are often particularly important for carbon sequestration, biodiversity conservation, the protection of water catchments and the regulation of regional climates
Forest	A vegetation type dominated by trees. Many definitions of "forest" are in use worldwide, reflecting wide differences in biogeophysical conditions, social structure and economics. Forest is defined under the Kyoto Protocol as a minimum area of land of 0.05–1.0 hectare with tree-crown cover (or equivalent stocking level) of more than 10–30% with trees with the potential to reach a minimum height of 2–5 m at maturity in situ. A forest may consist either of closed forest formations where trees of various stories and undergrowth cover a high proportion of the ground or of open forest. Young natural stands and all plantations that have yet to reach a crown density of 10–30% or tree height of 2–5 m are included under forest, as are areas normally forming part of the forest area that are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest. For a discussion of "forest" see IPCC (2000) and IPCC (2003)
Global warming	Global warming refers to the gradual increase, observed or projected, in global surface temperature, as one of the consequences of radiative forcing caused by anthropogenic emissions

Global warming potential	An index, based on radiative properties of well mixed greenhouse gases, measuring the radiative forcing of a unit mass of a given well-mixed greenhouse gas in today's atmosphere integrated over a chosen time horizon, relative to that of carbon dioxide. The global warming potential represents the combined effect of the differing lengths of time that these gases remain in the atmosphere and their relative effectiveness in absorbing outgoing infrared radiation. The Kyoto Protocol is based on global warming potential from pulse emissions over a 100-year timeframe
Greenhouse effect	The infrared radiative effect of all infrared-absorbing constituents in the atmosphere. Greenhouse gases, clouds and (to a small extent) aerosols absorb terrestrial radiation emitted by the earth's surface and elsewhere in the atmosphere. These substances emit infrared radiation in all directions, but, everything else being equal, the net amount emitted to space is normally less than would have been emitted in the absence of these absorbers because of the decline of temperature with altitude in the troposphere and the consequent weakening of emission. An increase in the concentration of greenhouse gases increases the magnitude of this effect; the difference is sometimes called the enhanced greenhouse effect. The change in a greenhouse-gas concentration because of anthropogenic emissions contributes to an instantaneous radiative forcing. Surface temperature and troposphere warm in response to this forcing, gradually restoring the radiative balance at the top of the atmosphere
Greenhouse gases	Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the earth's surface, the atmosphere and clouds. This property causes the greenhouse effect. Water vapour (H_2O), carbon dioxide, nitrous oxide (N_2O), methane (NH_4) and ozone (O_3) are the primary greenhouse gases in the earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances, dealt with under the Montreal Protocol. Besides carbon dioxide, nitrous oxide and methane, the Kyoto Protocol deals with the greenhouse gases sulphur hexafluoride, hydrofluorocarbons and perfluorocarbons
Kyoto mechanisms (also called flexibility mechanisms)	Market-based mechanisms that Parties to the Kyoto Protocol can use in an attempt to lessen the potential economic impacts of their commitment to limit or reduce greenhouse gas emissions. They include Joint Implementation (Article 6), Clean Development Mechanism (Article 12), and Emissions trading (Article 17)
Kyoto Protocol	The Kyoto Protocol to the United Nations Framework Convention on Climate Change was adopted at the Third Session of the Conference of the Parties in 1997 in Kyoto. It contains legally binding commitments, in addition to those included in the Convention. Annex B countries agreed to reduce their anthropogenic greenhouse emissions (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride) by at least 5% below 1990 levels in the commitment period 2008–2012. The Kyoto Protocol came into force on 16 February 2005

Land use	Land use refers to the total of arrangements, activities and inputs undertaken in a certain land-cover type (a set of human actions). The term land use is also used in the sense of the social and economic purposes for which land is managed (e.g. grazing, timber extraction and conservation). In urban settlements it is related to land uses in cities and their hinterlands. Urban land use has implications for city management, structure, and form and thus on energy demand, greenhouse-gas emissions, and mobility, among other aspects
Land-use change	Land-use change refers to a change in the use or management of land by humans, which may lead to a change in land cover. Land cover and land-use change may have an impact on the surface albedo, evapotranspiration, sources and sinks of greenhouse gases or other properties of the climate system and may thus give rise to radiative forcing and/or other impacts on climate, locally or globally. See also IPCC (2000)
Indirect land-use change	Indirect land-use change refers to shifts in land use induced by a change in the production level of an agricultural product elsewhere, often mediated by markets or driven by policies. For example, if agricultural land is diverted to fuel production, forest clearance may occur elsewhere to replace the former agricultural production. (See also afforestation, deforestation and reforestation)
Land use, land-use change and forestry	A greenhouse-gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use, land-use change and forestry activities, excluding agricultural emissions
Mitigation (of climate change)	A human intervention to reduce the sources or enhance the sinks of greenhouse gases. The fifth assessment report of the Intergovernmental Panel on Climate Change assesses human interventions to reduce the sources of other substances which may contribute directly or indirectly to limiting climate change, including, for example, the reduction of particulate matter emissions that can directly alter the radiation balance (e.g. black carbon) or measures that control emissions of carbon monoxide, nitrogen oxides, volatile organic compounds and other pollutants that can alter the concentration of tropospheric ozone, which has an indirect effect on the climate
Nationally appropriate mitigation action	Nationally appropriate mitigation actions (generally known as NAMAs) are a concept for recognizing and financing emission reductions by developing countries in a post-2012 climate regime achieved through action considered appropriate in a given national context. The concept was first introduced in the Bali Action Plan in 2007 and is contained in the Cancún Agreements
Non-Annex I countries	Non-Annex I countries are mostly developing countries. The United Nations Framework Convention on Climate Change recognizes that certain groups of developing countries are especially vulnerable to the adverse impacts of climate change, including countries with low-lying coastal areas and those prone to desertification and drought. Others, such as countries that rely heavily on income from fossil-fuel production and commerce, feel more vulnerable to the potential economic impacts of climate-change response measures. The Convention emphasizes activities that promise to answer the special needs and concerns of these vulnerable countries, such as investment, insurance and technology transfer (see also Annex I countries)

Precautionary principle	A provision under Article 3 of the United Nations Framework Convention on Climate Change that stipulates that Parties to the Convention should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason to postpone such measures, taking into account that policies and measures to deal with climate change should be cost-effective in order to ensure global benefits at the lowest possible cost
Radiative forcing	Radiative forcing is the change in the net, downward minus upward, radiative flux (expressed in Wm^{-2}) at the tropopause or top of atmosphere due to a change in an external driver of climate change, such as a change in the concentration of carbon dioxide or the output of the sun
Reducing emissions from deforestation and forest degradation (REDD)	An effort to create financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. It is therefore a mechanism for mitigation that results from avoiding deforestation. REDD+ goes beyond reforestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks. The concept was first introduced in 2005 in the 11th Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change in Montreal and given greater recognition at the 13th Session in 2007 at Bali. The Bali Action Plan called for "policy approaches and positive incentives on issues relating to reducing emissions to deforestation and forest degradation in developing countries (REDD) and the role of conservation, sustainable management of forests and enhancement of forest carbon stock in developing countries"
Reforestation	The planting of forests on lands that have previously sustained forests but that have been converted to some other use
Reforestation (for the UNFCCC and the A/R CDM of the Kyoto Protocol)	Direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land. For the first commitment period, reforestation activities will be limited to reforestation occurring on those lands that did not contain forest on 31 December 1989
Reservoir	A component of the climate system, other than the atmosphere, which has the capacity to store, accumulate or release a substance of concern (e.g. carbon, a greenhouse gas or a precursor). Oceans, soils and forests are examples of reservoirs of carbon. Pool is an equivalent term (note that the definition of pool often includes the atmosphere). The absolute quantity of the substance of concern held within a reservoir at a specified time is called the stock. In the context of carbon dioxide capture and storage, this term is sometimes used to refer to a geological carbon dioxide storage location
Sequestration	The uptake (i.e. the addition of a substance of concern to a reservoir) of carbon containing substances, in particular carbon dioxide, in terrestrial or marine reservoirs. Biological sequestration includes direct removal of carbon dioxide from the atmosphere through land-use change, afforestation, reforestation, revegetation, carbon storage in landfills, and practices that enhance soil carbon in agriculture (cropland management, grazing land management). In parts of the literature, but not in this report, (carbon) sequestration is used to refer to carbon dioxide capture and storage

Standards	Sets of rules or codes mandating or defining product performance (e.g. grades, dimensions, characteristics, test methods and rules for use). Product, technology or performance standards establish minimum requirements for affected products or technologies. Standards impose reductions in greenhouse-gas emissions associated with the manufacture or use of the products and/or application of the technology
Uncertainty	A cognitive state of incomplete knowledge that can result from a lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from imprecision in the data to ambiguously defined concepts or terminology, or uncertain projections of human behaviour. Uncertainty can therefore be represented by quantitative measures (e.g. a probability density function) or by qualitative statements (e.g. reflecting the judgment of a team of experts). See also Moss and Schneider (2000); Manning et al. (2004); Mastrandrea et al. (2010)
United Nations Framework Convention on Climate Change	The Convention was adopted on 9 May 1992 in New York and signed at the 1992 Earth Summit in Rio de Janeiro by more than 150 countries and the European Community. Its ultimate objective is the "stabilisation of greenhouse-gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". It contains commitments for all Parties under the principle of "common but differentiated responsibilities". Under the Convention, Parties included in Annex I aimed to return greenhouse-gas emissions not controlled by the Montreal Protocol to 1990 levels by the year 2000. The convention entered in force in March 1994. In 1997, the UNFCCC adopted the Kyoto Protocol

ANNEX 1: TOOLS AND MODULES

SEPC-BERT[53]

The Social and Environmental Principles and Criteria—Benefits and Risks Tool (SEPC–BeRT) produced by the UN-REDD Programme is designed to serve two purposes: addressing social and environmental issues in UN-REDD Programme national programmes, and supporting countries in developing national approaches to REDD+ safeguards in line with the UNFCCC.

This Excel-based tool guides users through a series of questions on criteria and indicators on the basis of principles defined by the UN-REDD Programme. The SEPC–BeRt is expected to document the process of assessing potential risks and opportunities from these programmes and initiatives and is intended for use by national programme teams (UN-REDD Programme 2012).

A draft version of the tool can be downloaded at: www.unredd.net/index.php?option=com_docman&task=doc_details&gid=6352&Itemid=53.

TOOLS FOR A/R CDM PROJECT ACTIVITIES[54]

1. Tool for the demonstration and assessment of additionality This tool provides a step-wise approach to demonstrating and assessing the additionality of A/R CDM project activities: Step 0 → Preliminary screening based on the starting date of the A/R CDM project activity Step 1 → Identification of alternative land use scenarios Step 2 → Investment analysis Step 3 → Barrier analysis Step 4 → Common practice analysis. This tool is not applicable to small-scale project activities. More information: http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-01-v2.pdf/history_view.
2. Combined tool to identify the baseline scenario and demonstrate additionality This tool provides a step-wise approach to identifying baseline scenarios and simultaneously demonstrate additionality: Step 0→ Preliminary screening based on the starting date of the A/R CDM project activity Step 1 → Identification of alternative land-use scenarios Step 2 → Barrier analysis Step 3 → Investment analysis (if needed) Step 4 → Identification of the baseline scenario Step 4 → Common practice analysis. This tool is not applicable to small-scale project activities. More information: http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-02-v1.pdf/history_view.

53 Sources: UN-REDD Programme (2013b) and the draft web version of the tool at: www.unredd.net/index.php?option=com_docman&task=doc_details&gid=6352&Itemid=53.

54 Source: UNFCCC (2012).

3. Calculation of the number of sample plots for measurements This tool can be used for calculating the number of sample plots required for an estimation of biomass stocks from sampling-based measurements in the baseline and project scenarios of an A/R CDM project activity. The tool calculates the number of required sample plots on the basis of the specified targeted precision for the biomass stocks to be estimated. It is based on specific assumptions regarding the area of each stratum and the variance of biomass stocks. More information: http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-03-v2.1.0.pdf/history_view.
4. Tool for testing the significance of GHG emissions This tool facilitates the determination of significance for GHG emissions by source, decreases in carbon pools, and leakage emissions. It is used to determine if emissions from a given pool or other sources are insignificant so that they can be neglected. More information: http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-04-v1.pdf/history_view.
5. Procedure to determine when accounting of the soil organic carbon pool may be conservatively neglected This tool provides guidelines and criteria for determine when accounting of the soil organic carbon pool may be conservatively neglected in A/R CDM project activities. Where the availability of evidence on change in the soil organic carbon pool under land use or land-use change remains limited, a conservative approach has been adopted. There are specific conditions for the land area to which this tool can be applied. More information: http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-06-v1.pdf/history_view.
6. Estimation of non-CO_2 GHG emissions resulting from the burning of biomass attributable to an A/R CDM project activity This tool can be used for the estimation of non-CO_2 GHG emissions resulting from all occurrences of fire within a project boundary: i.e. the burning of biomass when fire is used for site preparation and/or to clear the land of harvest residue prior to replanting of the land, or when a forest fire occurs within the project boundary. More information: http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-08-v4.0.0.pdf/history_view.
7. Estimation of carbon stocks and change in carbon stocks in dead wood and litter This tool can be used for the ex-post estimation of carbon stocks and change in carbon stocks in dead wood and/or litter in the baseline and project scenarios of an A/R CDM project activity. This tool has no internal applicability conditions. More information: http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-12-v1.1.0.pdf/history_view.
8. Tool for the identification of degraded or degrading land for consideration in implementing A/R CDM project activities This tool provides a procedure for the identification of degraded or degrading lands (based on the documented evidence of degradation) for the purpose of applying A/R CDM methodologies. More information: http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-13-v1.pdf/history_view.

9. Estimation of carbon stocks and change in carbon stocks of threes and shrubs This tool can be used for the estimation of carbon stocks and change in carbon stocks of trees and shrubs in the baseline and project scenarios of an A/R CDM project activity. It has no specific internal applicability conditions. More information: http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-14-v2.1.0.pdf/history_view.
10. Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities This tool can be used for estimating the increase of GHG emissions attributable to the displacement of pre-project agricultural activities due to the implementation of an A/R CDM project activity, which cannot be considered insignificant according to the most recent: 1) "Guidelines on conditions under which increase in GHG emissions attributable to displacement of pre-project crop cultivation activities in A/R CDM project activity in insignificant" or 2) "Guidelines on conditions under which increase in GHG emissions related to displacement of pre-project grazing activities in A/R CDM project is insignificant". Specific definitions of the following terms are included: agricultural activities; crop cultivation activities; grazing activities; and displacement of agricultural activities. More information: http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-15-v1.pdf/history_view.
11. Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities This tool estimates the change occurring in a given year in soil organic carbon stocks of land within the boundary of an A/R CDM project activity. The tool is only applicable if litter remains on site during the A/R CDM project activity and soil disturbance is limited: it is not applicable on land containing organic soils or wetlands or if specific land management practices with inputs are applied. Specific management practice limitations are listed in the tool for each temperature/moisture regime. More information: http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-16-v1.1.0.pdf/history_view.
12. Demonstrating appropriateness of volume equations for estimation of aboveground tree biomass This tool allows demonstration of whether a volume table or volume equation, in combination with selected biomass expansion factors and basic wood density, is appropriate for the estimation of aboveground tree biomass in an A/R CDM project activity. It provides criteria for the direct applicability of an equation for ex-post calculations, and—if these criteria are not met—describes the process required for the verification of a volume equation. The tool has no internal applicability conditions. More information: http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-17-v1.pdf/history_view.
13. Demonstrating appropriateness of allometric equations for estimation of aboveground tree biomass This tool allows demonstration of whether an allometric equation is appropriate for the estimation of aboveground tree biomass in an A/R CDM project activity. It provides criteria. More information: http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-17-v1.pdf/history_view.

AMERICAN CARBON REGISTER

T-ADD: "ACR Tool for Determining the Baseline and Assessing Additionality in REDD Project Activities"	Project proponents shall use this tool to demonstrate additionality, and, as applicable, determine the baseline scenario, in REDD project activities. The tool is consistent with and amplifies the "three-prong" additionality guidance in the American Carbon Register (ACR) Standard and ACR Forest Carbon Project Standard. The tool provides a step-by-step approach to identifying credible alternative land-use scenarios, evaluate both the alternatives and the proposed project scenario, and demonstrate the additionality of the project scenario. In verifying the application of this tool, the ACR-approved verifier shall assess the credibility of data, rationales, assumptions, justifications and documentation provided by the Proponent to support the selection of the baseline and demonstration of additionality. Available at: http://americancarbonregistry.org/carbon-accounting/tools-templates.
T-BAR "Tool for AFOLU non-permanence risk analysis and buffer determination"	Approved in 2014. http://americancarbonregistry.org/carbon-accounting/tools-templates.
"ACR Tool for the Estimation of Stocks in Carbon Pools and Emissions from Emission Sources"	This tool provides procedures for the estimation of carbon stocks and GHG emissions for those pools and emission sources identified as significant and selected for inclusion in the GHG assessment boundary of forest carbon project activities. It includes procedures for all the carbon pools and emission sources required for ACR Reducing Emissions from Deforestation and Forest Degradation methodologies, including Avoiding Planned Deforestation, Avoiding Unplanned Deforestation and Degradation, and Avoiding Degradation through Fuelwood and Charcoal Production. In the future the tool may be referenced and/or modified for use in other ACR forest carbon project methodologies. Available at: http://americancarbonregistry.org/carbon-accounting/tools-templates.

Source: American Carbon Registry: http://americancarbonregistry.org/carbon-accounting/tools-templates.

CLIMATE, COMMUNITY & BIODIVERSITY STANDARDS[55]

Social and Biodiversity Impact Assessment Manual for REDD+ Projects
Social Impact Assessment Toolbox: www.climate-standards.org/documents The toolbox introduces a range of social impact assessment methods useful in the context of a forestry activity aimed at gaining carbon benefits. Further, it relates these to the seven stages in the Social and Biodiversity Impact Assessment Manual for REDD+ Projects. Project proponents need to decide which method fits the best the social impacts of a given project in a given context. The toolbox includes the following methods: stakeholder analysis; scenario analysis; the Sustainable Livelihoods Framework; the Social Carbon Methodology; participatory impact assessment; the Basic Necessities Survey; and the Social Indicator Checklist.
Biodiversity Impact Assessment Toolbox: www.climate-standards.org/documents This toolbox provides guidance on each of the biodiversity-related criteria required for certification under the Climate, Community and Biodiversity standards. The toolbox is organized in four sections: a survey of typical biodiversity impacts of land-based carbon projects, both positive and negative; guidance for describing initial biodiversity conditions, identifying risks to that biodiversity, and projecting a "without-project" scenario for biodiversity; guidance for designing project activities and estimating their biodiversity impacts; and guidance for monitoring biodiversity impacts.

Sources: Pitman (2011); Richards (2011).

PLAN VIVO[56]

Basic eligibility checklist The checklist includes the following items: • Start date • Project participants • Project coordinators • Land tenure/use rights • Project activities • Project landscape • Expansion ambitions. Using the checklist is simple, and it provides a clear idea of whether the Plan Vivo Standard matches a project idea/activity.
Developing baselines (afforestation, reforestation, agroforestry) • ECCM [Edinburgh Centre for Carbon Management] Protocol: baseline survey for agroforestry projects • Winrock Sourcebook for Land Use, Land-Use Change and Forestry (Pearson et al. 2005b) • Bibliography for Carbon Sequestration and Biomass Estimation (Rombold 2003) • Approved small-scale CDM afforestation/reforestation methodologies
Carbon modelling tools • ECCM Protocol: Estimating tree growth (Berry, 2008a) • ECCM Protocol: Carbon modelling for afforestation and reforestation projects (Berry, 2008b) • CO2FIX www.efi.int/projects/casfor/models.htm. CO2FIX is a tool that can be used to quantify the carbon stocks and fluxes in forest biomass, soil organic matter and the wood products chain. Also included are a bioenergy module, a financial module and a carbon accounting module. The model is applicable to afforestation projects and agroforestry systems, and this provides a useful tool for Plan Vivo projects. The model is freely available on the web, together with examples and guidance documents.
Monitoring performance MacDicken,K. (1997) A guide to monitoring carbon storage in forestry and agroforestry projects. Verplanke, J.J. and Zahabu, E. (eds) 2009. A field guide for assessing and monitoring reduced forest degradation and carbon sequestration by local communities.

55 see: www.climate-standards.org/documents.
56 see: www.planvivo.org/tools-and-resources.

REDD
• Ecometrica Protocol: above-ground biomass survey for projects that aim to reduce greenhouse-gas emissions from deforestation and forest degradation. 2009. • BioCarbon Fund Methodology for Estimating Reductions of GHG Emissions from Mosaic Deforestation. • Coming soon: Plan Vivo REDD+ methodology

Source www.planvivo.org/tools-and-resources. All tools can be downloaded at this website.

VERIFIED CARBON STANDARD–VCS[57]

Including tools for projects and/or modules

APPROVED VCS TOOLS	
Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities, v3.0	This tool provides a step-wise approach for demonstrating and assessing additionality in AFOLU project activities. New and revised VCS methodologies may reference and require the use of the tool to demonstrate the additionality of AFOLU project activities. The tool is adapted from the CDM Tool for the demonstration and assessment of additionality in A/R CDM project activities. www.v-c-s.org/methodologies/VT0001
Tool for the Demonstration and Assessment of Additionality in IFM Project Activities, v1.0	This tool provides a step-wise approach demonstrate and assess additionality for IFM project activities. New and revised VCS methodologies may reference and require the use of the tool to demonstrate additionality of IFM project activities. This tool is applicable to VCS IFM project activities. www.v-c-s.org/methodologies/VT0002
Tool for the Estimation of Uncertainty for IFM Project Activities, v1.0	This tool provides a step-wise approach for estimating uncertainty in the estimation of emissions and removals in improved forest management project activities. The tool focuses on uncertainty associated with the estimation of stocks in carbon pools and changes in carbon stocks and on uncertainty in the assessment of project emissions This tool is applicable for use under VM0005 Converting from Low to High Productive Forests. www.v-c-s.org/methodologies/VT0003
Tools/modules for the REDD Methodology Modules (REDD-MF), v.1.4	Estimation of carbon stocks in the aboveground and belowground biomass of living tree and non-tree pools (CP-AB), v.1.0 Estimation of carbon stocks in the dead-wood pool (CP-C), v 1.0 Estimation of carbon stocks in the litter pool (CP-L), v1.0 Estimation of carbon stocks in the soil organic carbon pool (CP-S) v1.0 Estimation of carbon stocks in the long-term wood products pool (CP-W) v.1.1 Estimation of baseline carbon stock changes and greenhouse-gas emissions from planned deforestation and planned degradation (BL-PL) v. 1.2 Estimation of baseline carbon stock changes and greenhouse-gas emissions from unplanned deforestation (BL-UP), v3.2 See: www.v-c-s.org/methodologies/VM0007

57 See: www.v-c-s.org/methodologies/what-methodology The whole information regarding VCS methodologies was taken directly from VCS by end July 2013

Tool for the Estimation of Jurisdictional Leakage in VCS JNR programmes	This tool provides a step-by-step approach for estimating leakage for Jurisdictional and Nested REDD+ (JNR) programmes applying a VCS Scenario 2 or Scenario 3 approach where full accounting takes place at the jurisdictional level. This tool provides default values for determining the amount of activity shifting leakage and market leakage from global commodities, domestically traded products and subsistence activities. This tool also accounts for deforestation-to-degradation leakage. The tool is applicable to subnational Jurisdictional and Nested REDD+ (JNR) programmes without nation-wide monitoring and reporting of emissions. Jurisdictional programmes may apply either the Global Commodity Leakage Module: Effective Area Approach (www.v-c-s.org/methodologies/global-commodity-leakage-module-effective-area-approach) or the Global Commodity Leakage Module: Production Approach (www.v-c-s.org/methodologies/global-commodity-leakage-module-production-approach) to calculate a global commodity leakage value instead of applying the default value provided within the tool. www.v-c-s.org/methodologies/tool-estimation-jurisdictional-leakage-vcs-jnr-programs
Global Commodity Leakage Module: Production Approach	This module and the associated calculation tool provide a framework for determining the global commodity leakage that may result from a JNR programme applying a Scenario 2 or Scenario 3 approach. The module assesses jurisdictional market leakage associated with the production of agricultural, livestock and forest commodities. The module estimates a global commodity leakage value through a step-by-step approach based on the volume of commodities required to maintain international market demand. International market demand for these commodities is determined by assessing the baseline level of production and applying econometric factors to estimate demand for lost production. This approach conservatively assumes that commodity production will be distributed based on the international market share of the host country's top commodities. Commodity production is assumed to be distributed evenly across forest and agricultural land. www.v-c-s.org/methodologies/global-commodity-leakage-module-production-approach
Global Commodity Leakage Module: Effective Area Approach	This module provides a calculation framework to determine the global commodity leakage that may result from a JNR programme applying a Scenario 2 or Scenario 3 approach. The module assesses jurisdictional market leakage associated with the production of agricultural, livestock and forest commodities. The module estimates a global commodity leakage value through a step-by-step approach based on the area of land required to maintain production levels within the jurisdiction. This effective area is determined by analyzing a jurisdictional production baseline using data on the area of production and commodity yields, and comparing that baseline to the observed production. This approach conservatively assumes an area equal to the entire effective area will be deforested outside the jurisdiction based on the host country's international share of deforestation or at-risk forest carbon stocks. www.v-c-s.org/methodologies/global-commodity-leakage-module-effective-area-approach
Tool for the Demonstration and Assessment of Additionality in VCS IFM Project Activities on Lands Subject to Unextinguished Indigenous Rights and Title	The tool provides a step-wise approach for demonstrating and assessing additionality in VCS IFM project activities on lands subject to unextinguished indigenous rights and title. The tool is adapted from the VCS VT0001 Tool for the Demonstration and Assessment of Additionality in VCS AFOLU Project Activities. www.v-c-s.org/methodologies/tool-demonstration-and-assessment-additionality-vcs-ifm-project-activities-lands

Tool for Calculating Deforestation Rates Using Incomplete Remote Sensing Images	This tool calculates historical deforestation rates using incomplete remote sensing imagery when complete scenes are unavailable. A remote sensing image may be incomplete due to atmospheric conditions such as cloud and shadow cover, dust or smoke; and/or sensor-related errors such as anomalous speckles, data saturation, spatial offsets or missing data. The tool is intended for use in regions where limited archival imagery exists, such as regions that have persistent cloud cover or where existing complete archival imagery is too expensive. The tool assumes that project proponents have already conducted a classification of the incomplete remote sensing images into appropriate land-use/land-cover categories using established procedures. The tool describes how a series of incomplete classified remote sensing images can be combined to calculate a robust estimate of historical deforestation and degradation rates and transition matrices. www.v-c-s.org/methodologies/tool-calculating-deforestation-rates-using-incomplete-remote-sensing-images

Source: VCS at www.v-c-s.org/methodologies/what-methodology.

GOFC-GOLD[58]

Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD) is a coordinated international effort working to provide ongoing space-based and in situ observations of forests and other vegetation cover, for the sustainable management of terrestrial resources and to obtain an accurate, reliable, quantitative understanding of the terrestrial carbon budget.

GOFC-GOLD is working to accomplish its objectives by:

- Providing a forum for users of satellite data to discuss their needs and for producers to respond through improvements to their programmes.
- Providing regional and global datasets containing information on:
  - Location of different forest types;
  - Major changes in forest cover;
  - Biological functioning of forests (this will help quantify the contribution forests make as absorbers and emitters of greenhouse gases).
- Promoting globally consistent data processing and interpretation methods.
- Promoting international networks for data access, data sharing, and international collaboration.
- Stimulating the production of improved products.

Potential users of GOFC-GOLD products include global-change researchers, international agencies, national governments, non-governmental organizations, and international treaties and conventions (such as the United Nations Framework Convention on Climate Change—UNFCCC). One of the most important challenges facing GOFC-GOLD is to develop methods and implement systems that provide both research and operational information on a regular sustained basis.

The GOFC-GOLD Land Cover Characteristics and Change Theme promotes the use and refinement of land-cover data and information products for resource managers, policymakers, and scientists studying the global carbon cycle and biodiversity loss (see more information at: www.fao.org/gtos/gofc-gold/land.html). The GOFC-GOLD Fire Mapping and Monitoring Theme is aimed at refining and articulating international requirements for fire-related observations and making the best possible use of fire products from the existing and future satellite observing systems, for fire management, policy decision-making and global-change research (see more information at: www.fao.org/gtos/gofc-gold/f_fire.html). GOCF-GOLD also maintains various regional networks, which provide a forum for users and researchers operating in (or with an interest in) a common geographic area; they link national agencies, user groups and the global user/producer community (more information at: www.fao.org/gtos/gofc-gold/networks.html).

58 Information on GOFC-GOLD has modified from material at: www.fao.org/gtos/gofc-gold/index.html.

GOCF-GOLD has produced a sourcebook of methods and procedures for monitoring measuring and reporting GHG emissions from deforestation and forest degradation (GOFC-GOLD 2011). Based on the current status of negotiations and UNFCCC-approved methodologies, this sourcebook aims to provide additional explanation, clarification, and methodologies to support REDD early actions and readiness mechanisms for building national REDD monitoring systems. The book emphasizes the role of satellite remote sensing as an important tool for monitoring changes in forest cover, and provides clarification on the IPCC Guidelines for reporting changes in forest carbon stocks at the national level. It is the outcome of an ad-hoc REDD+ working group of GOFC-GOLD, which has been active since the initiation of the UNFCCC REDD process in 2005.

CIFOR AND WORLD AGROFORESTRY CENTRE

The Center for International Forestry Research and the World Agroforestry Centre are undertaking research and development related to the accounting of carbon benefits in the forest sector. The two organizations jointly developed a toolbox for forest and climate change—including mitigation and adaptation.[59] The toolbox is aimed at building understanding and technical proficiency on climate change and forests, such as mitigation, adaptation, carbon accounting and markets, and biofuels.

The toolbox is divided into five “topics. Topic 4 examines carbon accounting, and Topic 5 looks at mechanisms, markets and projects. Besides explanations of the importance and challenges of carbon accounting in forests, Topic 4 includes the “Forest Carbon Calculator”, which is a tool for learning about how carbon works in the forest sector. It is a simulation tool, not a measurement tool. It can be used for estimating potential carbon benefits but doesn’t replace the need to make periodic measurements of changes in carbon stock over time (i.e. through monitoring).[60]

CARBON BENEFIT PROJECT—GEF[61]

Structure of the modelling and measurement tools

- Simple Assessment: of the impact of a project on carbon stock and greenhouse-gas emissions. Requires information on land-use changes and/or livestock production in the project area. Suitable for a quick assessment at any stage including proposals. Uses standard information on greenhouse-gas emission rates.
- Detailed Assessment: of the impact projects have on carbon stocks and greenhouse-gas emissions. Requires information on land-use changes and/or livestock production in the project area plus can use local and project-specific field measurements and other local datasets. Suitable for detailed reporting in projects with a reasonable focus on climate change mitigation.
- Dynamic Modelling: uses the Century Model to assess soil and biomass carbon stock changes. For users with a scientific background who wish to model carbon stock changes in projects with a carbon focus.
- Direct Measuring: provides a general protocol and specific methodologies for field, laboratory and remote sensing measurements of carbon stocks and greenhouse gases. Requires extensive field measurements and remote sensing analysis to measure carbon stocks in soil and biomass and monitor their changes over time in the project area. Displays project spatial information in an online information system to manage measurement data in carbon and greenhouse-gas projects. Project indicators display a results framework of social, biodiversity and environmental indicators of carbon and greenhouse-gas benefits in the project area. The data derived from measurements can be used directly for reporting changes in the carbon and greenhouse-gas balance or the measurement data may be used as inputs for Carbon Benefit Project modelling assessments.
- Project planning tools: provide supporting information for project managers during the development phase of landscape carbon and other sustainable land management projects. The information provided is useful for making decisions on which trees to plant based on a large database of agroforestry trees, to

59 CIFOR, World Agroforestry Centre and USAID 2009 Forest and climate change toolbox [PowerPoint presentation]. Available from http://www.cifor.cgiar.org/fctoolbox.

60 Information taken from: http://landcarb.forestry.oregonstate.edu/default.aspx.

61 See: www.unep.org/ClimateChange/carbon-benefits/cbp_pim/# Information taken from the provisional webpage from CBP.

estimate the economic benefits that can be expected from participating in the carbon markets by planting trees and support in setting up project boundaries using available maps.

In addition to these tools, the Carbon Benefit Project offers a socioeconomic component, which serves to capture human–biophysical interactions relating to a project's carbon and greenhouse-gas balance. It aids the project in understanding a land user's socioeconomic rationale for adopting certain land management practices and not others by identifying the underlying drivers and barriers of adoption. It also helps to determine the tradeoffs that land users make in adopting carbon- and greenhouse-gas-friendly practices. This facilitates "no regrets" decision-making when balancing development and carbon sequestration objectives, helping to assess the sustainability of carbon and greenhouse-gas benefits.

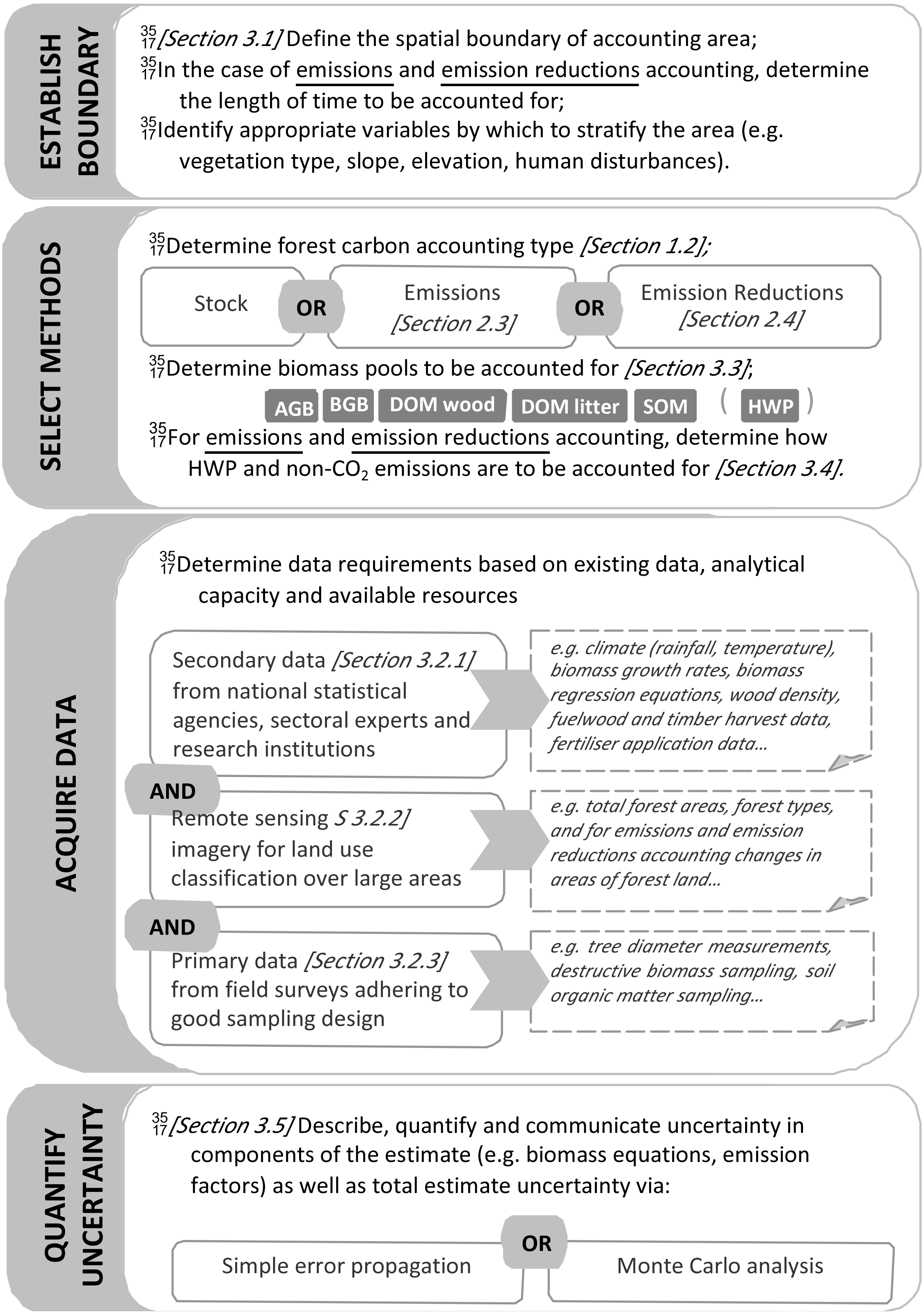
The table below summarizes the structure of the tools provided by the Carbon Benefits Project

Analysis tools	Simple Assessment	Includes guidance for undertaking three steps as follows: 1. Define project boundaries 2. Review supporting spatial data 3. Define project land use area
	Detailed Assessment	Provides a tool for undertaking clarification of: • initial land use; • baseline scenario; and • project scenario. It includes the following land-use categories: selecting among forest land, grassland, settlements, wetlands, annual crops, agroforestry and livestock categories
	Dynamic Modelling	Dynamic Modelling is a tool for assessing carbon-stock change associated with complex multiple land-use or land-management changes in large areas with several combinations of soil and climate. The emphasis is on changes in soil carbon. The tool is suitable for users with a soil carbon inventory background. Methods used are based on the GEFSOC modelling system.
	Socioeconomic tools	Including two tools: 1. Driver-Impact Response Analysis (DPSIR)—a qualitative analysis identifying the main drivers and barriers for the adoption of specific land management practices and possible responses to overcome them 2. Cost-Benefit Analysis—a quantitative tool determining the economic impact and labour barrier of a land-use activity
Direct Measuring		This directs to the GEF Guidelines on Integrating Carbon Benefit Estimates into GEF Projects
Project planning tools		Include the following tools: 1. Agroforestree database 2. Useful tree species for Africa 3. Multi-criteria tree species selection tool 4. Project boundary tool 5. Stratification tool 6. Data management tool 7. Community participation manual 8. Training the trainers manual 9. Manual on Carbon Benefits Project and other carbon standards
Carbon MRV tool		This toolbox supports an organization's needs for developing, managing and reporting carbon projects at the national or project level. It provides an enterprise-wide solution of online tools for planning and implementing national forest inventory for carbon, development and management of carbon projects across all of your organization's offices and units, and enterprise training and capacity-building. The Toolbox supports planning, tasking and implementation, and its distributed web-enabled approach allows managers in one office to communicate and interact with field offices and other offices or cooperators across the organization. This structure and its secure login and workspace design allows verifiers and others to review the project data, providing a level of transparency and openness needed for most carbon projects today. See: www.carbon2markets.org/content.cfm?id=52&m=52&mm=0.

Source: Carbon Benefit Source, preliminary website.

UNDP, UNEP AND UNEP–RISOE CENTRE

The figure below shows the structure of the UNDP, UNEP and UNEP–RISOE Centre guidelines.



Source: Watson (2009).

Other tools

TARAM: Tool for Afforestation and Reforestation Approved Methodologies	
Short description	The purpose of this spreadsheet tool is to facilitate the application of the following CDM approved methodologies: AR-AM0001, AR-AM0002, AR-AM0003, AR-AM0004, AR-AM0005, AR-AM0006, AR-AM0007, AR-AM0008, AR-AM0009, and AR-AM0010
Available at: www.forestcarbonportal.com/resource/tool-afforestation-and-reforestation-approved-methodologies-taram-v-13 .	
CVal: Assess the economics of participating in carbon markets	
Short description	CVal is a spreadsheet tool that will help foresters, managers, and project developers work with private forest landowners to assess the economic profitability of participating in carbon markets. CVal provides a discounted cash flow analysis based on a full accounting of variables, including tract size, carbon sequestration rate, carbon price, and enrolment and trading costs. Automated financial break-even analyses in the macros version quickly assess threshold values of key variables for profitable projects, and the programme readily performs "what if" calculations after storing starting values. CVal was designed to evaluate managed forest and afforestation projects traded on the Chicago Climate Exchange, but its methodology could be adapted for other trading mechanisms and agricultural sequestration projects. Available at http://www.fpl.fs.fed.us/documnts/fplgtr/fpl_gtr180.html.

Additional tools for REDD+

Training kit on participatory spatial information manamgement and comunication	The Training kit has been developed with the objective "to support the spread of 'good practice' in generating, managing, analysing and communicating community spatial information". The training kit has 15 modules, which can be downloaded at: http://pgis-tk-en.cta.int.
MRV tool for forest carbon management and mitigation	www.carbon2markets.org/content.cfm?m=52&id=52&startRow=1&mm=0.
REDD Integrity	Schemes aimed at reducing emissions from deforestation and forest degradation are at risk of corruption. Learn about the types of risk involved and potential anti-corruption approaches. More information: www.u4.no/themes/redd-integrity.
REDD+ database	The purpose of the REDD+ online database is to make information on REDD+ negotiations, readiness activities and projects available in a succinct manner for discussion, learning and analysis. It provides REDD+ project profiles, a REDD+ project matrix, National REDD+ reports, and international REDD+ event briefs. For more information: http://redd-database.iges.or.jp/red.
Rapid Equity Appraisal Matrix	A methodology for evaluating the equity capacity of REDD+ projects and stakeholders. The Rapid Equity Appraisal Matrix consists of three axes: a REDD+ project axis; a stakeholder axis; and an indicator axis. A systematic literature review was employed to establish ten indicators as minimum requirements for REDD+ projects to achieve socio-economic equity.
REDD Financial Feasibility Assessment Tool	SOCIALCARBON and CCBA have developed a tool for evaluating the financial feasibility of REDD projects. This tool is not a requirement of the CCB standards, but is intended to help project developers to design projects that are likely to be financially viable. See more under: www.socialcarbon.org/documents/redd-financial-feasibility-assessment-tool.

ANNEX 2: ADDITIONAL INFORMATION

A/R CDM

List of designated national authorities (DNAs) in ITTO producer members

Africa	
Benin	n.a.
Cameroon	n.a.
Central African Republic	Ministère des Eaux, Forêts Chasse et Pêche BP 830 Bangui Bangui République Centrafricaine Edouard Zama (ed_bekoba@yahoo.fr) Ingénieur des Eaux et Forêts, Chargé d'Etudes en matière de Traçabilité APV/FLEGT Phone: (236) 770 607 08/701 135 06/726 543 00
Congo	n.a.
Côte d'Ivoire	National Agency for Environment (ANDE) (www.mdpcotedivoire.org) 08 BP 09 Abidjan 08 Riviéra Attoban Rue I 32 En face du Groupe Scolaire Jules FERRY Ms Rachel Boti-Douayoua (rbdouayoua@gmail.com, botirach@yahoo.fr) CDM-d Coordinator Phone: (225 22) 43 23 10/(225 01) 03 28 95 Fax: (225 22) 43 19 57
Democratic Republic of the Congo	Ministère de l'Environnement, Conservation de la Nature et Tourisme BP 12348, Kinshasa 1 Republique Democratique du Congo Mr Venan Mabiala Ma Mabiala (venanmabiala@gmail.com) Directeur de l'Autorité Nationale Désignée du Mécanisme pour un Développement Propre Phone: (243) 99 99 89 917 Fax: (243) 88 4 3675 (PNUD-RDC) Ministère de l'Environnement, Conservation de la Nature et Tourisme BP 12348, Kinshasa 1 Republique Democratique du Congo Bavon N'Sa Mputu Elima (bavon_nsamputu2000@yahoo.fr) Minister Phone: (243 82) 2992718 Fax: (243 88) 4 3675 (PNUD-RDC)
Gabon	n.a.
Ghana	Environmental Protection Agency, Ministry of Environment, Science & Technology 91 Starlets Road PO Box M326 Accra Ghana Mr Jonathan A. Allotey (jallotey@epaghana.org) Executive Director Phone: (233 21) 662 693 Fax: (233 221) 662 690 Ministry of Environment, Science and Technology PO Box M232 Accra Ghana Mr Peter Justice Dery (peterjdery@yahoo.com) National Climate Change Coordinator Phone: (233) 0 302 267 3511/666 049 Fax: (233) 688 913/662 533
Liberia	n.a.

Mali	Agence de l'Environnement et du Développement Durable BP 2357 Bamako Mali Mr Boubacar Sidiki Dembele (aedd@environnement.gov.ml, boubacarsdembele@gmail.com) Phone: (223) 2023 1074 Fax: (223) 2023 5867
Mozambique	Ministério para a Coordenação da Acção Ambiental Av. Acordos de Lusaka No. 2115 PO Box 2020 Maputo Mozambique Ms Rosa Cesaltina Benedito (cesaltin@gmail.com) Phone: (258 21) 46 5141 Fax: (258 21) 46 6495
Togo	Direction de l'Environnement BP 4825 Lomé Togo Mr Koffi Volley (denv_togo@yahoo.fr, koffivolley@yahoo.fr, koffivolley@gmail.com) Phone: (228 2) 221 3321/5197 Fax: (228 2) 221 0333
Asia & Pacific	
Cambodia	Ministry of Environment, Climate Change Office 48, Samdech Preah Sihanouk Blvd, Phnom Penh Cambodia H.E. Thuk Kroeun Vutha (ETAP@online.com.kh, cceap@online.com.kh) Secretary of State, Cambodian Ministry of Environment Phone: (855 23) 218 370 Fax: (855 23) 218 370
Fiji	n.a.
India	Ministry of Environment and Forests, Government of India Core IV B, 2nd floor India Habitat Centre Lodhi Road, New Delhi India 110 003 Dr A. Duraisamy (a.duraisamy19@gmail.com) Director and Member Secretary Phone: (91 11) 2464 2176 Fax: (91 11) 2464 2175
Indonesia	National Committee on Clean Development Mechanism BUMN Building, 18th floor Jalan Merdeka Selatan 13 Jakarta 11110 Mr Rachmat Witoelar (dna-cdm@dnpi.go.id) Chairperson of the National Committee on CDM of the Republic of Indonesia Phone: (62 21) 35 11 400 Fax: (62 21) 351 1403

Malaysia	Ministry of Natural Resources and Environment Level 6, Tower Block 4G3, Precinct 4 Environmental Management and Climate Change Division Federal Government Administration Centre 62574 Putrajaya, Malaysia Mr Shahril Faizal Abdul Jani (faizal@nre.gov.my) Principal Assistant Secretary Phone: (603) 8886 1137 Fax: (603) 8888 4473 Ministry of Natural Resources and Environment Environmental Management and Climate Change Division Level 6, Tower Block 4G3, Precinct 4 Federal Government Administration Centre 62574 Putrajaya, Malaysia Dr Lian Kok Fe (drlian@nre.gov.my) Undersecretary Phone: (603) 8886 1125 Fax: (603) 8888 4473
Myanmar	Ministry of Forestry, Planning & Statistics Department Building No-28 Nay Pyi Taw Myanmar Mr Sann Lwin (dgpsmof@mptmail.net.mm) Phone: (95 067) 40 5009 Fax: (95 067) 40 5012
Papua New Guinea	n.a.
Philippines	Department of Environment and Natural Resources Environmental Management Bureau DENR Compound Visayas Avenue Diliman, Quezon City 1116 Philippines Mr Juan Miguel T. Cuna (attymitchcuna@yahoo.com, emb@emb.gov.ph) Director, Environmental Management Bureau (DNA-TEC Chair) Phone: (632) 920 2246 Fax: (632) 928 3725 Environmental Management Bureau DENR Compound, Visayas Avenue Diliman, Quezon City 1116 Philippines Mr Albert A. Magalang (albertmgg@yahoo.com) Head, Climate Change Office (DNA Forum Representative) Phone: (632) 920 2251 Fax: (632) 928 4674
Viet Nam	Ministry of Natural Resources and Environment of Viet Nam 10 Ton That Thuyet street Cau Giay District Hanoi, Viet Nam Mr Nguyen Khac Hieu (vnccoffice@viettel.vn, ngkhachieu@yahoo.com) Deputy Director General Department of Meteorology, Hydrology and Climate Change Phone: (844) 37759385 Fax: (844) 37759382

Latin America	
Brazil	Brazilian Ministry of Science, Technology and Innovation General Coordination for Global Climate Change Secretariat for Research and Development Policies and Programmes Esplanada dos Ministérios Bloco E, s. 268 70067-900, Brasilia-DF Brazil Mr Gustavo Luedemann (cimgc@mct.gov.br, gustavo.luedemann@mct.gov.br) General Coordinator for Global Climate Change Phone: (55 61) 2033-7923 Fax: (55 61) 2033-7657 Márcio Rojas da Cruz (cimgc@mct.gov.br) Alternate General Coordinator for Global Climate Change General Coordination for Global Climate Change—Executive Secretariat of the Interministerial Commission on Global Climate Change Phone: (55 61) 2033-7923 Fax: (55 61) 2033-7657
Colombia	Dirección de Cambio Climático, Ministerio de Ambiente y Desarrollo Sostenible Calle 37 No. 8-40 Bogota Colombia Dr Diana Milena Rodriguez Velosa (dmrodriguez@minambiente.gov.co) Phone: (571) 332 3400 Ext: 2484/2411 Fax: (571) 332 3607
Costa Rica	Ministerio del Ambiente y Energia (MINAE) Instituto Meterologico Nacional Apartado postal 5583-1000 San José Costa Rica Sr William Alpizar Zuñiga (cambioclimatico.cr@gmail.com) Phone: (506) 2221 3641/2222 4290 Fax: (506) 2223 1837
Ecuador	Undersecretary of Climate Change of the Ministry of Environment 1159 Madrid y Andalucía Street Quito Ecuador Ms Alexandra Buri Tene (aburi@ambiente.gob.ec) Phone: (593 2) 398 7600 ext. 1314
Guatemala	Ministerio de Ambiente y Recursos Naturales Mr Raúl Castañeda Illescas (ondl@marn.gob.gt) Coordinador de la Oficina Nacional de Desarrollo Limpio Phone: (502 242) 30500/30436 Ext.2311 Fax: (502 242) 30500 Ext. 1204 (Cell): (502) 55 899037
Guyana	n.a.
Honduras	Natural Resources and Environment Secretary (SERNA) (www.serna.gob.hn) Edificio Principal de la SERNA, 100 m al Sur del Estadio Nacional Postal Address: 1389 and 4710 Tegucigalpa Honduras Dr Rigoberto Cuellar (rigobertocuellar@hotmail.com) Phone: (504) 235 78 33/239 36 91 Fax: (504) 231 1918
Mexico	Comisión Intersecretarial de Cambio Climàtico Av. San Jerónimo 458, Piso 3, Col. Jardines del Pedregal, Delegación Álvaro Obregón, 01900 México, DF Mr Luis Muñozcano Álvarez (luis.munozcano@semarnat.gob.mx) Coordinador del Comité Mexicano p. Proyectos de Reducción de Emisiones y Captura de Gases (COMEGEI) Phone: (52 55) 5490 2115

Panama	Autoridad Nacional del Ambiente (www.anam.gob.pa) Zona 0843 Balboa, Ancón República de Panamá Mr Silvano Vergara (svergara@anam.gob.pa) Deputy Administrator General Phone: (507) 500 0823 Fax: (507) 500 0822 Ms Elia Guerra (equijano@anam.gob.pa) Negotiator in International Environment Affairs Phone: (507) 500 0899 Fax: (507) 500 0822
Peru	Ministerio del Ambiente Av. Javier Prado 1440, San Isidro Lima 27 Perú Mr Eduardo Durand López-Hurtado (edurand@minam.gob.pe, kmondonedo@minam.gob.pe) Director General de Cambio Climático, Desertificación y Recursos Hídricos Phone: (511) 611 6000 ext. 1350 Fax: (511) 611 6000 ext. 1634
Suriname	Ministry of Labour, Technological Development and Environment Wagenwegstraat 22 Paramaribo Suriname Mr Michael Miskin (ministeratm@atm.sr.org) Minister of the Ministry of Labour Phone: (597) 4520 960 Fax: (597) 410 465
Trinidad and Tobago	Ministry of Planning, Housing and the Environment HDC Building, 2nd floor #44–46 South Quay Port-of-Spain Trinidad Ms Esmé Rawlins-Charles (Esme.Rawlins-Charles@phe.gov.tt) Permanent Secretary Phone: (868) 624 3378 Fax: (868) 625 2793

Forest definitions for the A/R CDM in ITTO producer members

	Tree cover (10–30%)	Land area (0.05–1.0 ha)	Tree height (2–5 m)
Africa			
Benin	n.a.	n.a.	n.a.
Cameroon	n.a.	n.a.	n.a.
Central African Republic	n.a.	n.a.	n.a.
Congo	n.a.	n.a.	n.a.
Côte d'Ivoire	30	0.1	5
Democratic Republic of the Congo	30	0.5	3
Gabon	n.a.	n.a.	n.a.
Ghana	15	0.1	5
Liberia	n.a.	n.a.	n.a.
Mali	30	1	2
Mozambique	30	1	5
Togo	10	0.5	5
Asia & Pacific			
Cambodia	10	0.5	5
Fiji	n.a.	n.a.	n.a.
India	15	0.05	2
Indonesia	30	0.25	5
Malaysia	30	0.5	5
Myanmar	10	0.1	2
Papua New Guinea	n.a.	n.a.	n.a.
Philippines	10	0.5	5
Viet Nam	30	0.5	3
Latin America			
Brazil	30	1	5
Colombia	30	1	5
Costa Rica	30	1	5
Ecuador	30	1	5
Guatemala	30	0.5	5
Guyana	n.a.	n.a.	n.a.
Honduras	30	1	5
Mexico	30	1	4
Panama	30	1	5
Peru	30	0.5	5
Suriname	n.a.	n.a.	n.a.
Trinidad and Tobago	10	0.4	3

ANNEX 3: RECOMMENDED FORMAT FOR REPORTING CARBON BENEFITS FROM ITTO PROJECTS

The carbon benefits derived from ITTO projects may be monitored and reported using this format. Note that completing this format is voluntary. The format is in line with the reporting formats of the UNFCCC, as used in National Communications. It is aimed at keeping track of the carbon benefits obtained from ITTO-funded activities.[62]

CONTENTS			
Table	NAME	CONTENT	NOTES
1	Summary	Summary table of the project information, the monitoring actors and activities, and the total carbon benefits per activity	
2	Land-use matrix	Explains the land-use changes caused by the project (if any)	This table compares the land uses before the project (initial) and the expected land uses at the end of the project (final)
3	Summary of activities	Summary of all activities included in the project and their corresponding area	This table provides an overview of all activities in the project and facilitates the lecture of the following tables
3.1	Reducing deforestation	Detailed information on the quantification of carbon benefits from the reduction in deforestation during the reporting period	This table provides detailed information on selected pools, changes in carbon stocks, emissions from other sources, default values, and the approach to leakage in all activities related to reducing deforestation. It documents the information provided in the summary table
3.2	Reducing degradation	Detailed information on the quantification of carbon benefits from the reduction in degradation in the reporting period	This table provides detailed information on selected pools, changes in carbon stocks, emissions from other sources, default values and the approach to leakage in all activities related to reducing degradation. It documents the information provided in the summary table
3.3	Forest restoration	Detailed information on the quantification of carbon benefits from forest restoration in the reporting period	This table provides detailed information on selected pools, changes in carbon stocks, emissions from other sources, default values and the approach to leakage in all activities related to forest restoration. It documents the information provided in the summary table
3.4	Forest management	Detailed information on the quantification of carbon benefits from forest management in the reporting period	This table should be used only when no deforestation and/or degradation threat is present in the forest area under management. It provides detailed information on selected pools, changes in carbon stocks, emissions from other sources, default values and the approach to leakage in all activities related to forest management. It documents the information provided in the summary table
3.5	Plantations	Detailed information on the quantification of carbon benefits from plantations in the reporting period	This table includes any type of plantation, being reforestation or afforestation. It provides detailed information about selected pools, changes in carbon stocks, emissions from other sources, default values and the approach to leakage in all activities related to plantations. It documents the information provided in the summary table.
3.6	Integrated systems	Detailed information on the quantification of carbon benefits from integrated systems in the reporting period	This table includes agroforestry activities, i.e. agropastoral and agrosilvopastoral systems. It provides detailed information about selected pools, changes in carbon stocks, emissions from other sources, default values and approach to leakage in all activities related to integrated systems. It documents the information provided in the summary table.

62 This reporting format may be obtained as an Excel file by contacting the ITTO Secretariat (info@itto.int). It is recommended that ITTO projects use the Excel file when undertaking this reporting.

Table 3.0 SUMMARY OF ACTIVITIES

Activity	Sub-activity	Total number of strata	hectares established per year									
			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Total
Reducing deforestation												
Reducing degradation												
Forest restoration												
Forest management												
Plantations												
Integrated systems												
Total area established per year												

Table 3.1 REDUCING DEFORESTATION

FORMAT FOR VOLUNTARY REPORTING ON THE CARBON BENEFITS FROM REDUCING DEFORESTATION

Year:			Net carbon change per carbon pool per hectare													
								Soil organic matter (SOC)								
								Mineral soils		Organic soils						
			Above-ground biomass	Below-ground biomass	Litter	Dead wood	HWPs	SOC	N_2O emissions from N mineralized during SOC losses in mineral soils	Drainage			Rewetting			Other
	Area	Carbon stock changes without intervention								SOC	non-CO_2 GHG emissions		SOC	non-CO_2 GHG emissions		SOC
Activity/stratum	**ha**	tCO_2e	tCO_2					tC	tN_2O	tC	tCH_4	tN_2O	tC	tCH_4	tN_2O	tC
Stratum 1																
Stratum 2																
Stratum 3																
Stratum 4																
Stratum 5																
Stratum 6																
Stratum 7																
Stratum 8																
Stratum 9																
Stratum 10																
...																
Total																

	Pool selection					
	Above-ground biomass	Below-ground biomass	Litter	Dead wood	HWPs	Soil
Yes/No						
Rationale						

Emission factors		
Name	Value	Source

	Total emissions/sinks reported (without HWP)				Leakage			
Activity/stratum	Net CO_2	CH_4	N_2O	Net CO_2e	Is leakage expected?	Option 1 (0% reduction)	Option 2 (30-50%)	Option 3 (100% reduction)
	tonnes				Yes/No	tCO_2e		
Stratum 1								
Stratum 2								
Stratum 3								
Stratum 4								
Stratum 5								
Stratum 6								
Stratum 7								
Stratum 8								
Stratum 9								
Stratum 10								
...								
				Total	Total			

Total carbon benefits without HWPs	
Activity	tCO_2e
Stratum 1	
Stratum 2	
Stratum 3	
Stratum 4	
Stratum 5	
Stratum 6	
Stratum 7	
Stratum 8	
Stratum 9	
Stratum 10	
...	
Total	

Total carbon benefits
CBtx = MCtx – ECtx-L
CBtx = carbon benefits by year x
MCtx = Monitored changes in carbon stocks and emissions from other sources by year x
ECtx = carbon stock changes expected without intervention by year x → (estimated with a simplified tool e.g. with sCreen)
L = leakage

Other sources		
Name	Default value or measurement	Source

Notes:
For the purposes of this monitoring we consider fertilization in forestry activities to ber non-significant.
Burning activities should be reflected in changes in the carbon stocks of the corresponding pools.
If a given parameter is not needed/not considered in your project, please shade the cell black. HWP = harvest wood products

Table 3.2 REDUCING DEGRADATION

FORMAT FOR VOLUNTARY REPORTING THE CARBON BENEFITS FROM REDUCING DEGRADATION

Year:			**Net carbon change per carbon pool per hectare**													
								Soil organic matter (SOC)								
								Mineral soils		Organic soils						
			Above-ground biomass	Below-ground biomass	Litter	Dead wood	HWP	SOC	N_2O emissions from N mineralized during SOC losses in mineral soils	Drainage			Rewetting			Other
	Area	**Carbon stock changes without intervention**								SOC	non-CO_2 GHG emissions		SOC	non-CO_2 GHG emissions		SOC
Activity/stratum	**ha**	tCO_2e	tCO_2e					tC	tN_2O	tC	tCH_4	tN_2O	tC	tCH_4	tN_2O	tC
Stratum 1																
Stratum 2																
Stratum 3																
Stratum 4																
Stratum 5																
Stratum 6																
Stratum 7																
Stratum 8																
Stratum 9																
Stratum 10																
...																
Total																

	Pool selection					
	Above-ground biomass	Below-ground biomass	Litter	Dead wood	HWP	Soil
Yes/No						
Rationale						

Emission factors		
Name	Value	Source

	Total emissions/sinks reported (without HWP)				**Leakage** (Chapter 6)			
Activity/stratum	Net CO_2	CH_4	N_2O	Net CO_2e	Is leakage expected?	Option 1 (0% reduction)	Option 2 (30-50%)	Option 3 (100% reduction)
	tonnes				Yes/No	tCO_2e		
Stratum 1								
Stratum 2								
Stratum 3								
Stratum 4								
Stratum 5								
Stratum 6								
Stratum 7								
Stratum 8								
Stratum 9								
Stratum 10								
...								
			Total		Total			

Total carbon benefits without HWPs	
Activity	tCO_2e
Stratum 1	
Stratum 2	
Stratum 3	
Stratum 4	
Stratum 5	
Stratum 6	
Stratum 7	
Stratum 8	
Stratum 9	
Stratum 10	
...	
Total	

Total carbon benefits
CBtx = MCtx – ECtx-L
CBtx = Carbon benefits by year x
MCtx = Monitored changes in carbon stocks and emissions from other sources by year x
ECtx = carbon stock changes expected without intervention by year x → (estimated with a simplified tool e.g. with sCreen)
L= leakage

Other sources		
Name	Default value or measurement	Source

Notes:
For the purposes of this monitoring we consider fertilization in forestry activities to be non-significant.
Burning activities should be reflected in changes in the carbon stocks of the corresponding pools.
If a given parameter is not needed/not considered in your project, please shade the cell black. HWP = harvest wood products

Table 3.3 FOREST RESTORATION

FORMAT FOR VOLUNTARY REPORTING THE CARBON BENEFITS FROM RESTORATION ACTIVITIES

Year:			**Net carbon change per carbon pool per hectare**													
			Above-ground biomass	Below-ground biomass	Litter	Dead wood	HWP	Soil organic matter (SOC)								
								Mineral soils		Organic soils						
								SOC	N_2O emissions from N mineralized during SOC losses in mineral soils	Drainage			Rewetting			Other
	Area	**Carbon stock changes without intervention**								SOC	non-CO_2 GHG emissions		SOC	non-CO_2 GHG emissions		SOC
Activity/stratum	**ha**	tCO_2e	tCO_2					tC	tN_2O	tC	tCH_4	tN_2O	tC	tCH_4	tN_2O	tC
Stratum 1																
Stratum 2																
Stratum 3																
Stratum 4																
Stratum 5																
Stratum 6																
Stratum 7																
Stratum 8																
Stratum 9																
Stratum 10																
…																
Total																

Pool selection						
	Above-ground biomass	Below-ground biomass	Litter	Dead wood	HWP	Soil
Yes/No						
Rationale						

Emission factors		
Name	Value	Source

	Total emissions/sinks reported (without HWP)				**Leakage** (Chapter 6)			
Activity/strata	Net CO_2	CH_4	N_2O	Net CO_2e	Is there a leakage expected?	Option 1 (0% reduction)	Option 2 (30-50%)	Option 3 (100% reduction)
	tonnes				Yes/No	tCO_2e		
Stratum 1								
Stratum 2								
Stratum 3								
Stratum 4								
Stratum 5								
Stratum 6								
Stratum 7								
Stratum 8								
Stratum 9								
Stratum 10								
…								
			Total		Total			

Total carbon benefits without HWP	
Activity	tCO_2e
Stratum 1	
Stratum 2	
Stratum 3	
Stratum 4	
Stratum 5	
Stratum 6	
Stratum 7	
Stratum 8	
Stratum 9	
Stratum 10	
…	
Total	

Total carbon benefits
CBtx = MCtx – ECtx-L
CBtx = Carbon benefits by year x
MCtx = Monitored changes in carbon stocks and emissions from other sources by year x
ECtx = carbon stock changes expected without intervention by year x → (estimated with a simplified tool e.g. with sCreen)
L = leakage

Other sources		
Name	Default value or measurement	Source

Notes:
For the purposes of this monitoring we consider fertilization in forestry activities to be non-significant.
Burning activities should be reflected in changes in the carbon stocks of the corresponding pools.
If a given parameter is not needed/not considered in your project, please shade the cell black. HWP = harvested wood products

Table 3.4 FOREST MANAGEMENT

FORMAT FOR VOLUNTARY REPORTING THE CARBON BENEFITS FROM FOREST MANAGEMENT

Year:			**Net carbon change per carbon pool per hectare**													
								Soil organic matter (SOC)								
								Mineral soils		Organic soils						
			Above-ground biomass	Below-ground biomass	Litter	Dead wood	HWP	SOC	N2O emissions from N mineralized during SOC losses in mineral soils	Drainage			Rewetting			Other
	Area	**Carbon stock changes without intervention**								SOC	non-CO_2 GHG emissions		SOC	non-CO_2 GHG emissions		SOC
Activity/stratum	**ha**	tCO_2e	tCO_2					tC	tN_2O	tC	tCH_4	tN_2O	tC	tCH_4	tN_2O	tC
Stratum 1																
Stratum 2																
Stratum 3																
Stratum 4																
Stratum 5																
Stratum 6																
Stratum 7																
Stratum 8																
Stratum 9																
Stratum 10																
...																
Total																

Pool selection						
	Above-ground biomass	Below-ground biomass	Litter	Dead wood	HWP	Soil
Yes/No						
Rationale						

Emission factors		
Name	Value	Source

	Total emissions/sinks reported (without HWP)				**Leakage** (Chapter 6)			
Activity/strata	Net CO_2	CH_4	N_2O	Net CO_2e	Is leakage expected?	Option 1 (0% reduction)	Option 2 (30-50%)	Option 3 (100% reduction)
	T				Yes/No	tCO_2e		
Stratum 1								
Stratum 2								
Stratum 3								
Stratum 4								
Stratum 5								
Stratum 6								
Stratum 7								
Stratum 8								
Stratum 9								
Stratum 10								
...								
			Total		Total			

Total carbon benefits without HWP	
Activity	tCO_2e
Stratum 1	
Stratum 2	
Stratum 3	
Stratum 4	
Stratum 5	
Stratum 6	
Stratum 7	
Stratum 8	
Stratum 9	
Stratum 10	
...	
Total	

Total carbon benefits
CBtx = MCtx – ECtx-L
CBtx = Carbon benefits by year x
MCtx = Monitored changes in carbon stocks and emissions from other sources by year x
ECtx = carbon stock changes expected without intervention by year x → (estimated with a simplified tool e.g. with sCreen)
L = leakage

Other sources		
Name	Default value or measurement	Source

Notes:
For the purposes of this monitoring we consider fertilization in forestry activities to be non-significant.
Burning activities should be reflected in changes to the carbon stocks of the corresponding pools.
If a given parameter is not needed/not considered in your project, please shade it black. HWP = harvested wood products

Table 3.5 PLANTATIONS

FORMAT FOR VOLUNTARY REPORTING THE CARBON BENEFITS FROM PLANTATIONS

Year:			Net carbon change per carbon pool per hectare													
								Soil organic matter (SOC)								
								Mineral soils		Organic soils						
			Above-ground biomass	Below-ground biomass	Litter	Dead wood	HWP	SOC	N2O emissions from N mineralized during SOC losses in mineral soils	Drainage			Rewetting			Other
Activity/stratum	**Area**	**Carbon stock changes without intervention**								SOC	non-CO_2 GHG emissions		SOC	non-CO_2 GHG emissions		SOC
	ha	tCO_2e	tCO_2					tC	tN_2O	tC	tCH_4	tN_2O	tC	tCH_4	tN_2O	tC
Stratum 1																
Stratum 2																
Stratum 3																
Stratum 4																
Stratum 5																
Stratum 6																
Stratum 7																
Stratum 8																
Stratum 9																
Stratum 10																
...																
Total																

	Pool selection					
	Above-ground biomass	Below-ground biomass	Litter	Dead wood	HWP	Soil
Yes/No						
Rationale						

Emission factors		
Name	Value	Source

	Total emissions/sinks reported (without HWP)				**Leakage** (Chapter 6)			
Activity/stratum	Net CO_2	CH_4	N_2O	Net CO_2e	Is leakage expected?	Option 1 (0% reduction)	Option 2 (30-50%)	Option 3 (100% reduction)
	tonnes				Yes/No	tCO_2e		
Stratum 1								
Stratum 2								
Stratum 3								
Stratum 4								
Stratum 5								
Stratum 6								
Stratum 7								
Stratum 8								
Stratum 9								
Stratum 10								
...								
			Total		Total			

Total carbon benefits without HWP	
Activity	TCO_2e
Stratum 1	
Stratum 2	
Stratum 3	
Stratum 4	
Stratum 5	
Stratum 6	
Stratum 7	
Stratum 8	
Stratum 9	
Stratum 10	
...	
Total	

Total carbon benefits
CBtx = MCtx – ECtx-L
CBtx = Carbon benefits by year x
MCtx = Monitored changes in carbon stocks and emissions from other sources by year x
ECtx = carbon stock changes expected without intervention by year x → (estimated with a simplified tool e.g. with sCreen)
L = leakage

Other sources		
Name	Default value or measurement	Source

Notes:
For the purposes of this monitoring we consider fertilization in forestry activities to be non-significant.
Burining activities should be reflected in changes to the carbon stocks of the corresponding pools.
If a given parameter is not needed/not considered in your project, please shade the cell in black. HWP = harvested wood products

Table 3.6 INTEGRATED SYSTEMS

FORMAT FOR VOLUNTARY REPORTING THE CARBON BENEFITS FROM INTEGRATED SYSTEMS

Year:			Net carbon change per carbon pool per hectare													
								Soil organic matter (SOC)								
								Mineral soils		Organic soils						
			Above-ground biomass	Below-ground biomass	Litter	Dead wood	HWP	SOC	N2O emissions from N mineralized during SOC losses in mineral soils	Drainage			Rewetting			Other
										SOC	non-CO_2 GHG		SOC	non-CO_2 GHG		SOC
Activity/stratum	**Area** ha	**Carbon stock changes without intervention** tCO_2e	tCO_2					tC	tN_2O	tC	tCH_4	tN_2O	tC	tCH_4	tN_2O	tC
Stratum 1																
Stratum 2																
Stratum 3																
Stratum 4																
Stratum 5																
Stratum 6																
Stratum 7																
Stratum 8																
Stratum 9																
Stratum 10																
...																
Total																

Pool selection						
	Above-ground biomass	Below-ground biomass	Litter	Dead wood	HWP	Soil
Yes/No						
Rationale						

Emission factors		
Name	Value	Source

	Total emissions/sinks reported (without HWP)				Leakage Chapter 6)			
Activity/stratum	Net CO_2	CH_4	N_2O	Net CO_2e	Is leakage expected?	Option 1 (0% reduction)	Option 2 (30-50%)	Option 3 (100% reduction)
	T				Yes/No	tCO_2e		
Stratum 1								
Stratum 2								
Stratum 3								
Stratum 4								
Stratum 5								
Stratum 6								
Stratum 7								
Stratum 8								
Stratum 9								
Stratum 10								
...								
			Total		Total			

Total carbon benefits without HWP	
Activity	TCO_2e
Stratum 1	
Stratum 2	
Stratum 3	
Stratum 4	
Stratum 5	
Stratum 6	
Stratum 7	
Stratum 8	
Stratum 9	
Stratum 10	
...	
Total	

Total carbon benefits
CBtx = MCtx – ECtx-L
CBtx = Carbon benefits by year x
MCtx = Monitored changes in carbon stocks and emissions from other sources by year x
ECtx = carbon stock changes expected without intervention by year x → (estimated with a simplified tool e.g. with sCreen)
L = leakage

Other sources		
Name	Default value or measurement	Source

Notes:
For the purposes of this monitoring we consider fertilization in forestry activities to be non significant.
Burning activities should be reflected in changes to the carbon stocks of the corresponding pools.
If a given parameter is not needed/not considered in your project, please shade the cell black. HWP = harvested wood products

The aim of *Technical Guide on the Quantification of Carbon Benefits in ITTO Projects* is to provide basic knowledge and techniques on the quantification of carbon benefits in forest-related projects. The guide will help forest managers to:

- calculate the potential carbon benefits of their projects;
- determine which existing climate-change mitigation framework to use; and
- understand the specific requirements and challenges of the various frameworks and accounting mechanisms.

The guide also sets out a method for the voluntary monitoring and reporting of carbon benefits arising specifically from ITTO projects. It provides added value to existing technical guidance on accounting for carbon benefits by offering a comparison of existing accounting mechanisms.

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