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Climate Change

Choices in Quantifying Carbon for Jurisdictional REDD+

Overview from the Forest Carbon
Partnership Facility

This report was prepared by Till Neeff, Marco van der Linden, and Moon Herrick.

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The World Bank, 1818 H Street NW, Washington DC 20433
Telephone: 202-473-1000 Internet: www.worldbank.org

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1. EXECUTIVE SUMMARY

The Carbon Fund of the Forest Carbon Partnership Facility¹ (FCPF) is set up to pilot performance-based payment systems for emission reductions generated from REDD+ (reducing emissions from deforestation and forest degradation in developing countries) efforts in developing countries. The piloting efforts include setting a good practice benchmark for robust carbon quantification that is fit for the purpose of attracting performance-based payments.

An analysis of the choices that the country programs in the Carbon Fund make in quantifying carbon shows an emerging picture of what is currently feasible in terms of quantifying emissions and removals for REDD+.

- (i) The scope of carbon quantification for the country programs in the Carbon Fund is comprehensive; not only do all countries quantify emissions from deforestation, but almost all country programs (90 percent) include forest degradation, and despite considerable technical difficulties, many cover enhancement of carbon stocks (about 75 percent) as well.
- (ii) The country programs follow the strict Carbon Fund requirements for constructing reference levels. As a consequence, almost all country programs (more than 80 percent) use a 10-year reference period, and only a few programs (less than 20 percent) adjust the reference level above historical average emissions.
- (iii) Country programs are innovative; they apply a range of different approaches and data sets when quantifying emission reductions.
- (iv) All country programs quantify uncertainties and plan to set aside a portion of achieved emission reductions to ensure that emission reductions are estimated conservatively.
- (v) The permanence of transacted carbon credits is supported by setting aside a portion of emission reductions in a dedicated buffer

account. The set-aside depends on the reversal risk and averages 22 percent across the 18 programs in the portfolio.

There are differences between the choices that countries made for their programs in the Carbon Fund and the carbon quantification choices made in their United Nations Framework Convention on Climate Change (UNFCCC) submissions. This is largely due to the fact that the UNFCCC's Warsaw Framework for REDD+ gives countries more flexibility in choosing data sets and methodological approaches. There is, however, scope for scaling approaches piloted for the Carbon Fund up to national forest monitoring systems. On some aspects, for example the length of the reference period, the analysis shows that carbon quantification choices in submissions to the UNFCCC and to the Carbon Fund are already converging. A few countries have already resubmitted forest reference (emission) levels to the UNFCCC where improvements due to the country's experience in the FCPF process can be identified. A few years from now, it is likely that knowledge transfer from the Carbon Fund to the UNFCCC process will become more visible.

The impact of the Carbon Fund on the larger REDD+ process is only just beginning to be visible. The good practice benchmark set by the Carbon Fund can also inform the carbon quantification choices of countries that do not participate in the Carbon Fund. The data sets and approaches described in this paper represent what countries had been able to achieve by early 2020 with ample access to technical support, strong motivation from the prospect of results-based payments, and when working at the scale of subnational jurisdictions. The lessons learned from the Carbon Fund's work in this area can help raise the standard for all countries in their efforts to attract results-based payments for REDD+.

¹ For more information, see <http://www.forestcarbonpartnership.org>.

2. INTRODUCTION AND CONTEXT OF THIS REPORT

Under the United Nations Framework Convention on Climate Change (UNFCCC), it was agreed that countries should collectively aim to slow, halt, and reverse forest cover and carbon loss through reducing emissions from deforestation and forest degradation, forest carbon stock conservation, the sustainable management of forests, and the enhancement of forest carbon stocks—activities, commonly referred to as REDD+.² The Warsaw Framework for REDD+³ provides methodological guidance for tracking the implementation of REDD+ activities under the UNFCCC according to a process of stepwise improvements.

The Forest Carbon Partnership Facility (FCPF) was set up in 2008, before the Warsaw Framework for

REDD+. The FCPF's Readiness Fund helps countries establish the building blocks to implement REDD+, while its Carbon Fund offers technical assistance and results-based payments upon delivery of emission reductions units. To ensure impact, results are determined on a significant scale, either nationally or in large areas that align with one or more jurisdictions or a national-government-designated area (for example, ecoregion). The Carbon Fund is set to run until December 2025. By late 2019, 19 countries had proposed jurisdictional programs for consideration by the Carbon Fund, and 18 had been accepted into the portfolio (Figure 2.1). In early 2020, the Carbon Fund had signed Emission Reductions Payment Agreements with four countries: Chile, Democratic Republic of Congo, Ghana, and Mozambique.

² More information is available at <https://redd.unfccc.int/fact-sheets.html>.
³ Decision 9-15/CP.19.

Figure 2.1: The Carbon Fund Portfolio



In the FCPF Carbon Fund, country programs generate carbon credits—fungible assets that will earn financial compensation and that, in principle, can be traded and used for offsetting. These country programs therefore need to provide participants in the Carbon Fund with a high degree of assurance on the quality of the reported emission reductions. To support robust emission reductions claims, the FCPF has developed a Methodological Framework and established a technical assessment and verification process.⁴ The FCPF Methodological Framework provides guidance to countries in designing approaches for quantifying emissions and emission reductions and also provides a set of accounting rules.

This report provides a factual overview of the carbon quantification choices that the 18 country programs in the Carbon Fund portfolio made in their proposals, organized according to five key topics:

- Scope and scale of the program
- Construction of reference levels
- Approaches and data sets used for quantifying emissions
- Estimation of uncertainties
- Permanence of emission reductions

This analysis is intended to provide of overview of what countries (with a wide array of contexts) can do, provided they have sufficient support. It is hoped that this overview will provide useful information for the technical community that is thinking about the evolving requirements for REDD+ results-based financing. Findings may also be useful to countries that are preparing REDD+ submissions to the UNFCCC.

Note: Before a country program is accepted into the portfolio of the Carbon Fund, the country must submit an Emission Reductions Program Document (ERPD). Among other things, the ERPD establishes a reference level as the benchmark against which performance is measured and explains how emissions reductions will be monitored. The ERPDs abide by the FCPF Methodological Framework and undergo a technical assessment to evaluate how well they comply.

The content of this paper is informed by the ERPDs of all 18 Carbon Fund countries that were accepted in the portfolio. In all cases, the ERPD analyzed is the most recent version available on the webpage of the FCPF.⁵ Usually work has continued after documents were submitted. Sometimes methodologies have also been updated in response to requests from the Carbon Fund participants, but in other cases the program applied technical corrections to greenhouse gas emissions and removals reported in the reference period.⁶ Because of this, the published ERPDs will not always represent the latest and most developed state of country programs. Thus, there are instances in which this report reflects slightly outdated information because it reflects the ERPDs rather than subsequent changes.



⁴ <https://www.forestcarbonpartnership.org/requirements-and-templates>.

⁵ <https://www.forestcarbonpartnership.org/carbon-fund>.

⁶ The details of this process are described in Facility Management Team (FMT) Note CF-2018-4 available at https://www.forestcarbonpartnership.org/system/files/documents/FMT+note+CF-2018-04+Guidance+on+technical+corrections_Revised+Final_CFPs.pdf.

3. SCOPE AND SCALE

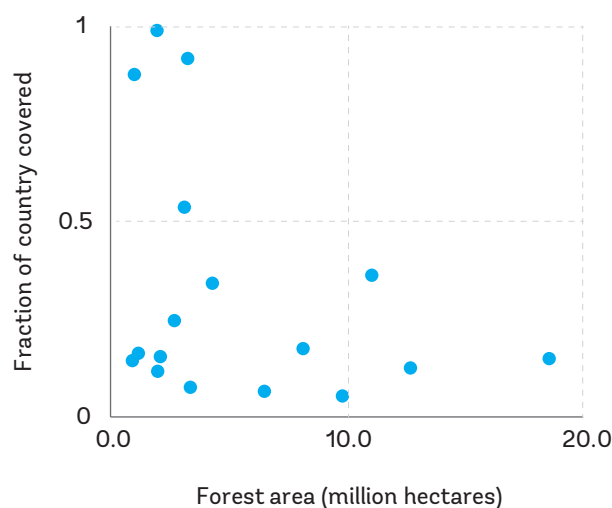
Countries need to determine which REDD+ activities, carbon pools, and greenhouse gases they include when quantifying carbon. This is often referred to as the scope of the carbon quantification. In their programs under the Carbon Fund, countries aim to address the most significant forest-related emissions and removals in the relevant jurisdiction.⁷ There is some variation between country programs on the REDD+ activities included because carbon stock enhancements are not always fully covered. Furthermore, there remains some flexibility regarding carbon pools beyond living biomass and greenhouse gases beyond carbon dioxide. More importantly, coverage is often limited because most jurisdictions are subnational (as opposed to national) in scale.

Countries' submissions to the Carbon Fund differ substantially from their submissions to the UNFCCC across all the parameters stated above. In their REDD+ submissions to the UNFCCC, it is common for countries to only report on a subset of REDD+ activities, carbon pools, and greenhouse gases.

3.1 Scale

The programs under the Carbon Fund are implemented at national or subnational scales.⁸ While most jurisdictional programs are significantly smaller than their national boundaries, they still cover very large areas (Figure 3.1), generally between 10 and 40 percent of the national territory and ranging from 1 million to 12 million hectares of forests. It is rare for programs to cover more than 40 percent of the territory, although it is possible to propose programs for most or all of a country, as several smaller countries have done (for example, Costa Rica and Fiji).

Figure 3.1: Scale of Country Programs



3.2 Forest Definition

In REDD+, only lands that are covered with forests are considered for quantifying emissions and removals. The definition of what counts as "forest" is therefore fundamental. The FCPF Methodological Framework requires aligning with the definitions used in other contexts, notably for reporting to the UNFCCC and to the United Nations Food and Agriculture Organization (FAO).⁹

Typically, "forest" is defined in terms of a set of minimum parameters for canopy cover, area, and achievable tree height in situ. The FAO lays out common ranges for these values: canopy cover 10-30 percent, area 0.1-1 hectares, tree height 2-5 meters.¹⁰ Threshold canopy cover and minimum area are especially important because these properties can be observed in satellite imagery, which plays an important role in carbon quantification.

⁷ See below for relevant indicators in the FCPF Methodological Framework.

⁸ FCPF Methodological Framework indicator 2.1: "The Accounting Area is of significant scale and aligns with one or more jurisdictions; or a national-government-designated area (e.g., ecoregion) or areas."

⁹ FCPF Methodological Framework indicator 12.1: "The definition of forest used in the construction of the Reference Level is specified. If there is a difference between the definition of forest used in the national greenhouse gas inventory or in reporting to other international organizations (including a Forest Reference Emission Level or Forest Reference Level to the UNFCCC) and the definition used in the construction of the Reference Level, then the ER Program explains how and why the forest definition used in the Reference Level was chosen."

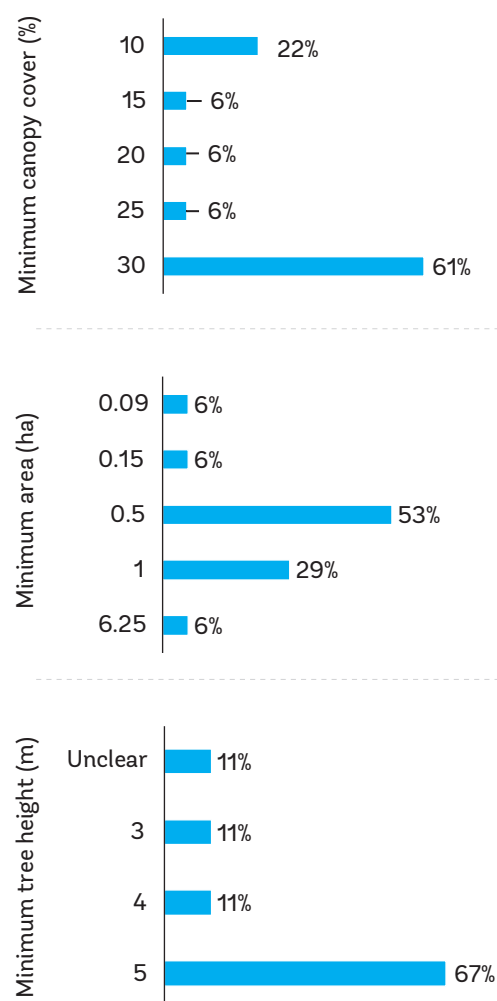
¹⁰ <http://www.fao.org/3/ap862e/ap862e00.pdf>.

For defining forests, most country programs choose the maximum crown cover value: 30 percent (Figure 3.2). Because reducing forest cover below this value will count as deforestation, using a lower threshold will potentially reduce the amount of observed deforestation.

Similarly, many countries choose large minimum area values of 0.5 or 1 hectare. Using these values, observed forest cover loss in smaller patches would be observed as forest degradation rather than deforestation.

Thresholds for forest definitions are not always translated one-to-one into measurements taken for carbon quantification. This is often because data with the necessary granularity are not available. Such discrepancies introduce error, but since they are caused by data limitations, these errors are often unavoidable.

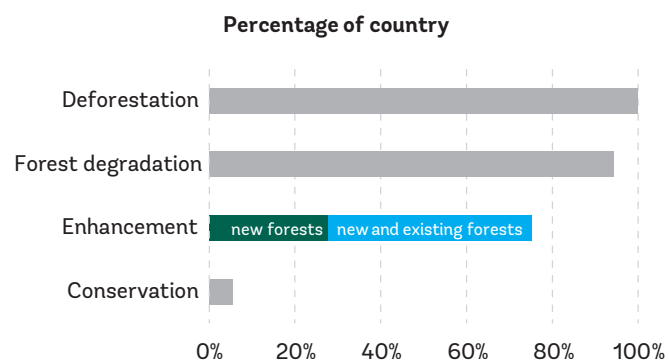
Figure 3.2: Forest Definitional Values in Country Programs



3.3 REDD+ Activities

Deforestation is widely considered the most significant source of emissions from forests and land use, and thus including deforestation is mandatory under the FCPF Methodological Framework.¹¹ Therefore, all Carbon Fund country programs include emissions from deforestation in their scope (Figure 3.3).

Figure 3.3: Country Programs Selection of REDD+ Activities



Methodological challenges in measuring emissions from forest degradation (Section 5.2) have prompted two out of three countries to exclude these emissions from their UNFCCC submissions (Section 3.6). Nevertheless, the FCPF Methodological Framework requires forest degradation to be included if the emissions from forest degradation are more than 10 percent of the total forest-related emissions.¹² As a result, almost all Carbon Fund country programs include forest degradation in the program scope as well, contributing significantly to the overall emissions considered (Figure 3.4).



¹¹ FCPF Methodological Framework indicators 3.2: "The ER Program accounts for emissions from deforestation."

¹² FCPF Methodological Framework indicators 3.3: "Emissions from forest degradation are accounted for where such emissions are more than 10% of total forest-related emissions in the Accounting Area, during the Reference Period and during the Term of the ERPA. These emissions are estimated using the best available data (including proxy activities or data)."

Figure 3.4: Annual Historical Emissions and Removals for Different REDD+ Activities

Sum of annual historical emissions / removals for the REDD+ activities across all country programs



Similar methodological challenges to tracking forest degradation apply to measuring carbon removals from enhancement of carbon stocks¹³ (Section 5.3). Nonetheless, and although there is no formal requirement in the FCPF Methodological

Framework, one out of three country programs includes enhancement of carbon stocks from existing forests and two out of three country programs include enhancement of carbon stocks from new forests (see the case of Peru in Box 3.1).

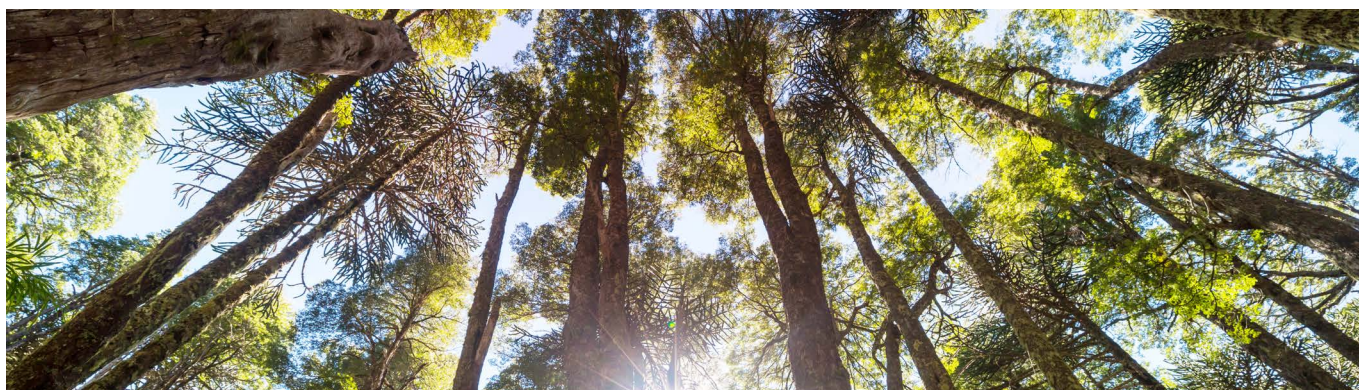
¹³ Enhancement of carbon stocks occurs in both existing forests and new forests. Existing forests have the potential to accumulate carbon when they are left undisturbed, especially as degraded forests recover. New forests grow due to natural recovery, for example, on fallowed agricultural areas. They also grow as a result of tree planting.

Box 3.1: Scope of REDD+ Activities in Peru’s Jurisdictional Program

In 2019, Peru proposed a program to the Carbon Fund for *Reducing Emissions from San Martín and Ucayali in the Peruvian Amazon, Peru*. Together, these two regions make up just under one-fifth of the Peruvian Amazon.

The scope of the program was selected following the requirements of the FCPF Methodological Framework. Accordingly, deforestation was included, which generated emissions of 23.9 MtCO₂e/year during the reference period. Forest degradation was also significant, with emissions of 9.8 MtCO₂e/year during the reference period, and thus also had to be included. The other REDD+ activities were not covered because of a lack of data, and the fact that including them is optional according to the FCPF Methodological Framework.

The country submitted a forest reference (emission) level to the UNFCCC in 2016 for all of its Amazon biome. Deforestation was the only REDD+ activity included. The submission explained that forest degradation and the other REDD+ activities were excluded, citing the quality of data and information currently available. As part of the submission to the Carbon Fund, Peru included an annex to the ERPD describing a quantification approach that was still under development (see Peru’s quantification approach annex). The Carbon Fund requested that Peru update the ERPD accordingly—and the same approach is also being tested for the UNFCCC forest reference (emission) level.

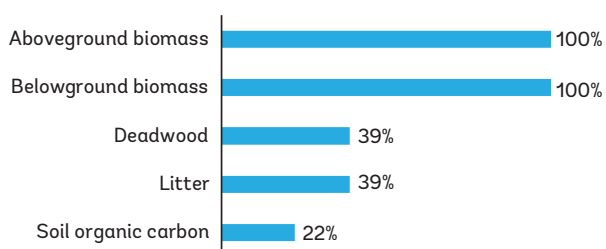


3.4 Carbon Pools

All of the country programs quantify emissions and removals in living biomass of trees, both above ground and below ground. In most ecosystems, this is where the bulk of carbon is stored. About half of the programs also include estimates of carbon in deadwood and litter, and a few countries have made the effort to include soil organic carbon (Figure 3.5).

The FCPF Methodological Framework requires programs to account for all significant carbon pools, except where their exclusion would underestimate total emission reductions.¹⁴ Deadwood and litter can often be excluded because they are not significant, although including them can be methodologically straightforward if the right data are available. Including soil organic carbon, on the other hand, is more demanding both methodologically and also with regard to developing the necessary data. This pool is therefore often excluded because country programs can demonstrate that the exclusion would underestimate total emission reductions.

Figure 3.5: Country Programs' Selection of Carbon Pools



3.5 Greenhouse Gases

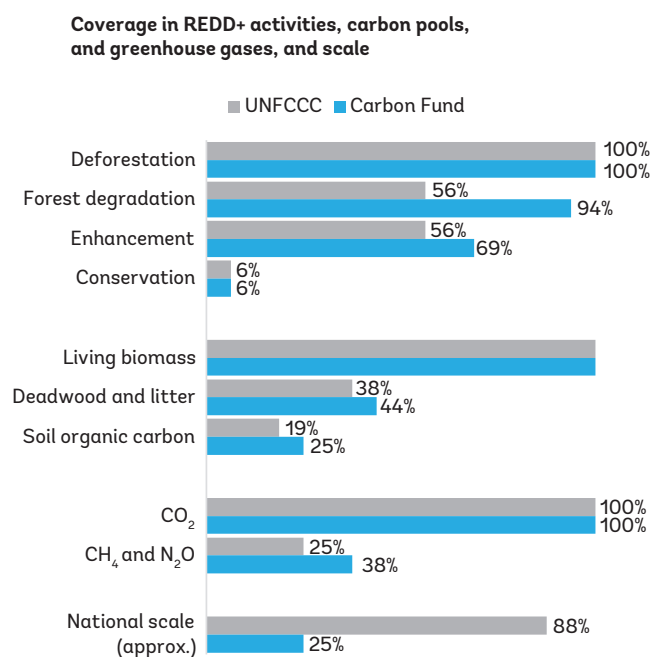
All country programs estimate emissions and removals in carbon dioxide, and 7 out of 18 also track other greenhouse gases. Given that forests store carbon in their biomass, the bulk of emission reductions is expected from carbon dioxide. However, where biomass burns or where organic soils decompose, emission of methane and nitrous oxide can also occur, but the amounts of emissions are not usually of a comparable scale to carbon dioxide.

3.6 Scope and Scale in Jurisdictional Programs and National REDD+ Programs

Most countries that develop jurisdictional programs for the Carbon Fund also report to the UNFCCC on their REDD+ efforts. Among the 18 countries included in the Carbon Fund portfolio, 16 have also submitted forest reference (emission) levels to the UNFCCC.¹⁵ Some countries closely align both processes (for example, Vietnam and Costa Rica), while in other countries, carbon quantification for the UNFCCC submissions and for the Carbon Fund are undertaken separately (for example, the Democratic Republic of Congo and Republic of Congo). The FCPF Methodological Framework requires countries to consider how both processes relate to each other and to make use of any synergies.¹⁶

The most obvious difference between submissions to the UNFCCC and those to the FCPF is the difference in scale (Figure 3.6): Four out of five countries submit national-scale reference levels to the UNFCCC, but almost all Carbon Fund submissions cover smaller jurisdictions.

Figure 3.6: Scope and Scale of REDD+ in Countries That Have Made Submissions Both to the UNFCCC and to the Carbon Fund



Note: The information in this graph is provided for countries that have submitted both a Forest Level Emission Level (FREL) to the UNFCCC and an ERPD to the Carbon Fund. Not all Carbon Fund countries had submitted a FREL to the UNFCCC at the time of this report, and therefore this figure represents a subset of the countries in the Carbon Fund portfolio.

14 FCPF Methodological Framework Indicator 4.1 states: "The ER Program accounts for all Carbon Pools and greenhouse gases that are significant within the Accounting Area, both for Reference Level setting and Measurement, Monitoring and reporting (MMR)." Also, Indicator 4.2 states: "Carbon Pools and greenhouse gases may be excluded if: (i) Emissions associated with excluded Carbon Pools and greenhouse gases are collectively estimated to amount to less than 10% of total forest-related emissions in the Accounting Area during the Reference Period; or (ii) The ER Program can demonstrate that excluding such Carbon Pools and greenhouse gases would underestimate total emission reductions."

15 <http://www.fao.org/3/ca6031en/ca6031en.pdf>.

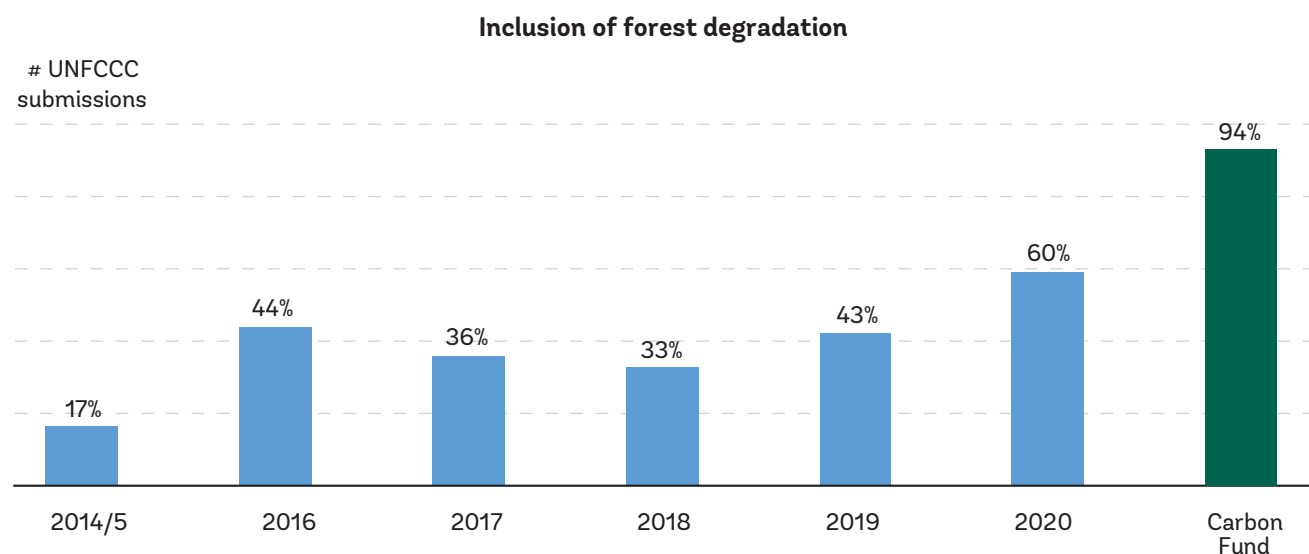
16 FCPF Methodological Framework criteria 10 and 15: "The development of the Reference Level is informed by the development of a Forest Reference Emission Level or Forest Reference Level for the UNFCCC." "ER Programs apply technical specifications of the National Forest Monitoring System where possible."

It is also common for UNFCCC submissions to cover only a subset of REDD+ activities, carbon pools, and greenhouse gases, while the programs for the Carbon Fund require more complete coverage. The FCPF Methodological Framework only allows exclusions if the exclusion is insignificant or conservative, that is, likely to lead to underestimating emission reductions.

Because of the difference in requirements, the programs for the Carbon Fund have a more complete scope than the same countries' UNFCCC submissions in terms of REDD+ activities, carbon pools, and greenhouse gases. About half of UNFCCC submissions include only deforestation, while almost all Carbon Fund submissions include forest degradation as well. Moreover, two-thirds of FCPF submissions included carbon stock enhancements. Although less pronounced, the scope of Carbon Fund submissions is also slightly more complete for carbon pools and greenhouse gases.

Many countries choose to only account for deforestation when reporting to the UNFCCC, arguably because quantifying emissions from forest degradation and carbon stock enhancements is challenging methodologically (Section 5.2, Section 5.3). Participation in the Carbon Fund provides countries the means to dedicate additional efforts to testing approaches at the scale of a jurisdiction. This suggests that there may be an opportunity in the future to integrate lessons learned by the jurisdictional programs into the national REDD+ program—in line with the stepwise approach under the UNFCCC. Over the last few years, the number of countries including forest degradation in their UNFCCC submissions has grown, indicating some convergence with the high standard set by the Carbon Fund (Figure 3.7).

Figure 3.7: Inclusion of Forest Degradation in Forest Reference (Emission) Level Submissions to the UNFCCC Compared with the Carbon Fund



4. CONSTRUCTION OF REFERENCE LEVELS

In constructing reference levels, countries are bound by the provisions of the FCPF Methodological Framework. Accordingly, reference periods usually span about 10 years. The reference level is based on the historical average of emissions during the reference period. Adjustments above (or below) that average are allowed, but only in special cases and where there is justification for doing so.

For their UNFCCC submissions, countries have greater flexibility in constructing their reference

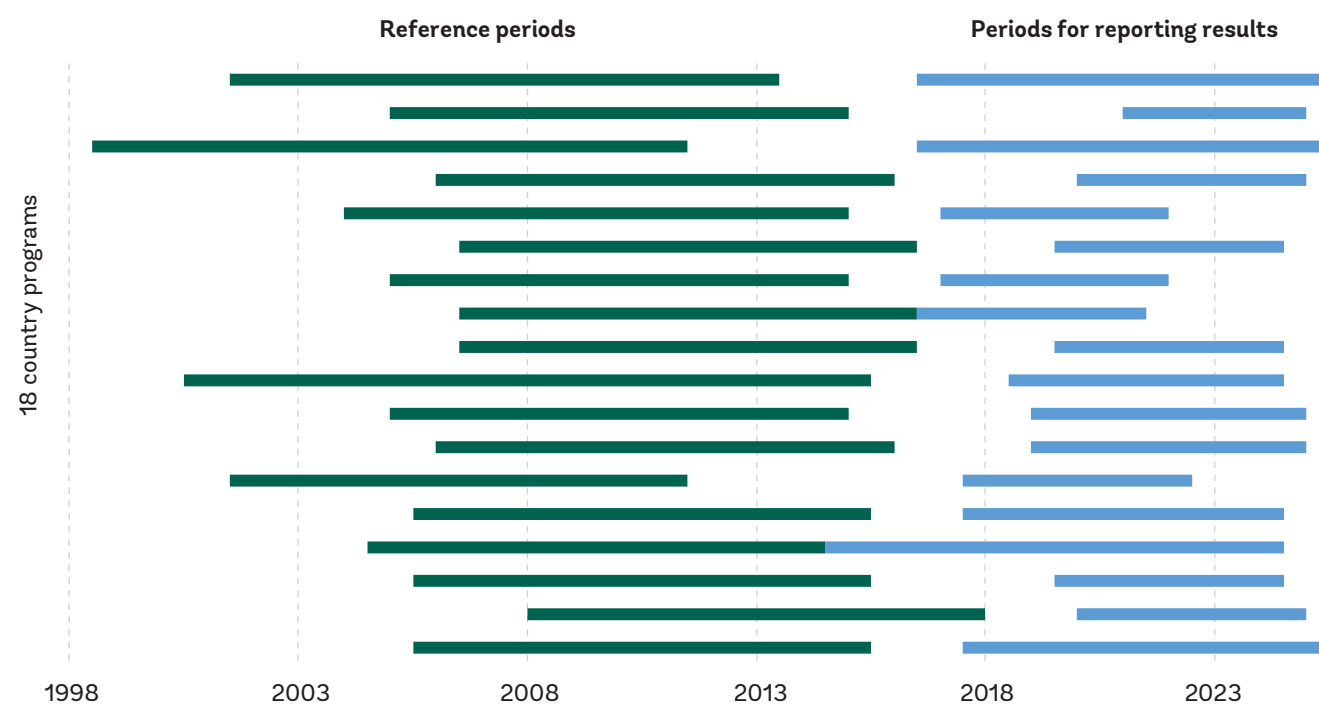
levels, and thus opt for a wider range of choices.

4.1 Reference Periods

Most country programs chose a 10-year period to establish their reference level.¹⁷ Since most of the country programs were submitted to the Carbon Fund portfolio during 2016-2018, and historical data had to be fully vetted at that point, the reference periods usually end 2014-2016 (Figure 4.1).

¹⁷ FCPF Methodological Framework indicator 11.2: "The start-date for the Reference Period is about 10 years before the end-date. [...]"

Figure 4.1: Reference Periods and Periods for Reporting Results in Country Programs



Note: x-axis labels refer to January 1st of years shown; some countries did not specify expected start dates of reporting results.

4.2 Historical Averages and Adjustments

By and large, country programs use the historical average of emissions to establish their reference levels. The FCPF Methodological Framework prescribes this approach for reference level construction in most cases.¹⁸ Only countries with high forest cover where the long-term historical deforestation has been minimal (so-called high-forest cover, low-deforestation [HFLD] countries) can include an upward adjustment to these

average annual historical emissions based on specific circumstances.¹⁹ Only two countries out of the 18 in the portfolio have demonstrated that they qualify as HFLD countries and have proposed reference levels that exceed the historical average emissions (the Republic of Congo and Democratic Republic of Congo). Even in this situation, the FCPF Methodological Framework limits the size of the adjustment.²⁰ (See the case of the Democratic Republic of Congo in Box 4.1).

¹⁸ FCPF Methodological Framework criterion 13: "The Reference Level does not exceed the average annual historical emissions over the Reference Period. For a limited set of ER Programs, the Reference Level may be adjusted upward by a limited amount above average annual historical emissions."

¹⁹ FCPF Methodological Framework indicator 13.2: "National circumstances have changed such that rates of deforestation and forest degradation during the historical Reference Period likely underestimate future rates of deforestation and forest degradation during the Crediting Period."

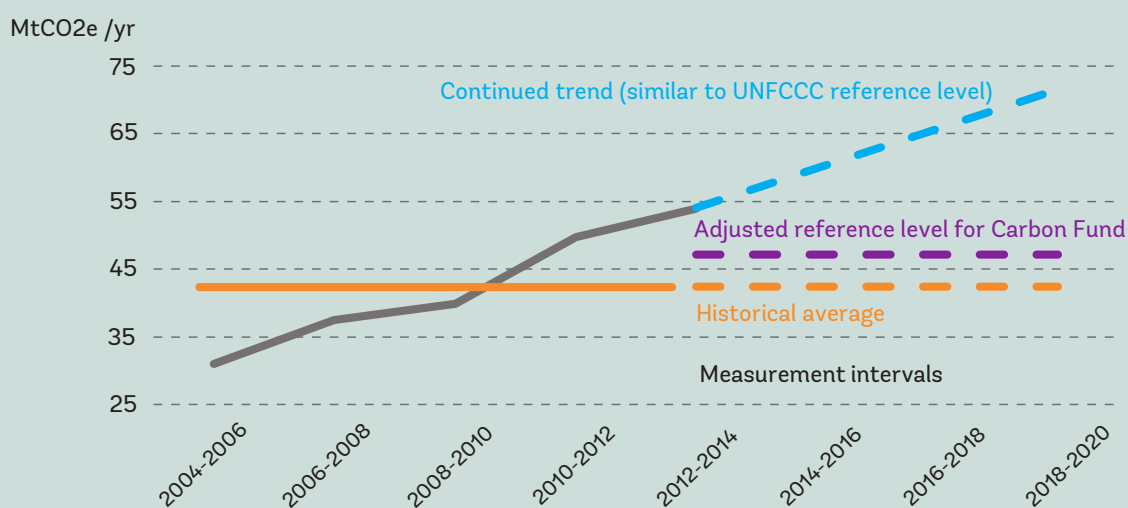
²⁰ FCPF Methodological Framework indicator 13.4: "An adjustment of the Reference Level above the average annual historical emissions during the Reference Period may not exceed 0.1%/year of Carbon Stocks."

Box 4.1: The Democratic Republic of Congo's Adjustment of the Reference Level above Historical Average Emissions

In 2016, the Democratic Republic of Congo's Mai-Ndombe Emission Reductions Program was accepted into the Carbon Fund pipeline. It is one of only two country programs that adjusted their reference level above historical average emissions.

Following the requirements of the FCPF Methodological Framework, the country program stated that the Democratic Republic of Congo had high forest cover and low deforestation (HFLD), which is a precondition for adjusting the reference level above the historical average. Accordingly, the country had a forest cover of approximately 152 million hectares in 2010 and an annual deforestation rate of approximately 0.30 percent between 1990 and 2010. The reference level was capped at 0.1 percent of carbon stocks, following the requirements of the FCPF Methodological Framework.

Figure B4.1.1: Options for Setting the Reference Level of the Democratic Republic of Congo's Country Program

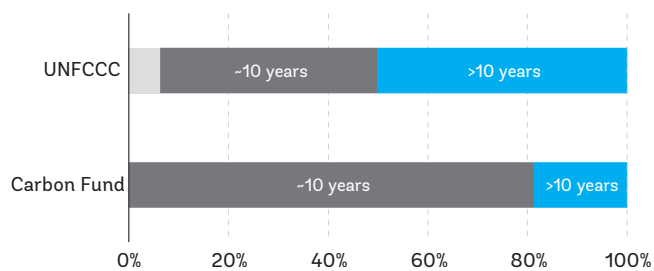


In its submissions to the UNFCCC in 2018, the country also opted for a forest reference (emission) level that exceeded historical average emissions (Figure B4.1.1). In that case, the national-scale reference level was built through projecting the historical emissions trends and was free of the cap that the jurisdictional program had to apply when following the FCPF Methodological Framework. Thus, the FCPF reference level is significantly more conservative than the UNFCCC one.

4.3 Construction of Reference Levels in Jurisdictional Programs and National REDD+ Programs

Countries have aligned the two processes and the resulting reference levels in ERPDs and UNFCCC submissions to varying degrees. Among the 18 country programs included in the Carbon Fund portfolio, 16 have also submitted forest reference (emission) levels to the UNFCCC (Section 3.6). When making submissions to the Carbon Fund, countries are required, in accordance with the FCPF Methodological Framework, to use a reference period of approximately 10 years, and only a few country programs have reference periods that are longer. The Warsaw Framework does not include guidance on choosing the reference period. Perhaps as a consequence, less than half of the countries choose a 10-year reference period, and longer periods are common in UNFCCC submissions (Figure 4.2).

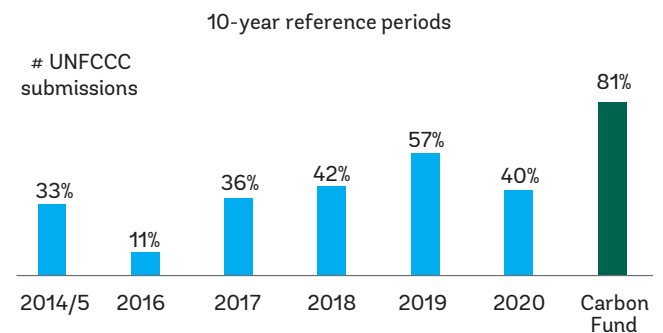
Figure 4.2: Percentage of Countries That Used a Particular Time Period for the Reference Period in Their Submissions to the UNFCCC and to the Carbon Fund



Note: Most recent UNFCCC submissions were used for this comparison, which may still be under technical assessment.

Over the past few years, there has been only a weak trend toward an increased use of 10-year reference periods in UNFCCC submissions (Figure 4.3).

Figure 4.3: Trends in Forest Reference (Emission) Level Submissions to the UNFCCC and to the Carbon Fund – Use of Approximate 10-year Reference Periods



Note: Most recent UNFCCC submissions were used for this comparison, which may still be under technical assessment.

Most countries in the Carbon Fund portfolio calculate their reference levels from historical average emissions alone in their submission both to the UNFCCC and to the Carbon Fund. Peru built a reference level off of historical average emissions when submitting to the Carbon Fund, but it proposed an upward adjustment in the submission to the UNFCCC. For Indonesia, a similar approach was used in the Carbon Fund and in the submission to the UNFCCC for projecting an increasing trend in historical emissions from peatland decomposition. However, this approach was looked at differently by the Carbon Fund, which considered it as an adjustment, and the UNFCCC, which considered it as a simple historical average.



5. APPROACHES AND DATA SETS

Countries use a set of typical approaches and data sets for measuring emissions and emission reductions for the Carbon Fund. The FCPF Methodological Framework requires countries to follow the guidance of the Intergovernmental Panel on Climate Change (IPCC),²¹ which broadly lays out available methods for estimating emissions.

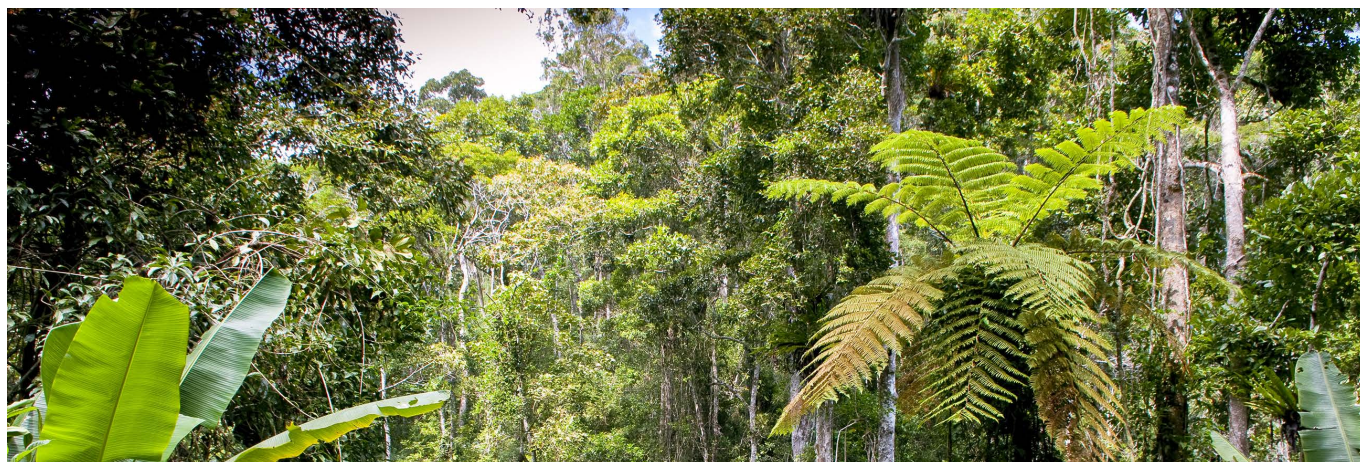
Countries use the same IPCC guidance when reporting to the UNFCCC, and therefore the broad approaches and data sets in country reports to the UNFCCC and to the Carbon Fund are similar. There are, however, some differences where country programs in the Carbon Fund have piloted specific approaches (See the case of Madagascar in Box 5.1)

Box 5.1: How Madagascar's Country Program Piloted Forest Monitoring for the National Forest Monitoring System

Madagascar's REDD+ process started shortly after the Bali Action Plan put REDD+ on the international agenda. The country submitted a Readiness Project Idea Note in 2008. During the following years, work was undertaken in the context of an FCPF-supported jurisdictional country program, the Atiala Atsinanana Emission Reductions Program. Subsequently, in 2018, the country adopted its REDD+ strategy.

An approach to carbon quantification was first tested in the Atiala Atsinanana Emission Reductions Program before rollout at the national level. While Madagascar's first forest reference (emission) level submission to the UNFCCC from early 2017 still relied on comparing maps for measuring deforestation area, the FCPF program had already tested a more advanced approach, incorporating a sample-based method, for the subnational jurisdiction. This approach later was adopted at the national level and became part of the national forest monitoring system. In 2018, Madagascar submitted an updated forest reference (emission) level to the UNFCCC that utilized these methodological improvements.

It was efficient to pilot quantification approaches at the subnational level and then scale methods up. In addition, this also ensured that both reference levels fully aligned with each other because the jurisdictional activity data are a subset of the activity data in the latest UNFCCC submission.



²¹ FCPF Methodological Framework criterion 5: "The ER Program uses the most recent Intergovernmental Panel on Climate Change (IPCC) guidance and guidelines, as adopted or encouraged by the Conference of the Parties as a basis for estimating forest-related greenhouse gas emissions by sources and removals by sinks."

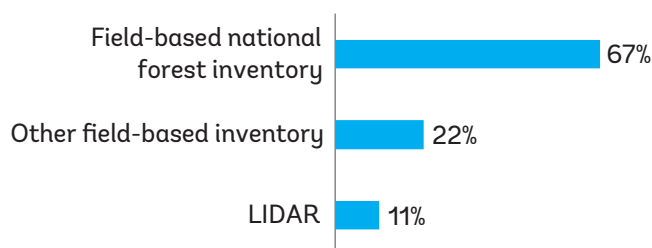
5.1 Emissions from Deforestation

All Carbon Fund country programs estimate emissions from deforestation (Section 3.3). For the most part, they estimate emissions from deforestation using the same commonly accepted approach that relies on a set of activity data and emission factors.²² Accordingly, country programs need to estimate the area deforested (activity data) and the amount of biomass lost during deforestation (emission factors).

About two out of 10 country programs estimate the activity data using maps. Typically, the maps are based on a semiautomated change analysis of medium-resolution satellite imagery, leading to a representation of forest versus nonforest areas, and any changes. These maps are usually simple and thematically distinguish only a few types of land use, which helps increase their accuracy. Some countries have used existing map-based cadastres rather than generating new maps specifically for REDD+ (for example, Chile). More than three-quarters of country programs have opted to estimate deforestation using sample-based methods, 64 percent of which use a stratified random sampling approach that include the maps for stratification purposes and 36 percent of which use systematic or simple random sampling. In these cases, a variety of available reference data sets support visual identification of land-use change within sample plots, which are then used to estimate deforestation across the total area. Some countries use map-based methods for calculating activity data but use sampling for accuracy assessments.²³

Once deforestation areas are established, biomass stocks in deforestation areas are the basis for estimating emission factors. Some countries, for example Vietnam and Chile, have access to data on biomass stocks from national forest inventories: large-scale campaigns where hundreds, if not thousands, of sample plots are measured in the field (Figure 5.1). Where such data do not exist, any other field inventories can provide a basis for estimating biomass stocks (for example, Madagascar and Mozambique). Only a few countries used advanced remote-sensing approaches for directly estimating biomass, notably through Light Detection and Ranging (LIDAR)²⁴ (for example, the Democratic Republic of Congo and Republic of Congo).

Figure 5.1: Approaches for Measuring Biomass Stocks

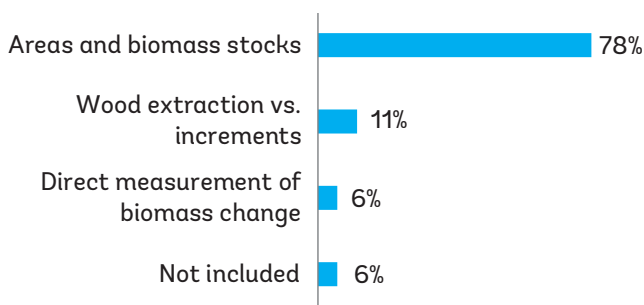


5.2 Emissions from Forest Degradation

Measuring emissions from forest degradation is often seen as difficult;²⁵ nevertheless, almost all country programs report on emissions from forest degradation.

From a methodological perspective, the programs can be grouped according to three principal approaches for estimating emissions from forest degradation (Figure 5.2). About half of the country programs estimate emissions from forest degradation by identifying indicators of degradation (such as crown cover) in satellite imagery and associated biomass loss in the field. A smaller group of country programs estimate emissions from degradation by estimating the balance of wood extraction and regrowth. This method draws on logging statistics, on models of fuelwood use, and on broad average increment factors. Only a few country programs directly estimate changes in biomass stocks through remeasurement of permanent sample plots.

Figure 5.2: Approaches for Estimating Emissions from Forest Degradation



All approaches present methodological challenges (Table 5.1). When identifying forest degradation in satellite imagery, uncertainties can be substantial and easily underestimated. When relying on wood extraction statistics and increments, there could be

²² This approach and its application to REDD+ is discussed in guidance documentation. See: <https://www.reddcompass.org/download-the-mgd>.

²³ <http://www.fao.org/3/ca6031en/ca6031en.pdf> and <https://www.reddcompass.org/download-the-mgd>.

²⁴ LIDAR uses light in the form of a pulsed laser to measure ranges. This enables mapping the vertical structures of the canopy and generating information on vegetation height.

²⁵ See discussion in <http://www.fao.org/3/ca6031en/ca6031en.pdf>.

bias that would be difficult to correct for, in addition to substantial random error. Although direct estimation of changes through permanent sample plots seems the most promising approach

methodologically, only a few countries maintain networks (which are costly) of permanent sample plots. Where they do, the amount of data outputs can be large, which can make them difficult to use.

Table 5.1: Three Principal Approaches for Estimating Emissions from Forest Degradation

Estimation Approach	Activity Data	Emission Factors	Challenges
Quantification of forest degradation area correlated against biomass stock differences, (for example, DRC)	For area estimation, degradation indicators vary, and various approaches are used (sampling satellite imagery, maps, and distance-based measures).	Forest biomass changes upon degradation, usually from field observation. Biomass stocks are correlated against the same degradation indicator.	Uncertainties can be substantial and easily underestimated.
Estimates of gains and losses in forest biomass from the balance of wood extraction and increments, (for example, Fiji)	For losses, statistics on logging and fuelwood collection. For gains, the areas of forest.	For losses, a range of expansion factors, notably for logging damage, wood densities, and biomass expansion. For gains, increment rates.	Quality of logging statistics could be variable. Increment rates are hard to establish. Substantial systematic error usually will not be estimated.
Direct estimation of changes in biomass stocks (for example, Chile)	The stock-change method relies on directly estimating changes in biomass stocks through remeasurement of permanent sample plots.		Collecting data from networks of permanent sample plots is costly. The data will only reflect multiyear time intervals.

There is a great deal of variety within these principal approaches. Notably, there are considerably different ways in which country programs rely on measuring forest degradation areas and correlating these with field-based observations of biomass loss. The most common ways country programs have done this include

- Sample-based visual detection of crown-cover reduction in satellite imagery (for example, the Democratic Republic of Congo);
- Automated classification of satellite imagery to identify degraded forest areas (for example, Republic of Congo); and
- Identification of forest strata more likely to be degraded based on distance to the forest boundary or infrastructure (for example, Nepal, Peru, and Madagascar).

The FCPF Methodological Framework also permits the used of “proxy-based approaches” and “proxy activities or data” for measuring emissions from forest degradation. Several country programs that quantify emissions from forest degradation through satellite imagery correlated with biomass loss refer to the use of “canopy-cover proxies” for the detection of crown-cover reduction. Other countries employ an indirect proxy-based method where the estimation of forest degradation is based on data such as wood extraction and increments. Some country programs have adjusted their approach based on lessons learned and feedback received from the Carbon Fund (see also the case of Ghana in Box 5.2).

Box 5.2: Ghana's Improvements to Activity Data in Response to a Request for Technical Correction

The Ghana Cocoa Forest REDD+ Program was included in the Carbon Fund portfolio in June 2017 on the condition that its deforestation and degradation assessment would be improved. Ghana then proceeded to carry out technical corrections to its activity data and reference level.

The technical corrections were comprehensive, especially regarding activity data. First, the 2017 submission estimated deforestation area based on a time series of forest or land-use change maps. An updated methodology introduced a direct change assessment to reduce classification errors. Second, the 2017 submission estimated forest degradation emissions from proxy data (notably timber extraction statistics), which raised the concern of possible double counting with the spatially explicit deforestation estimate. For the improvement of forest degradation data as well, a spatially explicit analysis was performed using dense time series analysis. Third, the original area estimates for carbon stock enhancement were based on potentially unreliable planting statistics. A dense time series analysis was applied to detect increases in canopy cover through remote sensing.

In early 2020, Ghana was finalizing a range of updates to its activity data and historical emission estimates. The reference level will be recalculated accordingly and become the basis for measuring emission reductions.

5.3 Removals from Enhancement of Carbon Stocks

Most country programs include not only emissions but also removals in their scope. As many as two out of three country programs included carbon stock enhancements in addition to emissions from deforestation and forest degradation (Section 3.3).

For the REDD+ activity "enhancement of carbon stocks," country programs refer to two types of removals: from new forests and from existing forests. New forests can grow as a result of deliberate planting activity (for example, Costa Rica and Ghana) or as a result of natural regeneration (for example, Nicaragua). Carbon stock enhancement in existing forests can occur when secondary or degraded forests recover or when plantations mature (for example, Vietnam and Fiji).

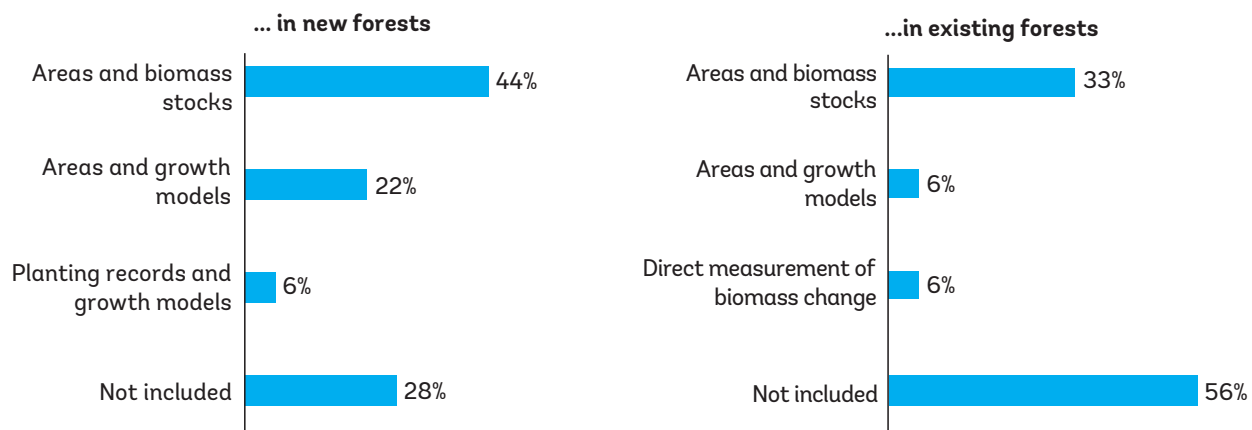
As is the case with forest degradation (Section 5.2), there is also a set of (closely related) approaches for quantifying removals from carbon stock enhancement (Figure 5.3):

- Measurement of regrowth of forest area correlated against biomass stocks (for example, Lao PDR and the Democratic Republic of Congo): This approach is analogous to the most common approach for quantifying emissions from forest degradation. In this case, rather than using losses in crown cover and biomass, crown cover gains are detected and associated with the

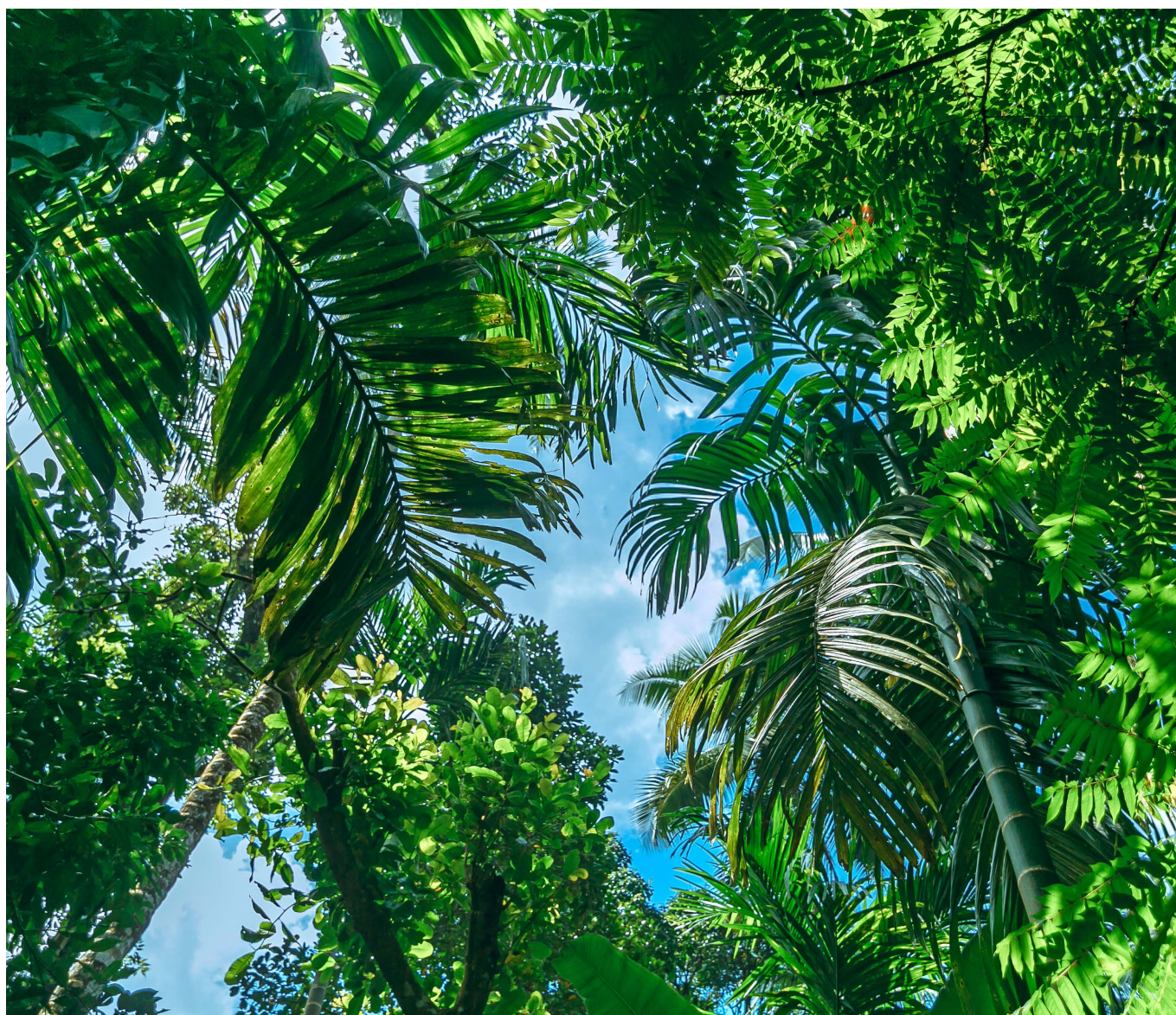
gains in biomass. Methodological challenges are similar, although gains tend to be even harder to estimate reliably than losses because they are more gradual and therefore harder to detect through remote sensing.

- Area records and growth models: For its activity data, this approach draws on records of planting (for example, Ghana), records of forest use (for example, Fiji), or direct measurement (for example, Nicaragua) to establish areas where enhancement of carbon stocks occurs. Growth models provide emission factors as mean annual increments in the simplest case. For the activity data, methodological challenges include bias from imperfect activity records, and variability in survival rates. For the emission factors, increment rates are hard to establish because of difficulties in building and validating growth models that would accurately reflect increment rates and resulting removals.
- Direct estimation of changes in biomass stocks (for example, Chile): This approach relies on remeasurement of permanent sample plots to detect both losses (forest degradation) and gains (enhancements). Methodological challenges also apply in the same way.

Figure 5.3: Approaches for Measuring Removals from Carbon Stock Enhancements



Most country programs that estimate removals from carbon stock enhancements do this by expanding the approaches used for measuring emissions from forest degradation. About half of all countries include removals by measuring enhancement areas and correlating these with biomass gains. Only a few country programs use alternative approaches: either drawing on direct estimation of biomass changes (for example, Chile) or on planting records and growth models.



6. UNCERTAINTIES

The FCPF Methodological Framework requires that programs identify and assess sources of uncertainty in their estimates, minimize the uncertainty where feasible and cost effective, and quantify the remaining uncertainty.²⁶ Through the use of discounts, programs are incentivized to reduce uncertainties associated with their carbon quantification approaches. As a consequence, Carbon Fund programs have paid close attention to estimating and reducing uncertainties, with all country programs reporting uncertainties for activity data, emission factors, and resulting emissions and removals.

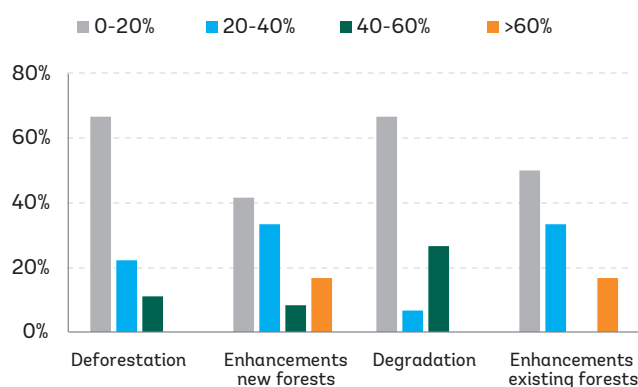
6.1 Activity Data

In estimating changes in forests, uncertainties depend on the types of change (Figure 6.1). Most country programs report uncertainties associated with deforestation to be less than 20 percent. Uncertainties associated with enhancements in new forests are higher, at 10-40 percent. Uncertainties in estimating changes within forests, for example, as a result of degradation or enhancements in existing forests, are on average at about 30 percent.²⁷



Figure 6.1: Uncertainty in Area Estimation

Percentage of countries that have reported that the uncertainty associated with a specific area change falls within the specified range



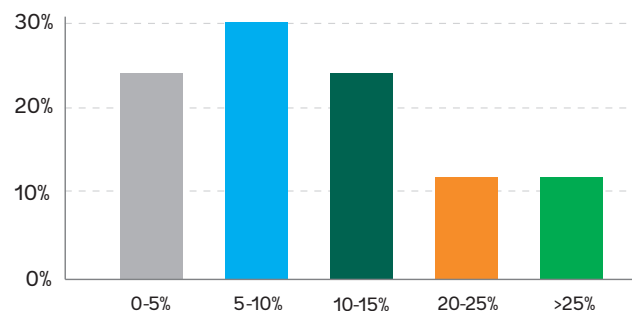
Note: Countries report on diverse forest categories, requiring aggregation to enable comparison.

6.2 Forest Carbon

In estimating forest carbon stocks, country programs in most cases report uncertainties below 15 percent (Figure 6.2). Some country programs report being able to estimate forest carbon with rather low levels of uncertainty (that is, less than 5 percent of the mean).

Figure 6.2 Uncertainty in Carbon Stocks Estimation

Percentage of country programs with uncertainty in estimating forest carbon in the specific range



Note: Countries report on diverse forest categories, requiring aggregation to enable comparison.

²⁶ FCPF Methodological Framework criteria 7 and 9, inter alia: "Sources of uncertainty are systematically identified and assessed in Reference Level setting and Measurement, Monitoring and reporting."
²⁷ "Uncertainty of activity data and emission factors used in Reference Level setting and Measurement, Monitoring and reporting is quantified in a consistent way, so that the estimation of emissions, removals and Emission Reductions is comparable among ER Programs."

²⁷ Some countries have chosen not to report this type of uncertainty and instead used a maximum conservativeness discount.

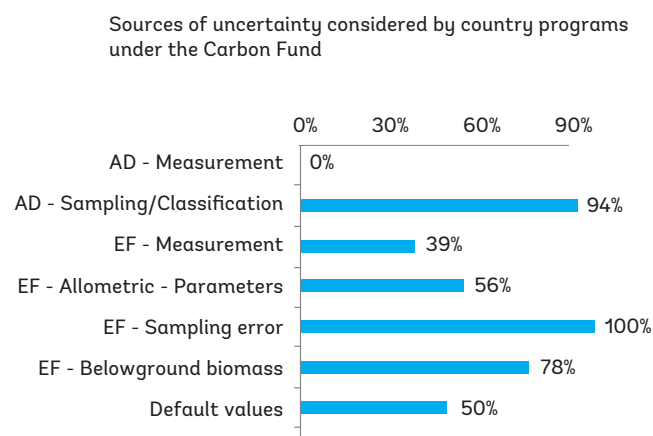
In most cases, carbon stocks estimates are less uncertain than area estimates. The methods used for national forest inventories have, with some variation, been used since the onset of organized forest management and therefore are very well understood. However, resources necessary for such inventories are substantial. Only a few countries conduct regular national forest inventories, and there are several countries where the FCPF technical assistance was used to perform the first forest inventory in many years.

6.3 Emissions and Emission Reductions

Uncertainties in quantifying emissions combine the uncertainties in estimating the underlying forest area and carbon inputs used for estimating emissions. Generally, the two main approaches for the estimation of combined uncertainties are (i) the use of error propagation equations or (ii) the use of a Monte Carlo simulation or similar techniques.²⁸ About 50 percent of the country programs use error propagation equations for quantifying uncertainties associated with emissions. One in three use Monte Carlo analysis, with the remaining countries using a mix of both approaches.

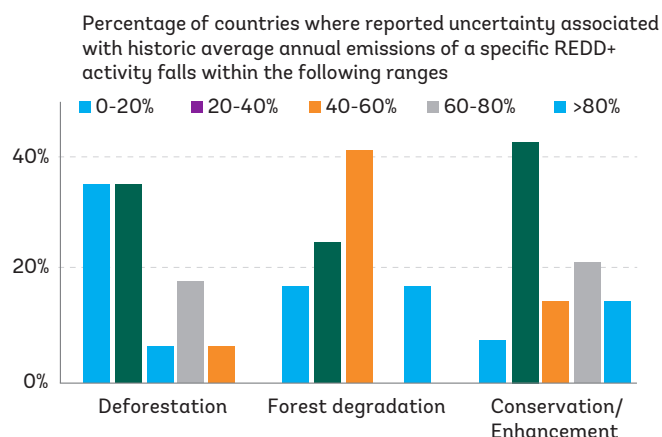
Variation exists also in the sources of uncertainty that are considered or propagated to quantify the overall uncertainty (Figure 6.3). Although all countries have identified and discussed the main sources of uncertainty identified in the 2006 IPCC Guidelines (that is, measurement error, statistical sampling error, and model error relative to both area estimates and carbon stocks), only a few of these have been quantified and propagated. Programs have mostly quantified and propagated the sampling error of both area estimates and carbon stocks, and the error associated with root-to-shoot ratios. Measurement errors (for example, errors in measuring “diameter at breast height” [DBH] or the height of a single tree) in general have not been quantified and propagated, and they have instead been assumed to be zero because they have been addressed through QA/QC procedures. One reason for not considering this source of error might be the technical difficulty and complexities of quantifying and propagating these sources because this would require a Monte Carlo analysis or similar numerical simulations.

Figure 6.3: Sources of Uncertainty Considered



The estimated uncertainties for emissions differ across the REDD+ activities (Figure 6.4). Almost all country programs' estimates of deforestation emissions have an uncertainty of 0-40 percent, while most emissions estimates from forest degradation have an estimated uncertainty of 40-60 percent. The uncertainty estimates for removals from enhancement of carbon stocks or conservation ranges from 20-40 percent in some country programs to exceeding 80 percent in others. The different uncertainties for the REDD+ activities mainly reflect different uncertainties in the underlying activity data (see Sections 5.1 – 5.3).

Figure 6.4: Reported Uncertainty of Historic Average

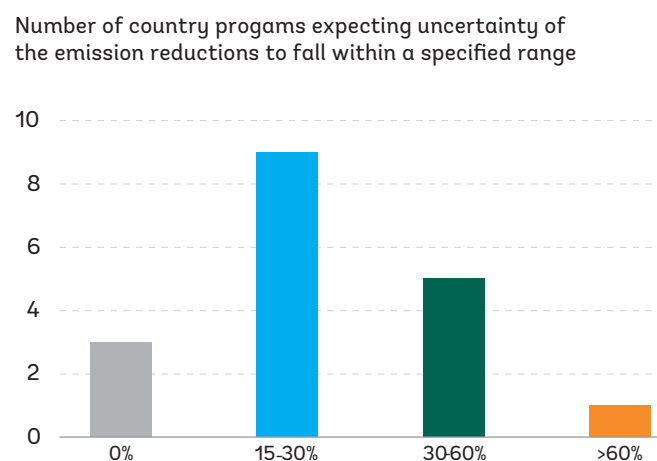


²⁸ For a description of the use of Monte Carlo simulations for propagation, refer to, for example, IPCC guidance on uncertainties (https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_3_Ch3_Uncertainties.pdf).

Once country programs begin reporting emission reductions for the purpose of accessing results-based payments, uncertainties in estimating emission reductions will become more important. While these relate closely to the uncertainties of emission estimates, estimates of emission reductions will be expected to be more uncertain.²⁹

In the Carbon Fund, country programs will be required to set aside a portion of achieved emission reductions depending on which range the uncertainties in estimating emission reductions fall in. These ranges are: (i) <15%; (ii) >15% and < 30%; (iii) >30% and <60%; (iv) >60% and <100%; and (v) >100%.³⁰ Based on the ex ante estimates, most programs expect that the uncertainty of the emission reductions will be in the 15-30 percent range (Figure 6.5). One in four cases expect the uncertainty to be in the 30-60 percent range, while several country programs expect uncertainties of less than 15 percent. Only one country program expects uncertainties to be more than 60 percent.

Figure 6.5: Expected Uncertainty of Emission Reductions in Country Programs



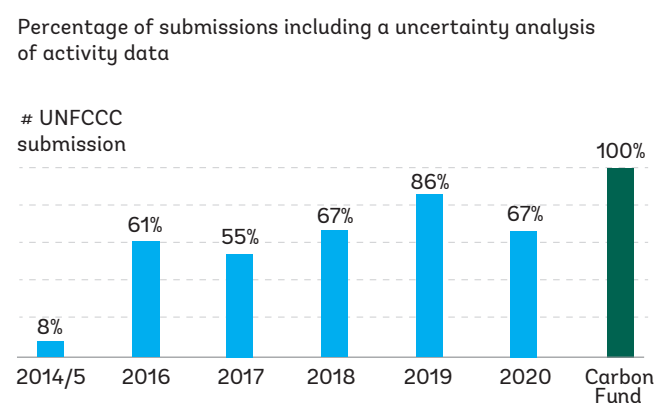
6.4 Uncertainties in Jurisdictional Programs and National REDD+ Programs

When reporting to the UNFCCC, transparency on the uncertainties involved in estimation is less of a priority than it is when reporting to the Carbon Fund. In their submissions to the Carbon Fund, all countries are required to report comprehensively

on uncertainties associated with activity data, emission factors, and historical emissions. However, in their UNFCCC submissions, only about half of these 18 countries report the uncertainty associated with estimating emissions.

Over the last few years, a growing number of REDD+ submissions to the UNFCCC have addressed uncertainties in a more comprehensive manner. For example, out of 60 submissions, only 30 (50 percent) quantified the uncertainty of the reference level, while in the past three years, three out of four of (all) forest reference (emission) levels submitted to the UNFCCC addressed uncertainties of activity data, up from only one in four for the years before that (Figure 6.6).

Figure 6.6: Trends in Forest Reference (Emission) Level Submissions to the UNFCCC and to the Carbon Fund – Uncertainty Analysis of Activity Data



Note: Most recent UNFCCC submissions were used for this comparison, which may still be under technical assessment.

However, the quantification of the reference level under the UNFCCC remains well below the Carbon Fund. Out of 60 submissions to the UNFCCC, only 30 (50 percent) quantified the uncertainty of the reference level, which contrasts with 100 percent under the UNFCCC.

In terms of sources of uncertainty considered the number of sources of uncertainty considered by UNFCCC submission remain significantly lower than for submissions under the Carbon Fund. Countries reporting under both the UNFCCC and the Carbon Fund have mostly considered the sampling error of

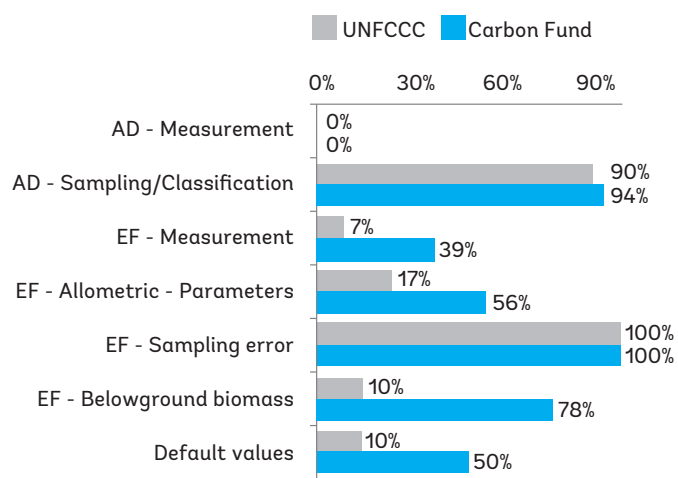
²⁹ This is because emission reductions are always smaller than baseline emissions, while the error is of a similar nature and magnitude in measuring baseline emissions and emission reductions (<http://www.fao.org/3/ap862e/ap862e00.pdf>).

³⁰ The FCPF Methodological Framework criterion 22 prescribes conservativeness factors between zero and 15 percent of emission reductions.

both activity data and emission factors, but on the other sources of uncertainty reporting of UNFCCC submission remain much lower. For instance, under the Carbon Fund more than half of countries have considered uncertainty of allometric models, belowground biomass (e.g. root-to-shoot ratios) and default values such as carbon fractions.

Figure 6.7: Sources of Uncertainty Considered by the Carbon Fund vs. the UNFCCC

Sources of uncertainty considered by UNFCCC submissions and country programs that have reported the uncertainty of their reference level



7. PERMANENCE OF EMISSION REDUCTIONS

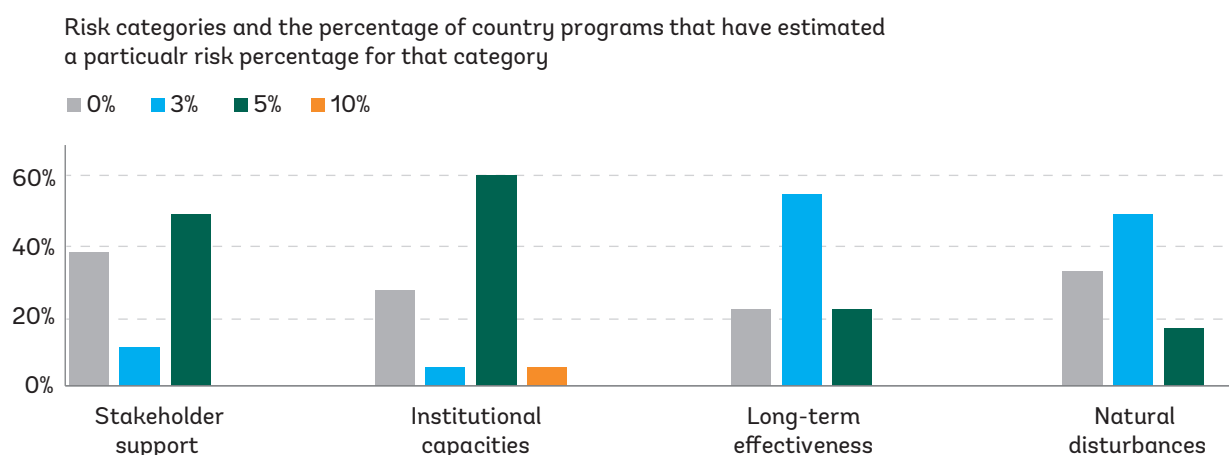
Under the Carbon Fund, compensation is only provided for permanent emission reductions. Since forests store carbon in their biomass, reversals can occur when living biomass is destroyed. Thus, an approach is needed to manage the risk of reversal. The Carbon Fund guarantees permanence by setting aside a fraction of achieved emission reductions in a dedicated buffer account.³¹ The portion set aside depends on the reversal risk at the time of verification, but the ex ante estimate averages 22 percent.

FCPF country programs assess reversal risks using four predefined reversal risk categories (Figure 7.1). According to the FCPF Methodological Framework, reversal risks relate to (i) stakeholder support, (ii) institutional capacities, (iii) long-term effectiveness,

and (iv) natural disturbances. Each risk is rated as high, medium, or low and the contribution of that particular risk category to the overall risks is then set as either 0 percent, 3 percent, 5 percent, or 10 percent. Most country programs find the risks related to institutional capacities and natural disturbances particularly high. However, risks related to stakeholder support and the long-term effectiveness of programs are, while lower in number, accounted for as well.

In contrast, the UNFCCC's Warsaw Framework for REDD+ is more open on approaches to addressing permanence of emission reductions. It states that REDD+ should "promote and support actions to address the risks of reversals"³² but provides no further guidance.

Figure 7.1: Reversal Risks in Country Programs



³¹ FCPF Methodological Framework criterion 19: "The ER Program accounts for Reversals from ERs that have been transferred to the Carbon Fund during the Term of the ERPA."

³² UNFCCC Decision 1/CP.16, Appendix paragraph 2(f).

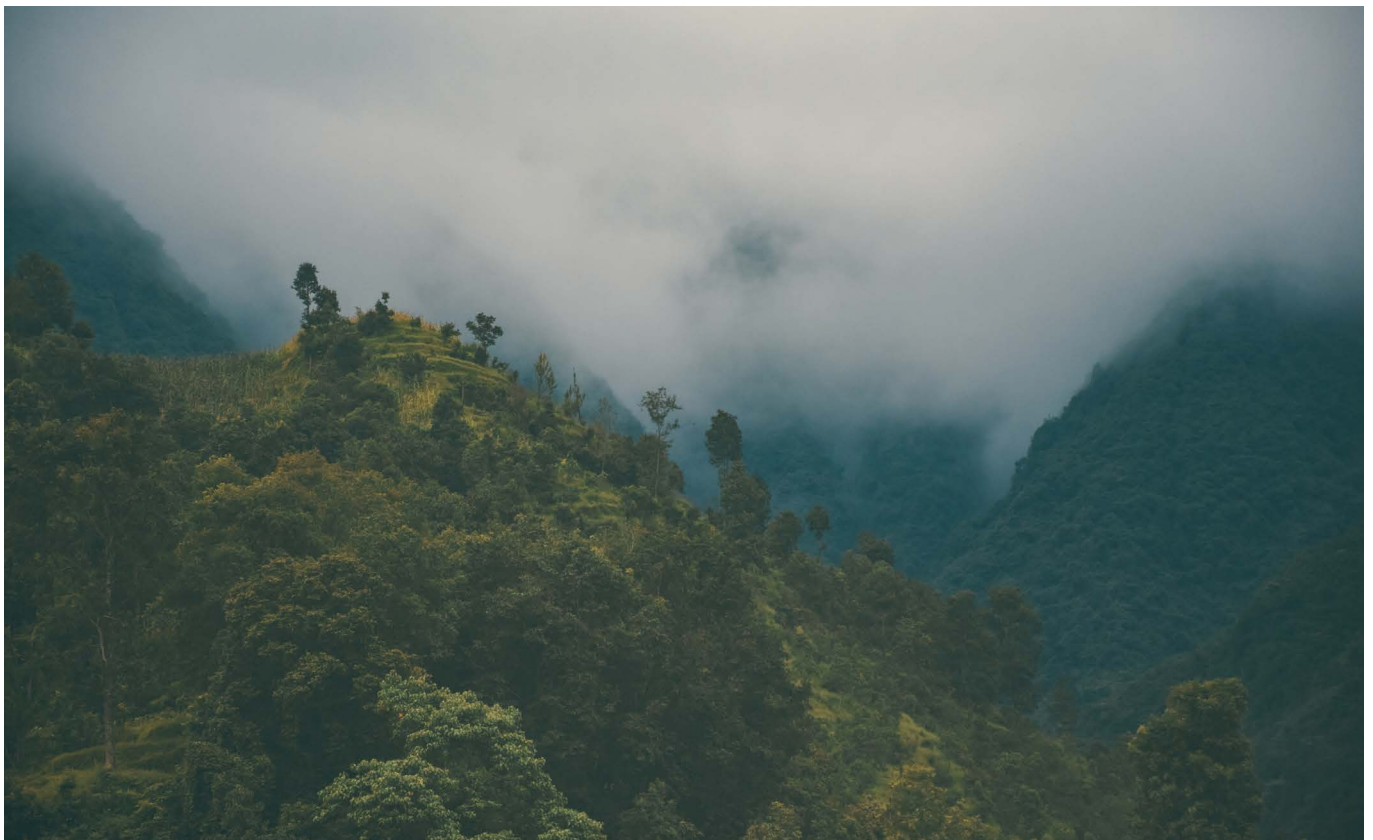
8. OUTLOOK

As of early 2020, several countries have fully executed their agreements with the Carbon Fund and are already reducing emissions. With this, a picture emerges on what country programs have been able to achieve with ample access to technical support, strong motivation from the prospect of results-based payments, and when working at the scale of subnational jurisdictions.

Methodological guidance for results-based payments and carbon credit sales from REDD+ programs at national or subnational scales continues to evolve. For example, in 2020, the REDD+ Environmental Excellency Standard under the Architecture for REDD+ Transactions (ART / TREES) was launched, and there is an ongoing discussion concerning the Green Climate Fund and potential further REDD+ results-based

payment windows. Stakeholders involved in these new programs and standards might be able to benefit from the lessons learned in the Carbon Fund portfolio from applying the FCPF Methodological Framework requirements.

The country programs in the Carbon Fund are still in the process of improving their data sets and applying technical corrections to their reference emission levels. Furthermore, the first submission of monitoring reports and the first verifications of achieved emission reductions, resulting in the first compensation payments from the Carbon Fund, are expected in 2021. This report will be updated in the future to reflect these new developments and to keep the technical community informed of what the country programs in the Carbon Fund are able to do to produce high-quality mitigation results.





9. GLOSSARY OF TERMS

1. **Activity data:** Data on the magnitude of human activity (for example, land use and land-use changes related to forests) resulting in emissions or removals taking place during a given period of time.³³
2. **Carbon pools:** Components of the climate system where carbon is stored, that is, reservoirs of carbon. In the context of the FCPF Carbon Fund Methodological Framework, there are five carbon pools:
 - a. Aboveground biomass
 - b. Belowground biomass
 - c. Dead wood
 - d. Litter
 - e. Soil organic carbon
3. **Emissions:** The release of carbon dioxide into the atmosphere over a specified area and period of time. The release of other greenhouse gases can be considered as feasible.³⁴
4. **Emission factor:** A coefficient that quantifies the emissions or removals of a gas per unit. Emission factors are often based on a sample of measurement data, averaged to develop a representative rate of emission for a given level of land-use changes related to forests under a given set of operating conditions.
5. **Emission reductions:** Difference between the reference Level and the actual measured, reported, and verified emissions and/or removals.
6. **Jurisdictional scale:** A geographical area encompassing one or more administrative units.
7. **Permanence:** Continued existence of an emission reduction once it has been monitored and reported. Requires the absence of reversals (see definition).
8. **REDD+ activities:** Activities listed in Decision 1/CP.16, para 70 as follows:
 - a. Reducing emissions from deforestation
 - b. Reducing emissions from forest degradation
 - c. Enhancement of forest carbon stocks
 - d. Conservation of carbon stocks
 - e. Sustainable management of forest

³³ IPCC defines activity data as "data on the magnitude of a human activity resulting in emissions or removals taking place during a given period of time." Data on energy use, metal production, land areas, management systems, and lime and fertilizer use are examples of activity data.

³⁴ Emissions (IPCC): The release of greenhouse gases and/or their precursors into the atmosphere over a specified area and period of time. (UNFCCC Article 1.4)

9. **Reference level:** An amount of emissions from the accounting area, expressed in tons of carbon dioxide equivalent per year, relative to which emission reductions are measured, reported, and verified.
10. **Reference period:** Time period for which historical emissions and removals from carbon stocks changes from forests or select REDD+ activities are estimated to establish the reference level.
11. **Removals:** Removal of carbon dioxide (CO₂) from the atmosphere by a sink.
12. **Reversals:** A situation where more emission reductions have been paid for than is warranted by the underlying reported and verified results.
13. **Sink:** Any process, activity, or mechanism that removes a greenhouse gas, an aerosol, or a precursor of a greenhouse gas from the atmosphere (from UNFCCC Article 1.8).
14. **Source:** Any process or activity that releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas into the atmosphere (from UNFCCC Article 1.9).



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