# Forest Carbon Partnership Facility (FCPF)

# Carbon Fund

## Exploring improvements to the uncertainty of Reference Levels

January 11, 2018

## Contents



## Background on discussion on updates to Reference Levels:

During CF14 a discussion took place around proposing guidance on updates to RLs after ERPA signature[1]. As part of these discussions four types of changes were discussed:

1. Updates to Activity Data (AD) and Emission Factors (EF) that improve accuracy and quality of the Reference Level
2. Updates to include additional Carbon Pools or greenhouse gases to improve accuracy and completeness of the Reference Level
3. Updates that change the REDD+ Activities associated with the Reference Level
4. Changes to Reference Levels that have been adjusted upward in accordance with Indicator 13.3

[1] https://www.forestcarbonpartnership.org/sites/fcp/files/2016/May/FMT%20note%20CF-2016-3%20Draft%20guidance%20on%20RL.pdf

No agreement was reached on this topic at the time of the meeting.

As part of CF16 the FMT presented a compilation of information on uncertainty in Activity Data from ER programs that had submitted their ERPDs to the FMT. Key messages were:

- Activity Data is critical to measure performance as emission factors are usually fixed for the reference period and the ERPA term so they affect the magnitude of ERs not the sign of the change;
- The activity data used by ER programs to establish their RLs have high statistically uncertainty (i.e. higher than 20% at 90% of confidence level), due mainly to the lack of guidance on how to reduce uncertainties;
- Countries might not be able to measure performance of their ER programs with such high uncertainties;
- Lack of possibilities of improving the uncertainty of RLs, would derive on limited possibilities for improvement in uncertainty through the ERPA term and would disable the incentive generated by the uncertainty buffer mechanism;
- The FMT is working closely with the GFOI partners in order to produce guidance for Countries. A new guidance module expected to be produced by end 2017/beginning 2018.

CFPs indicated during CF16 that they shared the concern raised and that they were open to explore potential solutions for this issue.

This notes has as objective to explore the issue on improving uncertainty to RLs and to propose solutions.

## Scope of updates to Reference Levels

There are different elements that are defined when setting a Reference Level (RL). There are two types of decisions: policy decisions, such as the decision on what REDD+ activities to be included; and technical decisions which are technical in nature and that are implemented under the framework set by the policy decisions.

| Policy decisions | Technical decisions |
|---|---|
| • REDD+ activities included<br>• Carbon pools included<br>• Gases included<br>• Reference period of the RL<br>• Forest definition<br>• Definition of REDD+ activities<br>• Other definitions<br>• Adjustments | • IPCC Approach (e.g. Approach 2, Approach 3 sampling or wall-to-wall)<br>• IPCC Tier (e.g. quality of data, such as representativeness of the data)<br>• Methods<br>• Sampling design (e.g. inventories for emission factors or area estimation) |

Based on the feedback received during CF14 and CF16, updates to Reference Levels that involve a change in policy decisions should not be considered as this would mean changing substantially the proposal made to CFPs and it could have further implications in terms of design of the ER program.

However, changes to technical decisions (provided the policy decisions are kept intact) such as the sampling design, have very different implications. **The present note of the FMT will only concentrate on updates linked to technical decisions that are described above.**

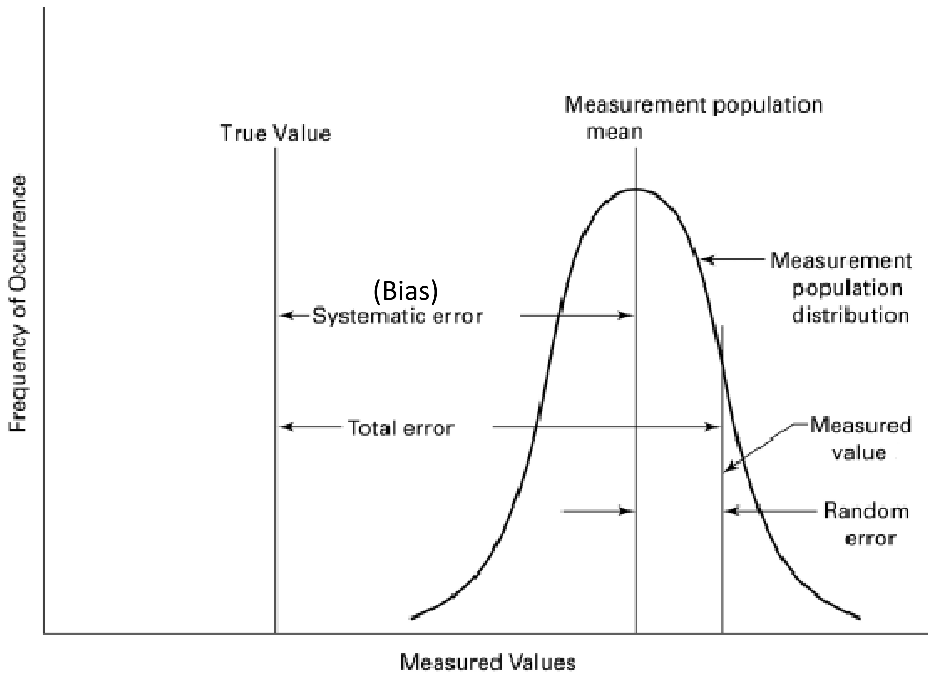
## Uncertainty

Uncertainty is defined as the lack of knowledge of the true value of a variable (e.g., reductions in emissions or increases in removals) that can be described as a probability density function characterizing the range and likelihood of possible values. Uncertainty depends on the analyst's state of knowledge, which in turn depends on the quality and quantity of applicable data as well as knowledge of underlying processes and inference methods.

Uncertainty consists of two components:

- **Bias or systematic error** (lack of **accuracy**) occurs, e.g., due to flaws in the measurements or sampling methods or due to use of an EF that is not suitable
- **Random error** (lack of **precision**) is a random variation above or below a mean value. It cannot be fully avoided but can be reduced by, for example, increasing the sample size.

The two components as shown practically in the following figure. Slides with more detailed explanations of what is the Accuracy and what is precision is provided in *Annex 1 - Effects on improving accuracy and precision*.




Looking at the figure above, we can notice that the measured (or estimated value) is just one of all possible measured values, presented the form of a Gaussian bell. Hence, **a new measurement or a new set of samples could lead to a different measured value or estimated value**. In the case of systematic errors, correcting these errors would also have an impact on the value.

Therefore, an improvement in accuracy (for instance, as a result of using a more representative emission factor), and an improvement in precision (for instance, as a result of increasing the sampling intensity) could both result in a change in the value. **Therefore, whether we improve accuracy or precision of a variable, the variable value might change**.

Some examples on impacts of improvements of precision and accuracy are provided in *Annex 1 - Effects on improving accuracy and precision*.

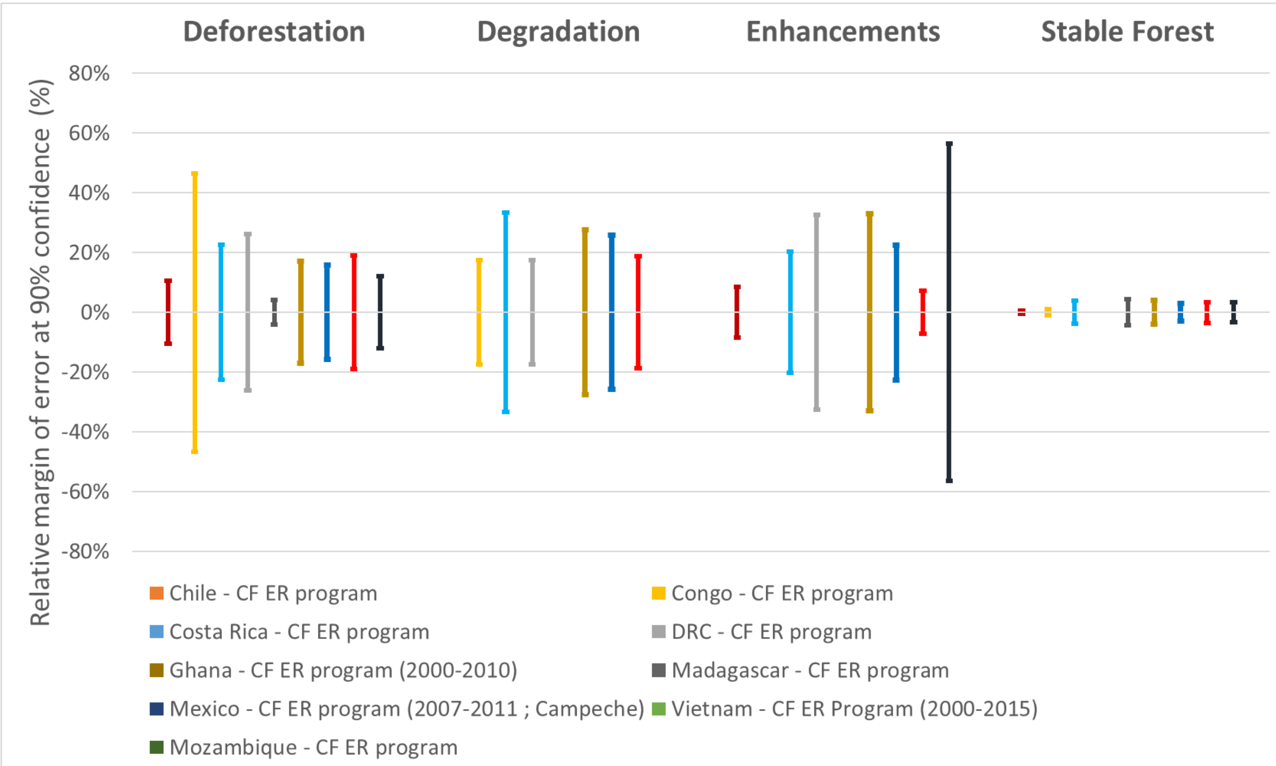
## Review of ER programs and needs assessment

So far 10 countries have submitted their ER Program Documents to the Carbon Fund. Countries have followed similar approaches to quantify GHG emissions and removals. In all cases for deforestation and in most of the cases for forest degradation (see more details in *Annex 2 - Integration methods in ER programs submitted to the CF*), the method used to quantify GHG emissions and removals has been the use of Activity Data derived from stratified sampling or maps, together with fixed emission factors or removal factors derived in most of the cases from terrestrial inventories. This integration method is usually referred as ADxEF.

In terms of Activity Data, most of the countries have used or will use in the future a sampling approach to derive the activity data of their RL. As indicated by the FMT during CF16, these sampling approaches have been applied as a result of emerging guidance from the GFOI that proposes not to use maps but to use sampling approaches. As shown in the below figure, because of the lack of specific guidance and, most importantly, experience on the application of these methods, countries have achieved high statistically uncertainties (well above 10% at 90% of confidence level) which could limit the capability to measure performance of Emission Reductions. Moreover, the lack of precision of their reference levels might constrain potential improvements of uncertainty of their MRV systems (i.e. they can improve monitoring but not the reference level) and might make dysfunctional the incentive of the uncertainty buffer mechanism to improve uncertainty[2] since countries would have little incentive and possibilities to improve the uncertainty of their ERs. Therefore, **countries might need to be able to improve the uncertainty of the AD based on more precise estimates obtained using the emerging guidance being created as part of the GFOI and improved methods**.

Countries **might also need to improve the accuracy of their estimates using new guidance available that was not available at the time of the submission of their ERPDs** (e.g. replace estimates from maps with sampling based estimates as recommended by Olofsson et al., 2004) **or using improved data that was not available** (e.g. very high resolution imagery or interpretation methods that were not available previously). This is important as new processing methods of historical imagery and new satellite imagery is being made available (e.g. SPOT missions or recently the 15 m imagery from ASTER for the period 2000-2012).

[2] MM FMT Note 2012H8: Recommendations of the Working Group on the Methodological and Pricing Approach for the Carbon Fund of the FCPF (2012) "*Accounting Element 1: Stepwise approach to reduce uncertainties ER Program data and methods are consistent with IPCC Tier 2, and ER Programs should, by using conservative assumptions and quantitative assessment of uncertainties, be incentivized to reduce uncertainties associated with all aspects of accounting, inter alia, reference levels, monitoring, and reporting (i.e., such that reductions in uncertainty are rewarded by a corresponding upward Adjustment in ER volume)*."




In terms of Emission Factors, in most of the cases (See *Annex 3 - Methods to estimate Emission Factors*) these have been derived from terrestrial inventories that are representative of the ER program or the country so they are not expected to be improved. However, there are some ER programs where EFs are based on secondary sources or IPCC defaults which are not ideal as they might not be representative of the country or of the ER program area (i.e. biased). Therefore, **there might be a need for countries to improve the uncertainty of their EFs by using more accurate values (i.e. more representative) that become available as part of their ongoing efforts to implement their MRV systems**.

Therefore, **countries in the portfolio or pipeline might need to improve the precision and accuracy of their activity data and emission factors**. A summary of the potential improvements from countries are provided in *Annex 4 - Potential improvements on accuracy and precision required by countries*.

## Different scenarios for updates on accuracy and precision of RLs

Based on the current situation from ER programs four different scenarios for improvement of uncertainty have been identified:

1. **Improvement in the precision of Activity Data** (e.g. increase in sampling intensity, improvement in stratification);
2. **Improvement in the accuracy and precision of Activity Data** (e.g. replace the use of maps by stratified sampling, use of better quality imagery such as very high resolution imagery);
3. **Improvement in the accuracy and/or precision of Emission and Removal Factors;**

4. **Improvement in the accuracy of GHG emissions by employing new methods** (i.e. forest degradation using new advanced methods).

## Scenario 1: Improvement in the precision of Activity Data (i.e. increase in sampling intensity, improvement in stratification)

### *Description of the improvement*

As presented by the FMT during CF16 and as presented above, the main source of uncertainty that countries are identifying when establishing their RLs is the precision of Activity Data. As shown previously, most of countries have presented AD with very high uncertainties, and they might need to have the opportunity to improve the uncertainty of their RLs.

The GFOI is currently preparing guidance for countries to improve the estimation of their Activity Data and in order to improve the uncertainty of their estimates. It is expected that such document will propose three initiatives to improve precision:

- Improve stratification by improving the quality of the maps used;
- Increase the sampling intensity to achieve the desired precision;
- Improve the sampling methods to achieve better precision at the same level of effort.

### *Consequences of the update*

If the precision of the AD is improved (lower random error), this would not only change the uncertainty of the estimate but **the new sample or realization would lead to a different value of Activity Data**.

Since the precision is improved, the previous and the new estimate should not be statistically different, i.e. confidence intervals overlap, but the previous value[3] could also be statistically lower or higher than the new estimate, i.e. the previous value is not within the confidence interval of the new estimate.

In this scenario of improvement, **the actual true value would be better pinned down and in some cases, the previous value was significantly higher or lower**, i.e. the previous value was not contained within the new estimates confidence interval.

Therefore,

- This improvement in precision of the AD would lead to a **different value of the RL**.
- However, the previous and new estimate would not be statistically different, but the previous value could be out of the confidence intervals of the new estimate.
- This improvement **would allow to measure performance** of the ER program or reduce the risk of not being able to measure it.
- The **uncertainty of ERs would also be improved** because of improving the uncertainty of the AD of the RL. This would **eliminate constraints on the uncertainty buffer to create necessary incentives** for countries to improve the uncertainty of their ERs.

[3] Here we refer to value to a number that is ultimately used to estimate Emission Reductions, regardless of its uncertainty

## Scenario 2: Improvement in the accuracy and precision of Activity Data (i.e. replace the use of maps by stratified sampling, or use of better quality imagery)

### *Description of the improvement*

As indicated previously, most of countries have followed the GFOI guidance and used statistical estimators to estimate Activity Data, while others have used maps. This is due in part to the fact that this was emerging guidance at the time these countries set their Reference Levels. Therefore, it might be the case that countries that have used maps to estimate AD, **might want to apply this guidance and replace them by statistical estimates with quantified uncertainty, and that can be considered as more accurate**.

In other cases, reference samples used to estimate AD during the reference period were collected using existing very high (Digital Globe sensors of 0.3-0.6 m) or high resolution imagery (SPOT). It is likely that new sources imagery of the reference period become available, such as 15 m ASTER or other archive imagery from Digital Globe, SPOT, meaning that accuracy could also be improved. This is the case for forest degradation that in many countries has been estimated using medium resolution imagery. Another case could be that methods for data collection have been improved as a result of the new existing guidance, e.g. improved stratification with new processing methods.

### *Consequences of the update*

If the precision and accuracy of the AD is improved **this would lead to a change in the value of the RL**.

Moreover, it would lead to more accurate and (should lead to more) precise values, therefore leading to **more accurate and precise Emission Reductions.** But, contrary to the previous Scenario 1, we could have the case that the new estimate is statistically different to the previous estimate, i.e. confidence intervals of the two estimates do not overlap.

Moreover, as in the previous Scenario 1, the previous value could also be statistically lower or higher than the new estimate, i.e. the previous value is not within the confidence interval of the new estimate.

In this case, **the uncertainty of ER should also be improved as a result of improving the precision of the AD of the RL**. However, in some cases, despite the improvement in accuracy the precision might not have been improved.

Therefore,

- This improvement in precision and accuracy of the AD would lead to a **different value of the RL**.
- This improvement in precision and accuracy **would allow to measure performance** of the ER program or reduce the risk of not being able to measure it.
- The **uncertainty of ER would also be improved** because of improving the precision of the AD of the RL. This would **eliminate constraints on the uncertainty buffer to create necessary incentives** for countries to improve the uncertainty of their ERs.
- The only **difference regarding Scenario 1** is that there **could be significant differences between the previous estimate and the new estimate**, i.e. the previous value would not be contained within the confidence intervals of the new value.

## Scenario 3: Improvement in the accuracy and precision of the Emission Factors

### *Description of the improvement*

Based on the information collected from all ER programs, there might be ER programs where Emission Factors might have to be improved[4], so this case might occur in practice.

The MF allows to update emission factors as part of monitoring provided these are the same or demonstrably equivalent to those used to set the Reference Level[5]. However, Emission Factors used for the Reference Level cannot be updated. If Emission Reductions are calculated based on an updated EF, but the EF of the Reference Level is not updated, this might **be a source of bias of Emission Reductions** as the two EFs are not equal even though they have been obtained with equivalent methods. The reason is that even if the new EFs is obtained using the same methods as the previous one, the new sample might have simply a different value as indicated previously.

Improvement in precision might occur as a result of improving stratification or using a higher sampling intensity, similarly to the case described in Scenario 1.

Improvement in accuracy would mean in practice the use of more representative values:

- Use of Tier 2 data instead of Tier 1 default values[6];
- Use of improved allometric equations;
- Use of results of representative surveys (NFI) instead of national values from literature.

### *Consequences of the improvement*

If the EF is updated by increasing accuracy and precision, **this would lead to a change in the value of the RL**.

In terms of ERs, Emission Factors are usually a constant, so a change in EFs **does not affect the relative change of emissions reductions** (ERs/RL, known as the trend in the IPCC), but would change the total Emission Reductions, **so it does not have the impact on measurement of performance as happens with the AD**. The magnitude of Emission Reductions would be proportional to the magnitude of the change in EFs.

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[4] **Costa Rica**: As part of the improvement of the RL, terrestrial inventories will be conducted in intact, degraded and very degraded forests so as to derive specific emission factors for degradation. This is planned to be done prior to ERPA signature, though.
**Mozambique**: The ERPD applies emission factors derived from literature or an ad-hoc inventory which might not be representative. The National Forest Inventory will be finalized November 2017 and new values of Emission Factors will be available in January 2018. These values are based on a robust sampling design across the country. The NFI values will be used to set the FREL submitted to the UNFCCC.
**DRC**: At the time of the ERPD development, the pre-NFI that was under development was not finalized. As a result, the estimates from a biomass map generated with LiDAR data were used instead. The pre-NFI values are being used for the national FREL submitted to the UNFCCC.

[5] **Indicator 14.3**: Emission factors or the methods to determine them are the same for Reference Level setting and for Monitoring, or are demonstrably equivalent. IPCC Tier 2 or higher methods are used to establish emission factors, and the uncertainty for each emission factor is documented. IPCC Tier 1 methods may be considered in exceptional cases.

[6] ER programs use in some cases Tier 1 default values.

The use of more accurate EFs, would improve the accuracy of Emission Reductions, but if the improved EFs have large uncertainty, they might not be proven to be more accurate than the existing ones, i.e. they are not statistically different or the previous value is not significantly higher or lower than the new estimate (Examples 2 or 3 shown in Annex 1).

The impact of an improvement in precision of EFs in the uncertainty of the RL is very reduced if the same EFs are used for both reference level and monitoring. The reason is that the EF would be correlated so errors would cancel each other.

Therefore,

- This improvement in precision and accuracy of the EF would lead to a **different value of the RL**.
- However, contrary to Scenario 1 and 2, this improvement **would not lead to an improvement in the ability to measure performance**. It impacts the value of ERs monitored, so the higher the ER the higher are the ER in the case of deforestation and degradation.
- The **uncertainty of ER would also be improved** because of improving the uncertainty of the EF of the RL, however, if fixed EFs are used for RL setting and monitoring, **the impact would be very little as EFs would be correlated so random errors would cancel each other partially**.

## Scenario 4: Improvement in the accuracy of GHG emissions by employing new methods (i.e. forest degradation using new advanced methods).

### *Description of the improvement*

In this case, it is not a matter of updating AD or EFs keeping similar methods, the method itself would change. For instance, if a country has used proxy methods to quantify degradation and better methods are identified, countries could employ better available methods to update their reference levels. In this case however, these new methods should lead to an improvement in accuracy of GHG emissions with regard to the previous method.

### *Consequences of the update*

If new methods are used, this should lead to a change in the value of the RL.

The improvement in accuracy linked to the use of new methods, should lead to an improvement in the accuracy of RLs. However, if the improved estimates have low precision, they might not be proven to be more accurate than the existing ones, i.e. they are not statistically different or the previous value is not significantly higher or lower than the new estimate (Examples 2 or 3 in Annex 1).

Therefore,

- This improvement in accuracy would lead to a **different value of the RL**.
- This improvement **might or might not improve the ability to measure performance**, as the new methods might be more imprecise (higher random errors)
- The **uncertainty of ER might or might not improve** depending on the precision of the estimate.

## Proposed next steps

Looking at the four scenarios above, the FMT has identified the following potential needs from ER programs (more details are provided in *Annex 4*)

| Country | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 |
|---|---|---|---|---|
| DRC | ✓ | ✓ | ✓ | |
| Costa Rica* | | ✓ | ✓ | |
| Chile | | ✓ | ✓ | |
| Mexico* | ✓ | ✓ | | |
| Vietnam | ✓ | | | |
| Congo | ✓ | ✓ | | |
| Ghana* | | ✓ | | ✓ |
| Mozambique | | | ✓ | |
| Madagascar | ✓ | ✓ | | |
| Nepal | | ✓ | | |

CFPs have two possible options:

- **Option A**: *Status quo*, providing guidance in a case by case basis;
- **Option B**: Provide guidance to countries to improve the uncertainty of their RLs for any or a combination of the following options:
  - Option 1: Improvement in the precision of Activity Data
  - Option 2: Improvement in the accuracy and precision of Activity Data
  - Option 3: Improvement in the accuracy and precision of the Emission Factors:
  - Option 4: Improvement in the accuracy of GHG emissions by employing new methods

If CFPs decide to go forward with **Option B**, guidance to countries for the improvement of uncertainty of Reference Levels, they could consider the following conditions for setting a formal guidance:

- Policy and main design decisions such as definitions, reference period, boundaries cannot be updated;
- Only improvement of uncertainty to the Reference Level is allowed prior to the first verification;
- CFPs might have to consider if they set a temporal limit to the guidance, e.g. only countries that have presented their RLs to the CF prior to June 2019;
- Monitoring has to be consistent with the new updates made.
-
- **Option 1**: Improvement in the precision of Activity Data

    - Including: Improvement in the sampling design through sampling intensity, improvement of stratification or sampling methods.
    - Only allowed if it leads to an improvement in the precision of the estimates of activity data.
- **Option 2**: Improvement in the accuracy and precision of Activity Data:
    - Including: replacement of map estimates by sampling estimates; use of better quality imagery for reference data collection; use of better protocols for data collection including QA/QC measures.
    - Only allowed if it leads to an improvement in the precision of the estimates of activity data OR it is demonstrated that the new methods are more robust and the previous value was significantly lower or higher than the revised estimate, i.e. the previous value is not contained within the confidence intervals of the new estimate.
- **Option 3**: Improvement in the accuracy and precision of the Emission Factors:
    - Including: Use of more representative values; use of more representative allometric equations; intensification of inventory;
    - Only allowed if it leads to an improvement in the precision of the estimates of activity data AND it is demonstrated that the new methods are more robust and the previous value was significantly lower or higher than the revised estimate, i.e. the previous value is not contained within the confidence intervals of the new estimate.
- **Option 4**: Improvement in the accuracy of GHG emissions by employing new methods
    - Including: Use of more accurate methods
    - Allowed in a case by case basis.

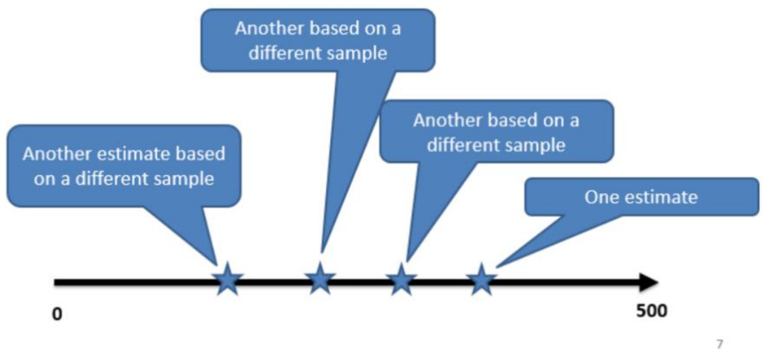
# Annex

## 1. Effects on improving accuracy and precision

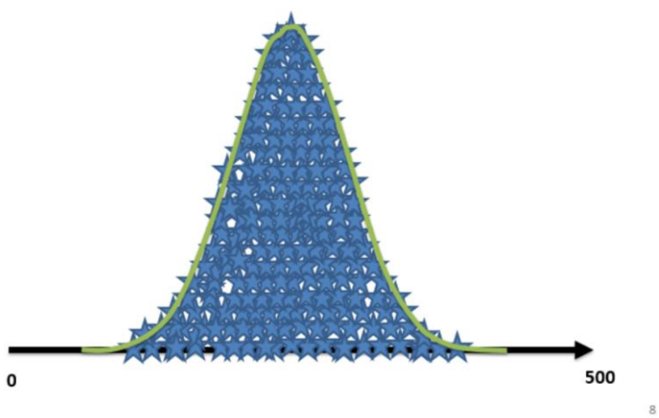
### a. Accuracy and precision

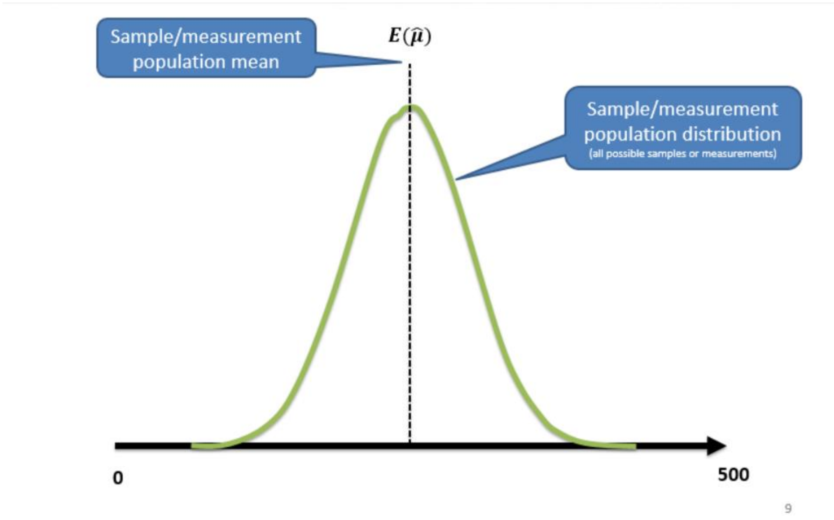
Let's assume that a variable is estimated through **sampling** and we can repeat the same sampling design **many times**...

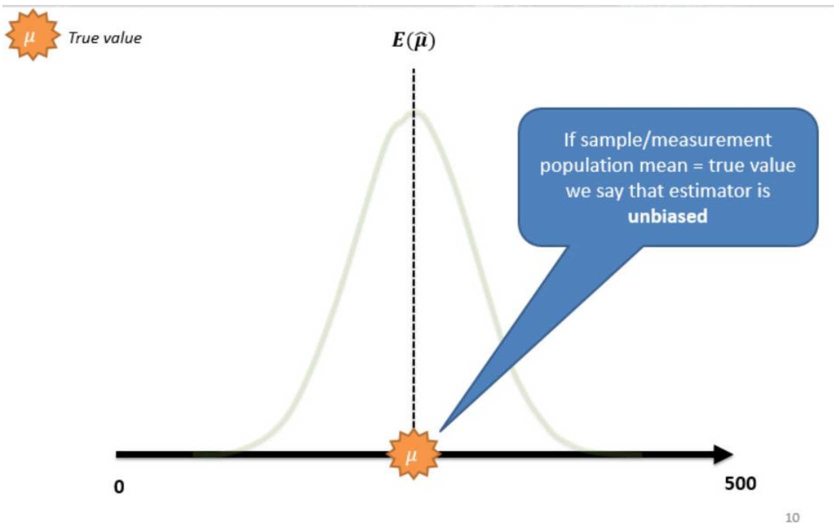
....every time we draw a sample (set of units) **we get a different value**..

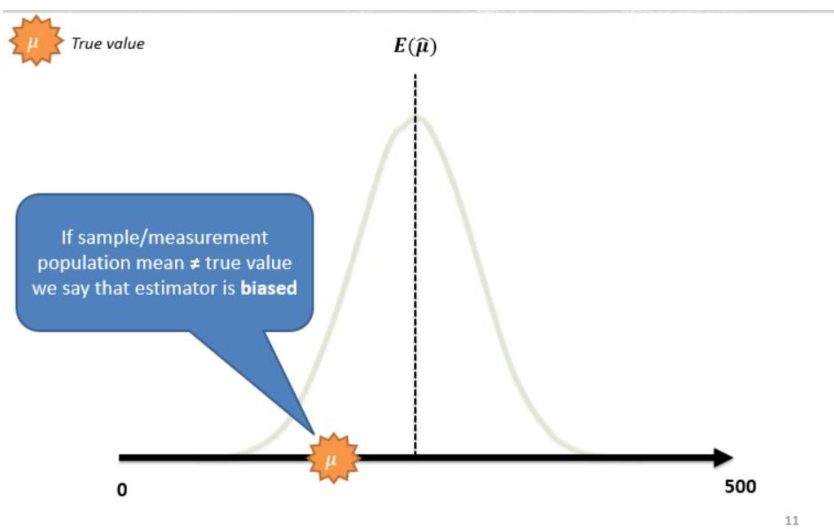


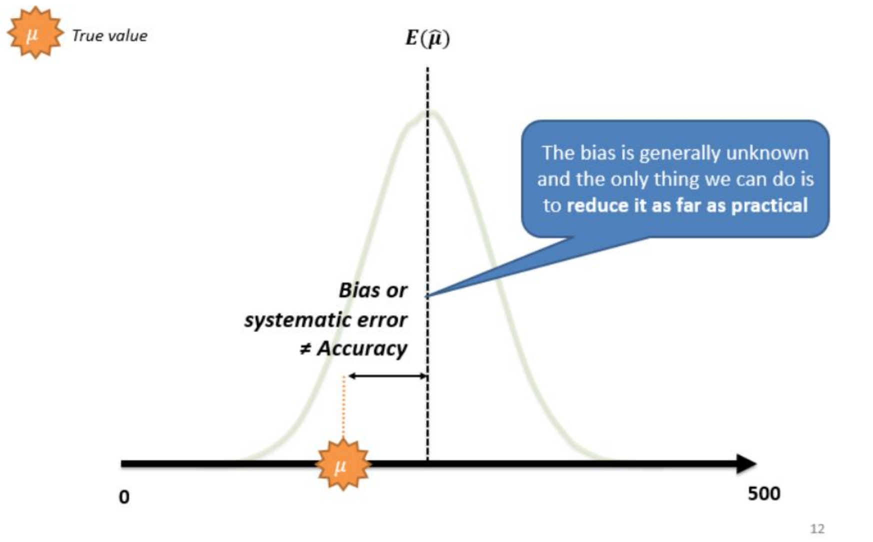

Now we repeat this many, many times....

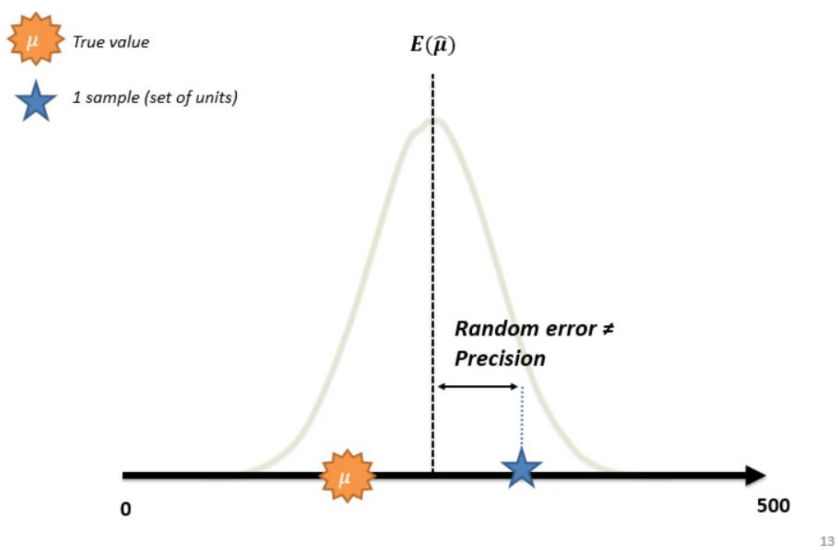


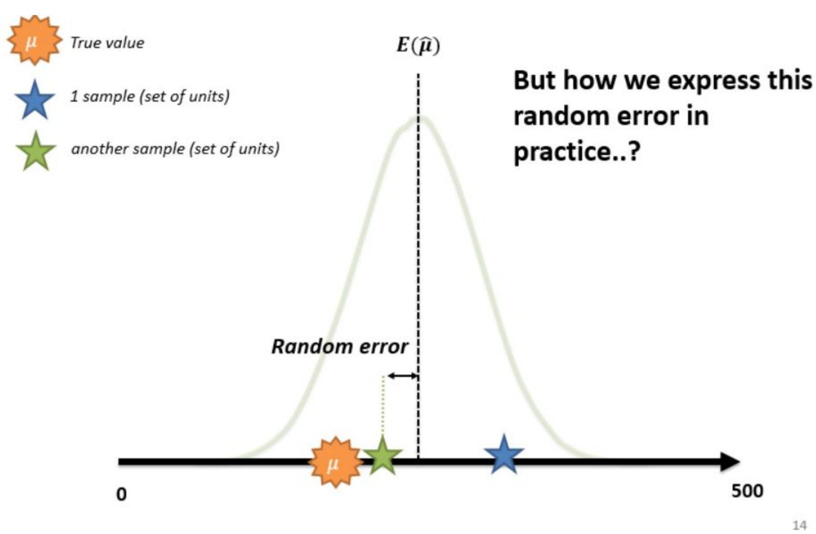

Sample/measurement population mean
$E(\hat{\mu})$
Sample/measurement population distribution
(all possible samples or measurements)
0
500
9

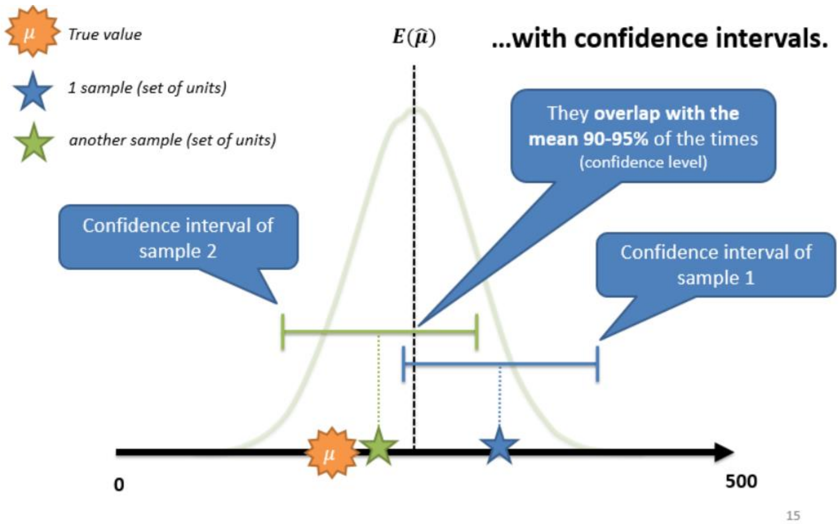

True value
$E(\hat{\mu})$
If sample/measurement population mean = true value we say that estimator is **unbiased**
0
500
10

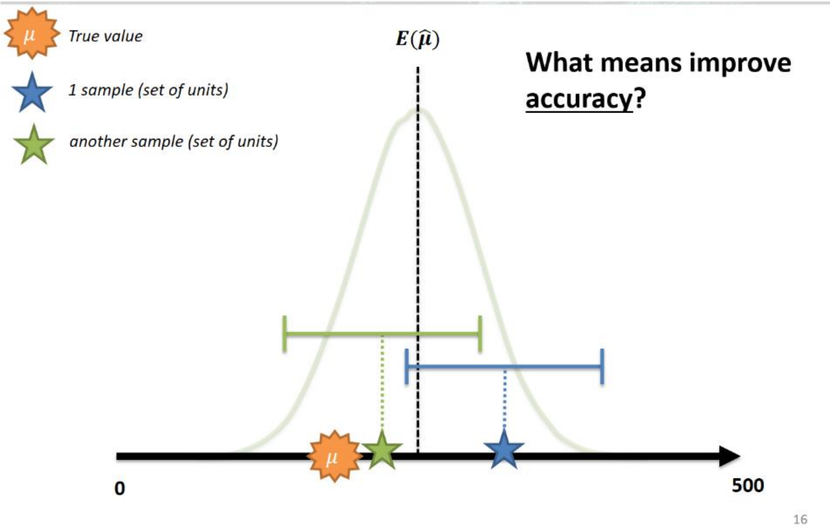

True value
$E(\hat{\mu})$
If sample/measurement population mean ≠ true value we say that estimator is **biased**
0
500
11

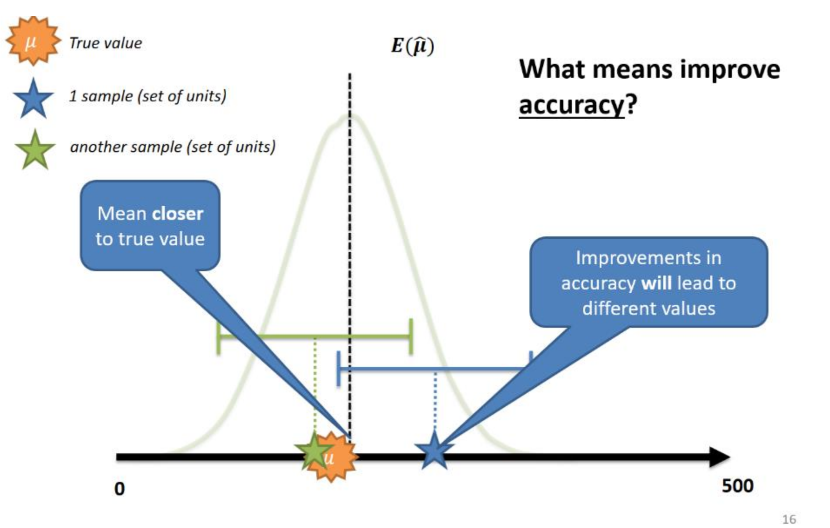

True value
$E(\hat{\mu})$
The bias is generally unknown and the only thing we can do is to **reduce it as far as practical**
Bias or systematic error ≠ Accuracy
μ
0
500
12

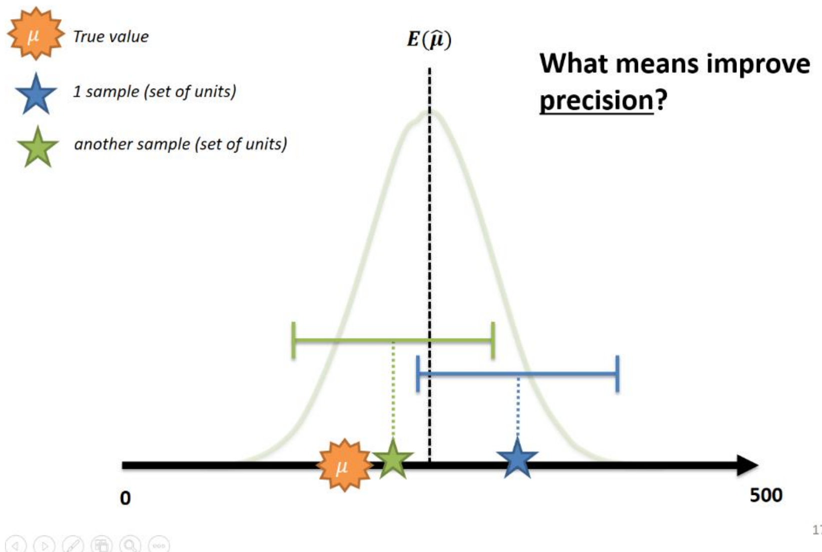

True value
1 sample (set of units)
$E(\hat{\mu})$
Random error ≠ Precision
μ
0
500
13

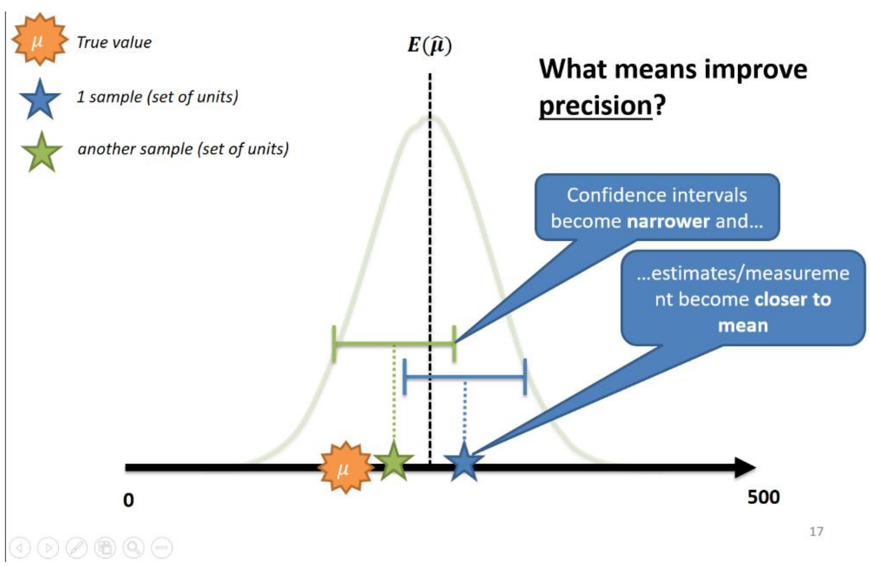

True value
1 sample (set of units)
another sample (set of units)
$E(\hat{\mu})$
But how we express this random error in practice..?
Random error
μ
0
500
14


True value
1 sample (set of units)
another sample (set of units)
$E(\hat{\mu})$
...with confidence intervals.
They overlap with the mean 90-95% of the times (confidence level)
Confidence interval of sample 2
Confidence interval of sample 1
0
500
15

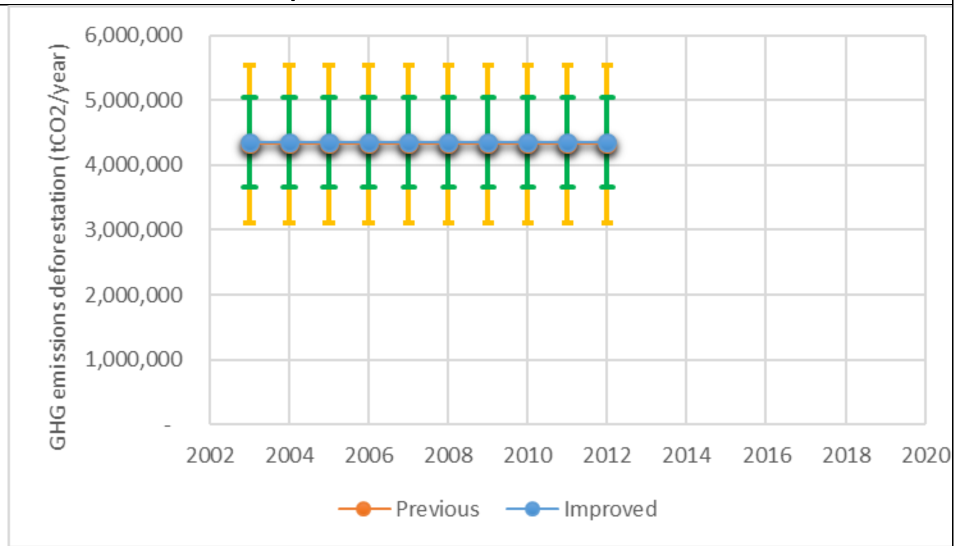
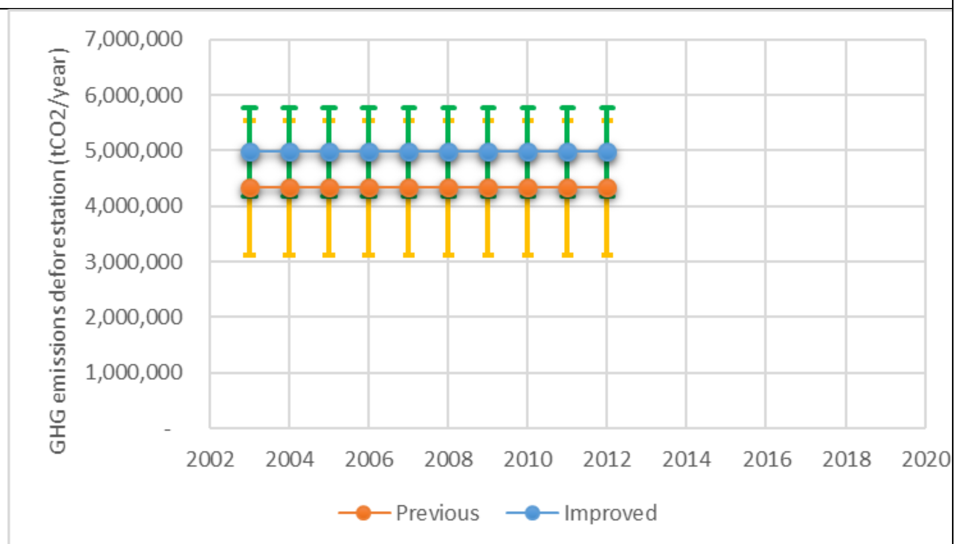
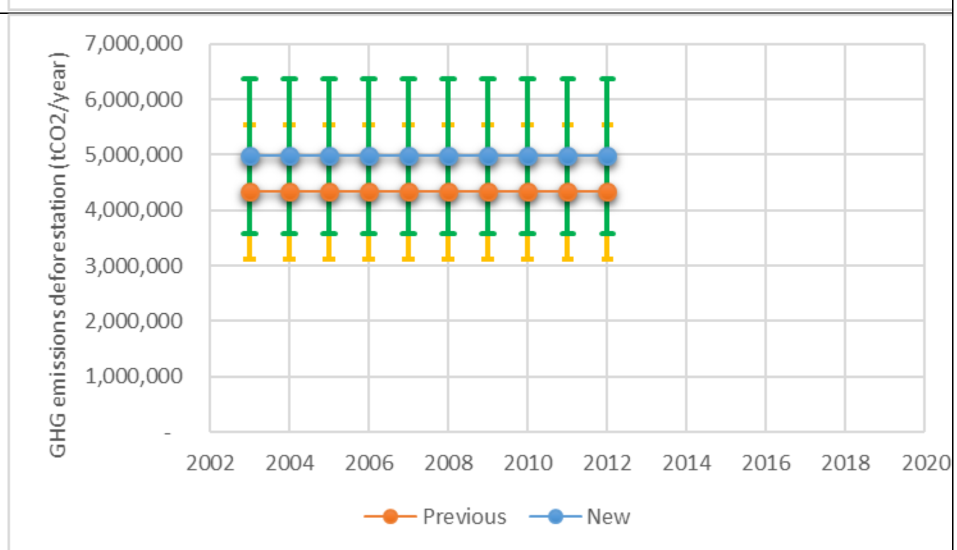

True value
1 sample (set of units)
another sample (set of units)
$E(\hat{\mu})$
What means improve accuracy?
0
500
16

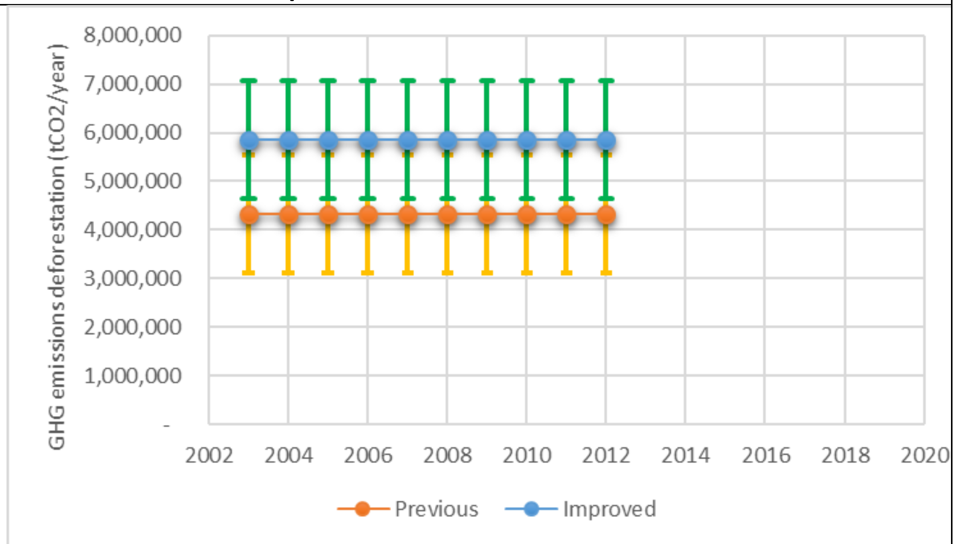

True value
1 sample (set of units)
another sample (set of units)
$E(\hat{\mu})$
What means improve accuracy?
Mean closer to true value
Improvements in accuracy will lead to different values
0
500
16




b. Specific examples on improving accuracy and precision

| Examples | |
|---|---|
| **1. Improvement in precision:** This is a simple, and unrealistic example of what an improvement in precision would mean. Error bars are now more narrow, but the estimate has not changed, which might not be realistic. In this case, the true value or the population mean (if there is no bias) is better pinned down and this would lead to a lower uncertainty buffer, for instance, but no change in the value. |  |
| **2. Improvement in precision:** This is a more realistic case as an improvement in uncertainty has also caused a change in the variable value while error bars are narrower. In this case the true value or the population average (if not biased) is better pinned down. This would lead to a lower uncertainty buffer and would change the value, yet statistically there would not be a difference with the previous estimate. |  |
| **3. Improvement in accuracy but not “precision”:** The assumption in this case, is that improved methods have been applied, leading to a more accurate value. In this case the error bars have not changed, while the estimate has changed. But in this case, the two values are not statistically different, so the improvement in accuracy cannot be demonstrated statistically. The uncertainty buffer would be the same in this case. |  |

| Examples | |
|---|---|
| **4. Improvement in accuracy but not in precision:** In this case error bars have not changed. However, the previous estimate is not within the error bars of the new estimate, which would show that the previous estimate most likely underestimates emissions. It would not have an impact in the uncertainty buffer, but it would in the accuracy of emissions. |  |
| **5. Improvement in accuracy but not in precision:** It is assumed that the use of improved methods has given a new more accurate value value but with similar error bars. Since the two values are significantly different, it can be confirmed that this resutls in an improvement in accuracy. |  |

## 2. Integration methods in ER programs submitted to the CF

In some cases, specifically in the case of forest degradation, countries have used other methods such as model based inference (Chile) or proxies like volumes of wood (Ghana).

| Country | Deforestation | Forest Degradation | Enhancement of carbon stocks (AR) | Enhancement of carbon stocks (FF) |
|---|---|---|---|---|
| DRC | ADxEF | ADxEF | ADxEF | ADxEF |
| Costa Rica | $AD^{\#}$xEF | $AD^{+}$xEF | $AD^{+}$xEF | |
| Chile | $AD^{\#}$xEF | Model based inference | $AD^{\#}$xEF | Model based inference |
| Mexico | $AD^{+}$xEF | $AD^{+}$xEF | $AD^{+}$xEF | $AD^{+}$xEF |
| Vietnam | ADxEF | ADxEF | ADxEF | ADxEF |
| Congo | ADxEF | ADxEF | | |
| Ghana | ADxEF | Proxy | $AD^{\$}$xEF | |

| Country | Deforestation | Forest Degradation | Enhancement of carbon stocks (AR) | Enhancement of carbon stocks (FF) |
|---|---|---|---|---|
| Mozambique | ADxEF | | | |
| Madagascar | ADxEF | ADxEF | ADxEF | |
| Nepal | AD#xEF | AD#xEF | AD#xEF | AD#xEF |

+Currently using maps but will use Approach 3 - sampling approach in the upcoming revisions of their RLs
#AD is derived from Approach 3 - maps
$AD is derived from national statistics. Approach 2.

Therefore, it can be safely said that the **ADXEF is the predominant integration method**. It is also important to indicate that in most of the cases, the Emission Factors and Removal Factors are proposed to be fixed throughout the ERPA term, so they be considered as constant factors.

## 3. Methods to estimate Emission Factors

Looking at the different ER programs in most of the cases values are derived from NFIs or other terrestrial inventories so they are not expected to be improved, yet there are others that are based on secondary sources or IPCC defaults which are not ideal as they might not be representative.

| Country | Deforestation | Forest Degradation | Enhancement of carbon stocks (AR) | Enhancement of carbon stocks (FF) |
|---|---|---|---|---|
| DRC | Biomass map | Biomass map | Biomass map | Biomass map |
| Costa Rica | Secondary sources | Secondary sources | Secondary sources | |
| Chile | National Forest Inventory | Model based inference | National Forest Inventory | Model based inference |
| Mexico | National Forest Inventory | National Forest Inventory | National Forest Inventory | National Forest Inventory |
| Vietnam | National Forest Inventory | National Forest Inventory | National Forest Inventory | National Forest Inventory |
| Congo | Biomass map | Biomass map | | |
| Ghana | – Biomass map<br>– Secondary sources<br>– IPCC (soil) | Proxy | – Biomass map<br>– Secondary sources | |
| Mozambique | Terrestrial inventory | | | |
| Madagascar | – Terrestrial inventory<br>– IPCC (soil) | Terrestrial inventory | Terrestrial inventory | |
| Nepal | Biomass map | Biomass map | Biomass map | Biomass map |

## 4. Potential improvements on accuracy and precision required by countries

Based on this assessment and after consultation with countries, the FMT has identified the following potential improvements on uncertainty:

| **Country** | **Potential improvements in uncertainty** |
|---|---|
| DRC | – Increase in precision in AD based on methodological improvements and better reference data<br>– Increase accuracy of EF using the latest EF used for the national FREL |
| Costa Rica* | – Increase in accuracy and precision in AD for forest degradation and afforestation/reforestation based on the CICOMUTE forest monitoring grid<br>– Increase in accuracy and precision in AD for deforestation adjusting map estimates using the CICOMUTE forest monitoring grid<br>– Increase in accuracy and precision in EFs for forest degradation |
| Chile | – Increase in accuracy and precision in AD for deforestation adjusting map estimates using samples |
| Mexico* | – Increase in accuracy and precision in AD based on the MADmex system |
| Vietnam | – Increase in precision in AD based on methodological improvements and better reference data |
| Congo | – Increase in precision in AD based on methodological improvements and increase in accuracy in AD using better reference data |
| Ghana* | – Increase in accuracy and precision in AD<br>– Increase in accuracy and precision in AD and EF of forest degradation |
| Mozambique | – Increase in accuracy and precision in EFs based on the values from the NFI (available January 2018) |
| Madagascar | – Increase in precision in AD based on methodological improvements and better reference data |
| Nepal | – Increase in accuracy and precision in AD for deforestation adjusting map estimates using samples |

*Prior to ERPA signature