



Report of the technical assessment of the proposed forest reference level of Panama submitted in 2018

Summary

This report covers the technical assessment of the voluntary submission of Panama on its proposed forest reference level (FRL), in accordance with decision 13/CP.19 and in the context of results-based payments. The FRL proposed by Panama covers the activities “reducing emissions from deforestation”, “reducing emissions from forest degradation”, “conservation of forest carbon stocks”, “sustainable management of forests” and “enhancement of forest carbon stocks”, which are the five activities included in decision 1/CP.16, paragraph 70. For its submission, Panama developed a national FRL. The FRL presented in the original submission, for the reference period 2006–2015, corresponds to –56,991,334 tonnes of carbon dioxide equivalent (t CO₂ eq) per year. As a result of the facilitative process during the technical assessment, the FRL was modified to –27,735,675 t CO₂ eq/year for a reference period of 2000–2015. The assessment team notes that the data and information used by Panama in constructing its FRL are transparent, complete and in overall accordance with the guidelines contained in the annex to decision 12/CP.17. This report contains the assessed FRL and a few areas identified by the assessment team for future technical improvement, in accordance with the provisions on the scope of the technical assessment contained in the annex to decision 13/CP.19.



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I. Introduction and summary

A. Overview

1. This report covers the technical assessment (TA) of the submission of Panama on its proposed forest reference level (FRL),¹ submitted on 15 January 2018 in accordance with decisions 12/CP.17 and 13/CP.19. The TA took place (as a centralized activity) from 19 to 23 March 2018 in Bonn, Germany, and was coordinated by the UNFCCC secretariat.² The TA was conducted by two land use, land-use change and forestry experts from the UNFCCC roster of experts³ (hereinafter referred to as the assessment team (AT)): Mr. Andres B Espejo (Spain) and Mr. Brian Zutta Salazar (Peru). In addition, Mr. Thiago de Araújo Mendes, an expert from the Consultative Group of Experts on National Communications from Parties not included in Annex I to the Convention, participated as an observer⁴ during the centralized activity in Bonn. The TA was coordinated by Ms. María José Sanz Sánchez (UNFCCC secretariat).

2. In response to the invitation of the Conference of the Parties (COP) and in accordance with the provisions of decision 12/CP.17, paragraphs 7–15, and its annex, Panama submitted its proposed FRL on a voluntary basis. This proposed FRL is one of the elements⁵ to be developed in the implementation of the activities referred to in decision 1/CP.16, paragraph 70. The COP decided that each submission of a proposed forest reference emission level (FREL) and/or FRL, as referred to in decision 12/CP.17, paragraph 13, shall be subject to a TA in the context of results-based payments, pursuant to decisions 13/CP.19, paragraphs 1 and 2, and decision 14/CP.19, paragraphs 7 and 8.

3. Panama provided its submission in Spanish. The submission is supported by a spreadsheet containing all the calculations made and methodologies chosen, which enhances the transparency of the Party's reporting, and by 11 annexes.⁶

4. The objective of the TA was to assess the degree to which the information provided by Panama is in accordance with the guidelines for submissions of information on reference levels⁷ and to offer a facilitative, non-intrusive, technical exchange of information on the construction of the FRL with a view to supporting the capacity of Panama for the construction and future improvement of its FRL, as appropriate.⁸

5. The TA of the FRL submitted by Panama was undertaken in accordance with the guidelines and procedures for the TA of submissions from Parties on proposed FRELs and/or FRLs.⁹ This report on the TA was prepared by the AT following the same guidelines and procedures.

6. Following the process set out in those guidelines and procedures, a draft version of this report was communicated to the Government of Panama. The facilitative exchange during the TA allowed Panama to provide clarifications and additional information, which were considered by the AT in the preparation of this report.¹⁰

7. As a result of the facilitative interactions with the AT during the TA, Panama provided a modified version of its submission on 5 July 2018, which took into consideration the technical inputs of the AT. The modifications improved the clarity and transparency of the submitted FRL. The following were the main changes made in the modified submission: the historical reference period was changed from 2006–2015 to 2000–2015; it was clarified that

¹ The submission of Panama is available at <https://redd.unfccc.int/submissions.html?country=pan>.

² Decision 13/CP.19, annex, paragraph 7.

³ Decision 13/CP.19, annex, paragraphs 7 and 9.

⁴ Decision 13/CP.19, annex, paragraph 9.

⁵ Decision 1/CP.16, paragraph 71(b).

⁶ Available at <https://webdav.miambiente.gob.pa/index.php/s/LV5nCXq7E56ozXX>.

⁷ Decision 12/CP.17, annex.

⁸ Decision 13/CP.19, annex, paragraph 1(a) and (b).

⁹ Decision 13/CP.19, annex.

¹⁰ Decision 13/CP.19, annex, paragraphs 1(b), 13 and 14.

tier 2 was used (activity data (AD) multiplied by emission factors (EFs)); the assumption underlying the estimation of removals in mature forests was revised based on latest scientific research; emissions from wood and timber harvesting were included; and the values of certain parameters were improved. This TA report was prepared in the context of the modified FRL submission. The modified submission, containing the assessed FRL, and the original submission are available on the UNFCCC website.¹¹

B. Proposed forest reference level

8. The national FRL proposed by Panama for the historical reference period 2000–2015 is the average of the carbon dioxide (CO₂) emissions and removals of all forest-related Intergovernmental Panel on Climate Change (IPCC) categories and subcategories, which include forest land remaining forest land, conversions to forest land and conversions of forest land to other land uses. Methane (CH₄) and nitrous oxide (N₂O) emissions from fires on forest land remaining forest land are also included. The proposed FRL includes natural forests and plantations, and all carbon pools other than soil organic carbon (SOC). The information on AD used in the construction of the FRL was from land use and land-use change assessments, which were conducted on the basis of the Food and Agriculture Organization of the United Nations (FAO) Collect Earth tool, a sampling approach in which the land-use condition was determined for each year of the reference period. The information on EFs was obtained from the scientific literature, data from the pilot phase (pre-inventory) of the National Forest and Carbon Inventory (INFC) and the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (hereinafter referred to as the 2006 IPCC Guidelines). The information on CO₂ removals for secondary forests and plantations was obtained from the scientific literature and the 2006 IPCC Guidelines. The information on both wood and fuelwood removals was based on the information provided by Panama to FAOSTAT.¹² The information on forest fires was obtained from national statistics. While there is a potential risk of double counting, the Party and the AT consider it to be negligible in this case. The Party has calculated that this approach may lead to double counting of less than 1 per cent of the total historical annual emissions.

9. The FRL presented in the modified submission, with the aim of accessing results-based payments for REDD-plus¹³ for the period 2016–2020, corresponds to net –27,735,675 tonnes of carbon dioxide equivalent (t CO₂ eq) per year for the reference period 2000–2015. In the original submission, Panama proposed a national FRL of –56,991,334 t CO₂ eq/year for the reference period 2006–2015. The differences between the original and modified submissions are outlined in paragraph 7 above.

10. In decision 1/CP.16, paragraph 70, the COP encouraged developing country Parties to contribute to mitigation actions in the forest sector by undertaking a number of activities, as deemed appropriate by each Party and in accordance with their respective capabilities and national circumstances, in the context of the provision of adequate and predictable support. The FRL proposed by Panama, on a voluntary basis, for a TA in the context of results-based payments, covers the activities “reducing emissions from deforestation”, “reducing emissions from forest degradation”, “conservation of forest carbon stocks”, “sustainable management of forests” and “enhancement of forest carbon stocks”.¹⁴ Panama stated that considering these activities as a whole would serve as a benchmark for assessing the country’s performance, without attributing progress to specific, separate activities. Pursuant to paragraph 71(b) of the same decision, Panama developed a national FRL covering its entire territory. For its submission, Panama applied a stepwise approach to developing the FRL, including in the report a description of planned improvements, in accordance with decision 12/CP.17,

¹¹ <https://redd.unfccc.int/submissions.html?country=pan>.

¹² Food and Agriculture Organization of the United Nations. FAOSTAT database. Available at <http://faostat.fao.org>.

¹³ In decision 1/CP.16, paragraph 70, the COP encouraged developing country Parties to contribute to mitigation actions in the forest sector by undertaking the following activities: reducing emissions from deforestation; reducing emissions from forest degradation; conservation of forest carbon stocks; sustainable management of forests; and enhancement of forest carbon stocks.

¹⁴ The five activities included in decision 1/CP.16, paragraph 70.

paragraph 10. The stepwise approach enables Parties to improve their FRELs/FRLs by incorporating better data, improved methodologies and, where appropriate, additional pools.

11. The proposed FRL includes the pools above-ground biomass, below-ground biomass, deadwood and litter. Regarding greenhouse gases (GHGs), the FRL is based on CO₂ emissions and non-CO₂ (i.e. CH₄ and N₂O) emissions from fires on forest land remaining forest land.

II. Data, methodologies and procedures used in the construction of the proposed forest reference level

How each element in the annex to decision 12/CP.17 was taken into account in the construction of the forest reference level

1. Information that was used by the Party in the construction of the forest reference level

12. The scope of the FRL includes all five REDD-plus activities included in decision 1/CP.16, paragraph 70: reducing emissions from deforestation, reducing emissions from forest degradation, conservation of forest carbon stocks, sustainable management of forests, and enhancement of forest carbon stocks. The AT noted that the estimates for the FRL include the total emissions and removals from land conversions to forest land, forest land conversions to other land uses and forest land remaining forest land, and correspond to the aggregated emissions and removals resulting from the five REDD-plus activities. The AT acknowledges that Panama states in its submission and modified submission that the forest definition and its application to activities are in accordance with decision 1/CP.16, paragraph 70.

13. Panama, in its modified submission, selected 2000–2015 as the historical reference period whereas in its original submission, the Party used a reference period of 2006–2015. Panama clarified that this change was necessary in order to remain consistent with the latest national communication, which includes information dating back to 2000; this was possible since there were land-use change data available from that year.

14. For the construction of the FRL, Panama used the methodologies in the 2006 IPCC Guidelines (volumes 1 and 4). Forest land was stratified by forest type (i.e. mature forest, secondary forest, mangrove, disturbed forest, coniferous plantation and broadleaf plantation). In order to assign AD to the land-use categories, Panama applied hierarchical classification rules on the basis of the percentage of each sampling unit that had a particular type of land cover (see paras. 15 and 21 below). Although the 2006 IPCC Guidelines recommend a default 20-year transition period, the Party has decided to include in its forest land remaining forest land category those lands that have been in the non-forest to forest category after a transition period of at least six years of age. GHG emissions in forest land remaining forest land were estimated using a combination of direct (remote sensing) and indirect (statistical) approaches. Historical annual GHG emissions and removals were estimated using emission and removal factors associated with various forest strata derived from the scientific literature, national reports, the results of the INFC pilot phase and the 2006 IPCC Guidelines. FRL values for the period 2016–2020 were calculated using the historical average.

15. The AD for historical land use and land-use change for each year of the period 2000–2015 were obtained from a land use and land-use change assessment conducted using the Collect Earth sampling approach. The sampling design comprised a systematic grid of 3 km x 3 km units for the entire country except the Darién and Colón provinces, for which the units were intensified to 1.5 km x 1.5 km. This design resulted in a total of 13,796 sampling units. Each unit consisted of a rectangle of 0.5 ha that was visually interpreted using free satellite imagery (Landsat 7 Enhanced Thematic Mapper Plus, Landsat 5 Thematic Mapper, Landsat 8 Operational Land Imager and very high resolution images from Google Earth¹⁵). The assessment was done by 26 local interpreters, who used a set of defined hierarchical rules and labelling protocols to assign a land-use class to each sampling unit for each of the years of the assessment period. The hierarchical rules were applied consistently

¹⁵ <http://www.openforis.org/tools/collect-earth.html>.

in assigning a land use, which was done on the basis of the percentage of area within each sampling unit that had a particular type of land cover, beginning with settlements (at least 20 per cent cover) and followed by crops (20 per cent), trees (30 per cent), pasture (20 per cent), wetlands (20 per cent) and other lands (>80 per cent). As a result of this assessment, annual data on land use were collected and later underwent quality assurance and/or quality control (QA/QC) in order to improve their quality and correct some “impossible” transitions, as defined by ecological succession (e.g. cropland cannot become secondary forest without first becoming grassland). These impossible transitions are described in the modified submission (table 12 in section 3.4.3.1). The QA/QC procedure resulted in the creation of a forest type that was not initially considered: mature disturbed forest. This forest type was identified in sampling units in which a transition from mature forest to secondary forest without total clearance of forest took place or in which mature forest was partially cleared. The resulting annual transition matrices were later used to estimate annual GHG emissions and removals.

16. The AD for forest fires on forest land remaining forest land were obtained from the Forest Department of the Ministry of Environment, as reported in Salazar (2017),¹⁶ from which an initial time series for the period 2005–2015 was obtained, including aggregate information for forests and agricultural areas.

17. The AD for wood and fuelwood removals used to estimate GHG emissions from forest land remaining forest land and not related to conversions were obtained from FAOSTAT.¹⁷ These data are considered to be official data reported by Panama. The Party clarified in the submission that it is planning to consider improving the data collection system in order to improve the quality of these data.

18. The carbon stock estimates used as EFs for above-ground biomass, deadwood and litter for all different forest types, except pine plantation, were based on data from the INFC pilot phase. In the case of the forest type “mature disturbed forest”, the carbon stock estimates were based on a combination of carbon stocks of secondary forest and mature forest, as identified in the INFC pilot phase. Below-ground biomass was estimated through root/shoot ratios derived from the scientific literature and the 2006 IPCC Guidelines. Annual growth values for above-ground biomass used to estimate GHG removals were sourced from the 2006 IPCC Guidelines and the *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands* (hereinafter referred to as the Wetlands Supplement), except for mature forest remaining mature forest, for which the underlying assumption was revised according to the latest scientific research resulting in the modified assumption that the net gains and losses were zero as per Chave et al. (2008).¹⁸ EFs for CH₄ and N₂O applied to burned areas of forest land remaining forest land were based on default values for tropical forests in the 2006 IPCC Guidelines (volume 4, chapter 2).

2. Transparency, completeness, consistency and accuracy of the information used in the construction of the forest reference level

Methodological information, including description of data sets, approaches and methods

19. The AT noted that Panama did not maintain consistency in the methods, data and assumptions between its most recent national GHG inventory (included in its second national communication submitted in 2012¹⁹) and the submitted FRL, as required by decision 12/CP.17, paragraph 8. During the TA, the Party clarified that the data, methodology and approaches used for future GHG inventories, as well as any improvements, will be consistent and aligned with the FRL. The AT commends Panama for its initiative regarding this matter.

20. Panama clarified in its original submission that forest degradation is the transition from mature forest to disturbed forest, and that this conversion class was not initially

¹⁶ Salazar EL. 2017. Consultoría: Apoyo para fortalecer las capacidades técnicas de la Unidad de Cambio Climático. Contrato No. 11013 PAN 2017.

¹⁷ Forestry production and trade data for “Industrial roundwood, non-coniferous tropical (export/import)”. See <http://www.fao.org/faostat/en/#data/FO>.

¹⁸ Chave J, Condit R, Muller-Landau HC, et al. 2008. Assessing evidence for a pervasive alteration in tropical tree communities. *PLoS Biol.* 6(3): e45. Available at <https://doi.org/10.1371/journal.pbio.0060045>.

¹⁹ Available at <https://unfccc.int/documents/138834>.

identified in the land-use assessment but was added later, after determining that it was possible to measure forest degradation. The Party indicated that it based its degradation categorization on the interpretation of a time series of satellite images available using Collect Earth. The person responsible for interpreting the images could detect the forest disturbance event, which still complied with the definition of forest, within the reference period and could follow the land-use dynamics within the sampling unit over time. During the TA, Panama clarified that in practice, sampling units of forest degradation are either: (1) sampling units that are “partially deforested”; or (2) sampling units that have transitioned from mature forest to secondary forest but for which no clearance of vegetation occurred prior to the conversion to disturbed forest (with clearance, the classification would be secondary forest). With regard to (1), the AT noted that although these sampling units may comply with the Party’s definition of forest degradation (partial loss of canopy cover), they may be in reality deforestation events that are not fully covered by the sampling unit. In essence, they are part of the random error that occurs at the boundary between forest and non-forest, which is common in sampling strategies. The implications are that the forest cover of mature forest will be underestimated to a certain extent because, if a given sampling unit is close to the border of a forest or a secondary forest, it will not be classified as mature forest despite the fact that it partially contains forest. This underestimation would, however, occur in every period so it should not lead to a systematic error. With regard to (2), the AT noted that the detection of this type of degradation depends on the magnitude of the disturbance and the resolution of the imagery: low-level disturbance events can be identified only through high or very high resolution imagery, while high-level disturbance may be detected with medium resolution imagery, which is the main type of imagery available. Panama indicated that sampling units that show a transition from mature forest to secondary forest through a prior transition to non-forest are not classified as forest degradation, and also clarified that this occurs very rarely and only represents 0.12–0.66 per cent (average of 0.34 per cent) of the total annual net emissions included in the historical reference period, not representing a significant error in the final FRL estimates. During the TA, the AT noted that Panama may wish to enhance the transparency of future submissions by providing these explanations and including additional information on the operationalization of the definition of forest degradation. In response, Panama increased the transparency of its modified submission by providing a description of how the transitions are interpreted in practice (section 7.5).

21. The AD for historical land use and land-use change were obtained from the visual interpretation of satellite imagery. As described in paragraph 15 above, a set of hierarchical rules was established to assign a land use to each sampling unit on the basis of the percentage of its area occupied by a particular type of land cover. In terms of the interpretation protocol, during the TA Panama clarified the rules to distinguish: (a) secondary forest and (b) *rastrajo*.²⁰ Secondary forest is a successional state after total clearance of vegetation and subsequent *rastrajo* which becomes a forest after a number of years, so it can be classified by clearance that has occurred in previous years. *Rastrajo* is the initial stage of succession to secondary vegetation that does not reach its threshold of 5 m height. Panama clarified that *rastrajo* is not officially considered secondary forest until it reaches five years of maturity, and that this ‘rule’ was used by interpreters to distinguish when ‘new’ *rastrajo* becomes a secondary forest. Moreover, based on local regulations, *rastrajo* may be considered as forest if the area is legally classified for forest use. Although the clarifications given were useful to understand the operationalization of the forest definition, the AT considered that Panama could enhance the transparency and completeness of the submission by clarifying how it assessed the entire data set of sampling units collected initially to identify those that contained disturbed forest and by providing a more detailed description of the interpretation protocol and the set of rules used. As a result of this request, the Party provided more information on these issues in the modified submission including details of the actual procedure for interpreting sampling units (section 7.5). However, the AT notes it is still unclear how temporal rules could be replaced at the beginning of the period of the land-use change assessment (i.e. year 2000): yet, the AT considers that this issue should have minor

²⁰ “Stubble” is the literal translation in English. According to the modified submission, *rastrajo* is defined as the secondary vegetation of arboreal, shrub and herbaceous species that appears naturally after agricultural use. It has an average height of less than 5 metres.

implications as the assessment interpreters looked back to images circa 1990. The AT notes that no areas of *rastrojo* have been classified as forest based on the legal designation since there are no data by which to make this operational (section 5.1 of the modified submission).

22. In the original submission, Panama estimated GHG emissions from forest fires using AD sourced from official statistics from the Directorate for the Protection of Environmental Quality of the Ministry of Environment. The Party clarified during the TA that the data comprise burned areas in forests, as measured in the field and reported by specialists. The AT noted that Panama could enhance the transparency and completeness of future submissions by providing more information on this source of AD. In response, Panama provided in its modified submission additional information as follows. Forest fire data were collected in the field by officials with training in the use of the Global Positioning System (GPS) and in fighting forest fires. They were also trained in the identification of vegetation types: disturbed primary forest, secondary forest, stubble, mangrove forest, planted forest, low vegetation floodplain, grasses (grasslands and pastures), established agricultural crops and pastures (under agricultural use). Point surveys were made using GPS to obtain the perimeter of areas affected by the fire and to determine their surface condition. The collection and archiving of these data is centralized by the Forest Department of the Ministry of Environment. The data were reported in Salazar (2017), from which an initial time series for the period 2005–2015 was obtained that includes aggregate information for forests and agricultural areas. The burned areas were classified according to the classes of forest land, cropland within pastures and Gramineae. Details of the classification of the burned areas can be found in the Excel file, sheet “Fire areas” (see para. 36 below). The AT commends Panama for improving the transparency of the submission by providing this information.

23. As described in the original submission, Panama estimated the AD through a workshop (“Mapatón”) in which participants (interpreters) from various regions in Panama and with at least some knowledge in informatics and with expertise in land-use dynamics conducted the land-use assessment. Twenty-six participants working in data collection were given three days of training, during which the software and the classification protocol were taught to them as well as refined together with them. Data collection was completed in two weeks. During the TA, Panama clarified that once the data were collected, they underwent QA/QC in several stages. First, the data were cleaned using the data cleaning tool Collect.²¹ Second, the sampling units that showed “impossible” transitions were re-classified. Third, the sampling units were overlaid onto a 2012 land-cover map based on RapidEye satellite imagery, and the sampling units that were not consistent with the map were re-interpreted. The AT noted that these stages form a robust QA/QC procedure, but they were not included in the original submission. In response, Panama included in its modified submission further details on the data collection and QA/QC process, including the filtering rules applied. The AT noted, however, that when visual interpretation is conducted by various interpreters, with imperfect satellite imagery and including many classes, some of which are not fully described in the classification protocol, the measurement error could become very significant. The AT stresses the importance of having clear procedures in place for future assessments of AD, having a routine to re-evaluate a percentage of the sampling units in order to confirm the effective implementation of the standard operating procedures, and, potentially, using more than one interpreter for each sampling unit. As shown in McRoberts et al. (2018),²² using only one interpreter can lead to significant bias in the estimation and a large uncertainty which could exceed the statistical sampling uncertainty.

24. The AT noted that the following technical improvements could be made in the application of Collect Earth imagery to land-use assessment, which could improve the accuracy of Panama’s historical data: Aster 15 m resolution images are available in Google Earth Engine for the period 2000–2012; RapidEye imagery available to Panama could be loaded into a geographic information system platform and synchronized with Google Earth; 32-day cloud-free composites from Landsat 5, Landsat 7 and Landsat 8 exist in Google Earth

²¹ Available at <http://www.openforis.org/tools/collect.html>.

²² McRoberts RE, Stehman SV, Liknes GC, et al.. 2018. The effects of imperfect reference data on remote sensing-assisted estimators of land cover class proportions. *ISPRS Journal of Photogrammetry and Remote Sensing*. 142(August): pp.292–300. Available at <https://doi.org/10.1016/j.isprsjprs.2018.06.002>.

Engine, which allow images to be better attributed to a certain year; and ALOS PALSAR²³ and Sentinel 1 imagery are now available. Moreover, the script of Google Earth Engine used provides a Sentinel 2 composite of the greenest pixels in the 365 days prior to the day of assessment, not of the last calendar year.

25. In Panama's original submission, the biomass densities used to derive some of the emission and removal factors were based on data from three independent inventories with different geographical scopes and methods: 33 sampling units from the INFC pilot phase; 49 sampling units from the natural forest inventory in the hydrological basin of the Panama Canal, conducted in 2015; and 10 sampling units from the *rastrojo* inventory in the hydrological basin of the Panama Canal, also conducted in 2015. During the TA, Panama clarified that data from 82 sampling units had been collected as part of the INFC pilot phase, with data from a few sampling units in indigenous territories remaining to be collected. The AT noted that INFC has a robust sampling design covering the whole country and a consistent methodology for data collection which if used would strengthen the consistency and accuracy of future submissions. The AT also noted constraints in using data from different inventories, especially in aligning the data with the land-use classification system used in Collect Earth and in using plots with different sizes, which might require the use of ratio estimators to estimate the carbon stocks. In response, Panama increased the accuracy of EFs and based the carbon stocks solely on estimates derived from the INFC pilot phase. The AT further noted that Panama may wish to update the emission and removal factors in future submissions with estimates derived from INFC, once the inventory is finalized. Moreover, because the sampling units of INFC can be overlapped with the sampling units of the Collect Earth land-use survey, the Party could consider using the Collect Earth survey to assign sampling units of INFC to each stratum.²⁴

26. Panama indicated in its original submission that biomass density in mangrove forests was sourced from the Wetlands Supplement (table 4.3). The AT noted that this value is for subtropical regions and might be inconsistent with the application of other IPCC default values for which Panama assumed a tropical humid climate. During the TA, The Party clarified that as part of INFC, data from a number of additional mangrove sampling units have been collected. Panama improved the accuracy of its modified submission by using the results of the INFC pilot phase to estimate the carbon stocks in mangrove forests. The AT commends Panama for this improvement.

27. In Panama's original submission, the biomass densities sourced from the terrestrial inventory data were estimated using the equation of Cairns et al. (1997).²⁵ The AT noted that this equation is not consistent with the method used to estimate growth in below-ground biomass, which is based on the 2006 IPCC Guidelines. Panama corrected this issue in the modified submission by using the equation of Cairns et al. (1997) in a consistent manner. The AT noted, however, that Mokany et al. (2006),²⁶ from which the 2006 IPCC Guidelines default values are sourced, provides values that might be more accurate than those of Cairns et al. (1997). Panama may wish to consider using, in future submissions, a source that is more accurate than Cairns et al. (1997), such as the 2006 IPCC Guidelines.

28. In Panama's original submission, 0.49 is the fraction of carbon used for all forest types except for mangrove forests and broadleaf plantations. The AT noted that this is the value for "wood, tree diameter > 10 cm" in the 2006 IPCC Guidelines (table 4.3), and that it is applied to total biomass, whereas table 4.3 of the 2006 IPCC Guidelines provides other default values

²³ Advanced Land Observing Satellite (ALOS) Phased Array type L-band Synthetic Aperture Radar (PALSAR).

²⁴ Some possible ways to address this issue are provided by Birigazzi L, Gamarra JGP and Gregoire TG. 2018. Unbiased emission factor estimators for large-area forest inventories: domain assessment techniques. *Environmental and Ecological Statistics*. 25(2): pp.199–219. Available at <https://doi.org/10.1007/s10651-018-0397-3>.

²⁵ Cairns MA, Brown S, Helmer EH, et al. 1997. Root biomass allocation in the world's upland forests *Oecologia*. 111(1): pp.1–11. Available at <https://doi.org/10.1007/s004420050201>.

²⁶ Mokany K, Raison RJ, and Prokushkin AS. 2006. Critical analysis of root: shoot ratios in terrestrial biomes. *Global Change Biology*. 12(1): pp.84–96. Available at <http://dx.doi.org/10.1111/j.1365-2486.2005.001043.x>.

that are applicable to total biomass and might be more accurate. In response, Panama modified the value to 0.48, which better adheres to the 2006 IPCC Guidelines.

29. The AT commends Panama's inclusion of removals from forest land remaining forest land, which improves the completeness of the estimates of emissions and removals. In Panama's original submission, a value of 3.62 t dry matter/ha/year of gains for mature forests is assumed, as sourced from Malhi et al. (1999),²⁷ which reports a study conducted in Barro Colorado. This value is applied on a yearly basis to mature forest remaining mature forest and it is applied across the time series. The AT noted that, according to Malhi et al. (1999), the value is 3.62 t carbon/ha/year, which is equivalent to 7.24 t dry matter/ha/year, and it refers to wood, not total biomass. In addition, it was unclear in Panama's submission whether the value referred to net primary growth. The AT, therefore, asked Panama to clarify whether the value applied is accurate and representative of the conditions observed in Panama. In response, and based on an additional literature review by the Party, Panama assumed zero carbon stock changes for standing mature forests. The AT considers this assumption is consistent with the findings of Chave et al. (2008), which show that net biomass change for tropical forest in Barro Colorado is zero or even a negative value.

30. In its original submission, Panama assumed that disturbed forest remaining disturbed forest grows at 30 per cent of the rate of mature forests. During the TA, the Party clarified that this growth rate is based on the assumption that in disturbed forests, at least 30 per cent of the area is covered by trees that remain from the undisturbed stage of mature forests, and therefore that the growth rate is 30 per cent of that of a mature forest. The AT acknowledges the challenge in deriving data for disturbed forests, but noted that the remaining 70 per cent of the area might include secondary formations or be regenerating at a higher growth rate. In response, Panama modified its assumption for the growth rate of disturbed forests to 70 per cent of the rate of secondary forests, which better adheres to the adopted IPCC guidance and guidelines.

31. The original submission included methods to estimate emissions and removals from forest land converted to other land uses that followed the guidance in the 2006 IPCC Guidelines. Panama assumes that lands on which conversion to other land-use categories occurs are accounted for in the conversion land-use change category in the year of change, and that in the following year, they are accounted for in the land-use change category of land remaining that land. The AT noted that it would enhance the transparency of future submissions if this information and any other information on methodological choices was presented in the main report rather than in the annexes. In its modified submission, Panama included detailed information on methodological options and choices it made in the construction of its FRL, thereby improving the transparency of its reporting.

32. In the case of non-forest land being converted to forest land, i.e. conversion from *rastrojo* to secondary forest, in the year in which this transition occurs, the carbon stock of the land is instantaneously changed from the average carbon stock of *rastrojo* to the average carbon stock of secondary forests. The AT noted that this practice could overestimate removals from the transition of non-forest land to forest land since this transition in reality occurs over a number of years; yet, this overestimation might be partially mitigated for emission reduction estimation if the same assumption is used for monitoring. The AT acknowledges the Party's approach might be appropriate if the age of the secondary forest is not known, but noted that in Panama's case, the age of the secondary forest can be inferred because the year of conversion is known; therefore, it might be possible to estimate removals on a yearly basis. The AT acknowledges that this approach might require more complex and laborious calculations and increased capacity that may take time and resources. Panama may wish to consider revising its assumption regarding the carbon stock of non-forest land converted to forest land in future submissions so as to improve the accuracy of the estimates of GHG removals for all carbon pools.

33. Panama assumes an annual biomass growth value of 11 t dry matter/ha/year as prescribed in the 2006 IPCC Guidelines for a young secondary forest (<= 20 years). However, the value for a mature secondary forest (>20 years) is approximately 3.1 t dry matter/ha/year.

²⁷ Malhi Y, Baldocchi DD and Jarvis PJ. 1999. The carbon balance of tropical, temperate, and boreal forests. *Plant, Cell and Environment*. 22: pp.715–740.

The AT considers that Panama's application of the value for young forests to all the secondary forests might overestimate removals. Because the Party has data on forest cover going back to 1990, it can infer the age of a significant part of the secondary forest in each sampling unit and attribute the right rate to the forest in that unit. The AT acknowledges that this approach might require more complex and laborious calculations and increased capacity that will require additional resources. Panama may wish to consider revising, in future submissions, its assumptions regarding biomass density and growth rate in order to improve the accuracy of its estimates.

34. The AT commends Panama for providing a complete calculation spreadsheet, which enabled the estimation of GHG emissions and removals of all sources and sinks in a transparent manner. The AT identified some errors in the formulae in the spreadsheet. In response, Panama corrected the errors and simplified the overall spreadsheet, thereby improving the transparency and accuracy of its reporting.

35. The AT acknowledges that both the original and the modified submission provided information on the uncertainties of EFs but notes that estimates of the uncertainties of AD and a propagation of the uncertainties of both AD and EFs were not provided. The AT recommends a future improvement to the uncertainty analysis through the estimation of the uncertainty of the AD (yearly transition matrices) and the propagation of this uncertainty with that of EFs and other factors. This could be done through either method to propagate uncertainties, Approach 1 or Approach 2, but considering the complexity of the transition matrices and the possibility that the Probability Distribution Functions are non-normal, Approach 2 might be more appropriate.

Description of relevant policies and plans, as appropriate

36. In its FRL submission, Panama provided a detailed description of relevant policies and plans. The modified submission also includes information on national circumstances, including policy context and population growth (sections 1 and 2). One significant initiative reported is the Alliance for the Million,²⁸ a public-private partnership that seeks to reforest one million hectares in the period 2015–2035. The implementation of this programme was the catalyst for the approval by the Government of Law No. 69 (30 October 2017), under which a programme providing incentives for increasing forest cover and conserving natural forests was established. The date of approval of the Alliance is consistent with the endpoint of the reference period and the starting point of the validity period of the reference period.

3. Pools, gases and activities included in the construction of the forest reference level

37. According to decision 12/CP.17, annex, subparagraph (c), reasons for omitting a pool and/or activity from the construction of the FRL should be provided, noting that significant pools and/or activities should not be excluded. The AT noted that in Panama's submission non-CO₂ emissions from forest land converted to non-forest land were not considered and adequate justification for this omission was not provided; however, the AT considers this source might not be significant. Panama may wish to improve the transparency of future submissions by providing a table summarizing the pools and gases included in the FRL.

38. The pools included in the FRL are above-ground and below-ground biomass, deadwood and litter. The SOC pool was included in the original submission, but Panama decided to exclude it in its modified submission owing to the lack of data to provide accurate estimates.

39. The AT considers that exclusion of the SOC pool is adequately justified by Panama and commends the Party's efforts to obtain better information on this pool, with the aim of including it in future submissions as part of the stepwise approach. The AT concludes that emissions from the SOC pool are likely to be insignificant and their exclusion in this submission is justified.

40. The AT commends Panama for including non-CO₂ emissions from forest fires on forest land remaining forest land in its submission. Non-CO₂ emissions from the conversion of forest land to other land-use classes were excluded. The AT noted that this might constitute

²⁸ *Alianza por el millón* in Spanish. See <https://www.alianzaporelmillon.org/>.

an underestimation of GHG emissions as ‘slash and burn’ agriculture, including in mature forests, occurs in Panama (Tschakert et al., 2007²⁹). The underestimation would, however, be small as non-CO₂ emissions from fires comprise a small proportion of the total GHG emissions from deforestation, and Panama included most of the carbon pools, gases and activities. Nevertheless, Panama did not justify the exclusion of this source so the AT notes that the transparency and completeness of the submission would be improved by including such a justification.

41. The AT commends Panama for developing a FRL that serves as a benchmark for assessing the country’s performance in implementing all five activities identified in decision 1/CP.16, paragraph 70, in accordance with its national capabilities and circumstances. In addition, the FRL is constructed with an overall estimate of emissions by sources and removals by sinks that serves as a benchmark for all activities.

4. Definition of forest

42. Panama provided in its submission the definition of forest used in the construction of its FRL. According to this definition, a forest is an area of land of at least 0.5 ha with a canopy cover of 30 per cent or more and with trees higher than 5 m. The definition excludes lands that are predominantly agricultural or urban, in accordance with Panamanian legislation. This has been made operational through the application of hierarchical rules, as described in paragraph 15 above.

43. The AT commends Panama for the completeness of the information in the section of the submission on forest definition, which also includes definitions of other land-use categories and subcategories and biophysical characteristics of each. Panama differentiates between mature forest and two successional stages in the establishment of mature forest, namely *rastrajo* and secondary forest. During the TA, the Party clarified that *rastrajo* could become secondary forest after five years if no disturbances occur. Moreover, Panama clarified that based on local regulations, *rastrajo* may be considered as forest if the area is legally classified for forest use. The AT notes that no fallows have been classified as forest based on legal designation as there are no data to make this operational (section 5.1 of the modified submission).

44. The AT noted that Panama’s forest definition is different from the one the Party used for its national GHG inventory, but that the former is contained in the latter. In the latest inventory (year 2000), the definition of forest was a minimum area of 0.5–1.0 ha, a minimum crown cover of 10–30 per cent and a minimum tree height of 2–5 m. As clarified by Panama in the submission, the definition adopted for the FRL will be contained in future GHG inventories and used to update the estimates reported in previous inventories (e.g. year 2000). Panama also clarified that the upcoming national communication will incorporate these updated estimates. The AT commends Panama for including these details in the modified submission.

45. The definition of forest is consistent with the one the Party used for reporting to the FAO Global Forest Resources Assessment (FRA) in 2015, although Panama’s definition was adapted to the common definition of FRA, which uses 10 per cent canopy cover. In terms of total area, the area of forest for 2015 reported in the FRA is 4,617,000 ha compared with 4,344,752 ha reported for 2015 in the FRL submission. Panama clarified in the modified submission that the FRA estimate was based on a 2012 land-cover map that was prepared using a different methodology from the map used for the FRL. The AT commends Panama for including these details in the modified submission.

²⁹ Tschakert P, Coomes OT and Potvin C. 2007. Indigenous livelihoods, slash-and-burn agriculture and carbon stocks in Eastern Panama. *Ecological Economics*. 60(4): pp.807–820. Available at <https://doi.org/10.1016/j.ecolecon.2006.02.001>.

III. Conclusions

46. The information used by Panama in constructing its FRL is transparent, complete and in overall accordance with the guidelines for submissions of information on reference levels (as contained in the annex to decision 12/CP.17).

47. The FRL presented in the modified submission, for the reference period 2000–2015, corresponds to $-27,735,675$ t CO₂eq/year. The AT noted that Panama changed the reference period from 2006–2015 in the original submission to 2000–2015 in the modified submission.

48. The AT acknowledges that Panama provided a comprehensive submission, which included all activities and all significant carbon pools except the SOC pool; namely, the submission included CO₂ emissions and removals for land-use change, and CH₄ and N₂O emissions for fires on forest land remaining forest land. The AT found that the exclusion of the SOC pool was justified in the modified submission. Non-CO₂ emissions from non-forest land converted to forest land were not included, and though the AT considers this source might not be significant, it notes that Panama did not provide an appropriate justification for the omission in its modified submission. The AT considers that Panama followed decision 1/CP.16, paragraph 71(b), on the elaboration of a national FRL and decision 12/CP.17, paragraph 10, on implementing a stepwise approach. The AT commends Panama for the information provided on the identified areas for improvement of the FRL in the modified submission (section 7).

49. As a result of the facilitative interactions with the AT during the TA, Panama submitted a modified submission, which took into consideration the technical inputs of the AT. The AT notes that the transparency and completeness of information improved significantly in the modified FRL submission and commends Panama for the efforts it made. The new information provided in the modified submission, including the data made available online,³⁰ increased the reproducibility of the FRL calculations.

50. The AT notes that, overall, the FRL does not maintain consistency, in terms of sources of AD and EFs, with the GHG inventory included in Panama's national communication.³¹ However, the Party indicated that consistency would be achieved in the national GHG inventory to be included in the next national communication.

51. Pursuant to decision 13/CP.19, annex, paragraph 3, the AT identified the following areas for future technical improvement:

(a) Address the measurement or interpretation error in land-use assessment by adjusting QA/QC procedures (see para. 23 above);

(b) Make technical improvements to the application of Collect Earth imagery, which could improve the historical data (see para. 24 above);

(c) Update the emission and removal factors with carbon stock estimates derived from data from the complete INFC rather than its pilot phase (see para. 25 above);

(d) Consider revising the assumption, for non-forest land converted to forest land (secondary forest), that in the year of transition the carbon stocks instantaneously change from non-forest to the average of secondary forests, which results in overestimation of removals, and instead consider estimating removals on a yearly basis by adopting fully integrated methods for estimating GHG emissions and removals in accordance with the 2006 IPCC Guidelines (volume 4, section 4.3). Panama may consider revising this assumption so as to improve the accuracy of the estimates of GHG removals for all carbon pools (see para. 32 above);

(e) Consider revising the assumption regarding the carbon stock of non-forest land converted to forest land in future submissions given that the age of the secondary forest can

³⁰ https://drive.google.com/open?id=109P_7gyatWnEi61vYljpygoyYfgWiSY1 and <https://drive.google.com/open?id=0ByBGYgD77uxwS0xMVDB6a2hpeGs>.

³¹ In reference to the scope of the TA, decision 13/CP.19, annex, paragraph 2(a).

be inferred since the year of conversion is known, so as to improve the accuracy of the estimates of GHG removals for all carbon pools;

(f) Consider revising the assumption that above-ground biomass in secondary forest remaining secondary forest grows at a rate of 11 t dry matter/ha/year, which might overestimate removals (see para. 33 above);

(g) Consider undertaking a full uncertainty analysis of the estimates (see para. 35 above);

(h) Further consider the use of stratification as a way to improve estimations of AD, as proposed by Panama in section 7.2 of the modified submission.

52. In assessing the pools and gases included in the FRL, pursuant to decision 13/CP.19, annex, paragraph 2(f), the AT identified the following additional areas for future technical improvement:

(a) Treatment of emissions and removals from the SOC pool (see para. 39 above);

(b) Treatment of non-CO₂ gases in forest land converted to other land in such a way that is consistent with the 2006 IPCC Guidelines and related guidance (see para. 40 above).

53. The AT acknowledges and welcomes the intention expressed by Panama to improve the data for wood and fuelwood removals to improve future estimates of the FRL.

54. In conclusion, the AT commends Panama for showing a strong commitment to the continuous improvement of its FRL estimates, in line with the stepwise approach. A number of areas for future technical improvement of Panama's FRL have been identified in this report. At the same time, the AT acknowledges that such improvements are subject to national capabilities and policies, and notes the importance of adequate and predictable support.³² The AT also acknowledges that the assessment process was an opportunity for a rich, open, facilitative and constructive technical exchange of information with Panama.

55. The table contained in the annex summarizes the main characteristics of Panama's proposed FRL.

³² Decision 13/CP.19, annex, paragraph 1(b), and decision 12/CP.17, paragraph 10.

Annex

Summary of the main features of the proposed forest reference level based on information provided by Panama

	<i>Main features of the FRL</i>	<i>Remarks</i>
Proposed FRL (in t CO ₂ eq/year)	-27 735 675 (total)	The national FRL includes CO ₂ emissions and removals, and CH ₄ and N ₂ O emissions from forest fires on forest land and any forest land conversion (see para. 9 of this document)
Type and duration of FRL	FRL = historical emissions 2000–2015	See paragraph 13 of this document
Adjustment for national circumstances	No	–
National/subnational	National	–
Activities included	Reducing emissions from deforestation, reducing emissions from forest degradation, conservation of forest carbon stocks, sustainable management of forests, enhancement of forest carbon stocks	Mature forest remaining mature forest is assumed to have a removal value of zero (see para. 29 of this document)
Pools included	Above-ground biomass, below-ground biomass, deadwood, litter	Panama did not include soil organic carbon in the modified submission owing to the lack of data (see paras. 37 and 38 of this document). Panama provided a justification for the omission
Gases included	CO ₂ , CH ₄ , N ₂ O	CH ₄ and N ₂ O emissions from forest fires on forest land remaining forest land are included (see para. 40 of this document)
Forest definition	Included	Minimum area 0.5 ha, minimum crown cover 30 per cent and minimum tree height 5 m (see para. 42 of this document). This definition differs from that in the GHG inventory (2000), which is minimum area 0.5–1.0 ha, minimum crown cover 10–30 per cent and minimum tree height 2–5 m (see para. 44 of this document)
Relationship with latest GHG inventory	Methods used for FRL are not consistent with the latest GHG inventory (2000)	Panama indicated it will work to achieve consistency between the FRL and the GHG inventory in the forthcoming GHG inventory (see para. 19 of this document)
Description of relevant policies and plans	Included	A detailed description of policies and plans is provided by Panama in its submission
Description of assumptions on future changes in policies	Not applicable	–
Descriptions of changes to previous FRL	Not applicable	–
Future improvements identified	Yes	Several areas for future technical improvements were identified (see para. 51 of this document)

Abbreviations: FRL = forest reference level, GHG = greenhouse gas.