



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

Summary

This report covers the technical assessment of the voluntary submission of Madagascar on its proposed forest reference emission level (FREL), in accordance with decision 13/CP.19 and in the context of results-based payments. The FREL proposed by Madagascar covers the activity “reducing emissions from deforestation”, which is among the activities included in decision 1/CP.16, paragraph 70. For its submission, Madagascar developed a national FREL. The FREL presented in the original submission, for the reference period 2005–2013, corresponded to 21,403,938 tonnes of carbon dioxide equivalent (t CO₂ eq) per year. As a result of the facilitative process during the technical assessment, as well as an update by the Party to the methodologies and activity data used, the reference period was changed to 2006–2015, while the FREL was modified to 34,342,327 t CO₂ eq/year. The assessment team notes that the data and information used by Madagascar in constructing its FREL are complete, partially transparent and in overall accordance with the guidelines contained in the annex to decision 12/CP.17. This report contains the assessed FREL 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 Madagascar on its proposed forest reference emission level (FREL),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. Manuel Estrada (Mexico) and Ms. Esther Mertens (Belgium). 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. Jenny Wong (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, Madagascar submitted its proposed FREL on a voluntary basis. Madagascar provided its submission in French. The proposed FREL 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 FREL and/or forest reference level (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 decision 13/CP.19, paragraphs 1 and 2, and decision 14/CP.19, paragraphs 7 and 8.

3. The objective of the TA was to assess the degree to which the information provided by Madagascar is in accordance with the guidelines for submissions of information on reference levels⁶ and to offer a facilitative, non-intrusive, technical exchange of information on the construction of the FREL with a view to supporting the capacity of Madagascar for the construction and future improvement of its FREL, as appropriate.⁷

4. The TA of the FREL submitted by Madagascar was undertaken in accordance with the guidelines and procedures for the TA of submissions from Parties on proposed FRELs and/or FRLs.⁸ This report on the TA was prepared by the AT following the same guidelines and procedures.

5. Following the process set out in those guidelines and procedures, a draft version of this report was communicated to the Government of Madagascar. The facilitative exchange during the TA allowed Madagascar to provide clarifications and additional information, which were considered by the AT in the preparation of this report.⁹ As a result of the facilitative interactions with the AT during the TA, Madagascar provided a modified version of its submission on 2 June 2018, which took into consideration the technical inputs of the AT. In addition, the Party modified the methodology for obtaining activity data and used the new data for the construction of the FREL in its modified submission. Information on the revised methodology used for the modified FREL was initially provided for information purposes and was contained in an annex to the original submission. According to Madagascar, the change in methodology will improve the consistency of the estimates over time. This TA report was prepared in the context of the modified FREL submission. The modified

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

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 Decision 12/CP.17, annex.

⁷ Decision 13/CP.19, annex, paragraph 1(a) and (b).

⁸ Decision 13/CP.19, annex.

⁹ Decision 13/CP.19, annex, paragraphs 1(b), 13 and 14.

submission, containing the assessed FREL, and the original submission are available on the UNFCCC website.¹⁰

B. Proposed forest reference emission level

6. In decision 1/CP.16, paragraph 70, the COP encourages developing country Parties to contribute to mitigation actions in the forest sector by undertaking a number of activities,¹¹ 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 FREL proposed by Madagascar, on a voluntary basis, for a TA in the context of results-based payments, covers the activity “reducing emissions from deforestation”, which is one of the five activities included in decision 1/CP.16, paragraph 70. Pursuant to paragraph 71(b) of the same decision, Madagascar developed a national FREL, which covers its entire territory. For its submission, Madagascar applied a stepwise approach to developing the FREL, in accordance with decision 12/CP.17, paragraph 10. The stepwise approach enables Parties to improve their FRELs/FRLs by incorporating better data, improved methodologies and, where appropriate, additional pools.

7. Madagascar submitted its first proposed FREL on 16 January 2017, followed by a modified submission on 8 July 2017.¹² The assessed FREL in Madagascar’s 2017 submission was 20,474,434 ± 3,366,669 tonnes of carbon dioxide equivalent (t CO₂ eq) per year for the historical reference period 2005–2013.¹³ The FREL proposed by Madagascar in 2018 is its second submission. The 2018 modified submission differs from the 2017 modified submission with the assessed FREL owing mainly to:

(a) New above-ground biomass and deadwood data for the dry forest ecoregion obtained from the 2017 forest inventory for that ecoregion (see paras. 15 and 22 below);

(b) New activity data for the reference period 2006–2015, estimated using a different data collection methodology that is based on stratified sampling of the four forest ecoregions¹⁴ (see para. 13 below).

8. The proposed modified FREL covers an altered historical reference period, 2006–2015. The FREL was constructed by summing the annual emissions per strata of each ecoregion, resulting in the total annual greenhouse gas (GHG) emissions over the 10-year reference period. The emissions are solely from deforestation, comprising non-CO₂ emissions from traditional slash-and-burn practices (tavy) and the emissions and post-deforestation removals in the deforested areas. The FREL presented in the modified submission is 34,342,327 t CO₂ eq/year,¹⁵ which is an increase of 67.7 per cent with respect to the assessed FREL proposed in the 2017 modified submission (see para. 7 above).

9. The activity data used in the construction of the FREL were derived from two sources that were used to create a stratified land use and deforestation map: (1) a historical time series of Landsat satellite imagery for the years 2005, 2010 and 2013 produced as part of an ecoregional REDD-plus project for humid forests (PERR-FH);¹⁶ and (2) the results from the

¹⁰ <https://redd.unfccc.int/submissions.html?country=mdg>.

¹¹ In decision 1/CP.16, paragraph 70, the COP encourages 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.

¹² Both are available at <https://redd.unfccc.int/submissions.html?country=mdg>.

¹³ See document FCCC/TAR/2017/MDG.

¹⁴ In its original and modified submissions of 2017 and its original submission of 2018, Madagascar used a pixel count methodology on a land cover change map to estimate areas of deforestation. According to the Party, this methodology did not ensure that the emissions are neither overestimated nor underestimated in line with guidance from the Intergovernmental Panel on Climate Change.

¹⁵ In its original submission of 2018, Madagascar had proposed a revised FREL of 21,403,938 t CO₂ eq/year, which was again revised in its modified submission of 2018.

¹⁶ This project (in French, *Projet Eco-Régional REDD+ des Forêts Humides*) was implemented in 2013–2015 as part of Madagascar’s REDD-plus readiness activities, undertaken by a consortium comprising the Wildlife Conservation Society, the Madagascar National Office for the Environment

analyses of the temporal Landsat image series for the period 2000–2012 (Hansen et al., 2013).¹⁷ Information on emission factors was obtained from: (1) Madagascar’s ecological national forest inventory (IEFN), published in 1996,¹⁸ for the spiny forests ecoregion; (2) an inventory in 2014 (under PERR-FH) of the eastern dense humid forests; (3) an inventory in 2017 of the dry forest ecoregion; and (4) a study by Jones et al. published in 2014 on mangroves.¹⁹

10. The carbon pools included in the FREL are above-ground and below-ground biomass, soil organic carbon and deadwood. The litter and harvested wood products carbon pools were excluded. Regarding GHGs, the submission includes CO₂ and the non-CO₂ gases methane and nitrous oxide from fires in deforested areas.

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

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

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

11. For the construction of the FREL, Madagascar used the methodologies in the Intergovernmental Panel on Climate Change (IPCC) *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (hereinafter referred to as the 2006 IPCC Guidelines).

12. In its submission, Madagascar defined deforestation as a direct and permanent anthropogenic conversion of a continuous area of forest of at least 1 ha to non-forest land.²⁰ Madagascar provided two examples of what it considers as deforestation in the construction of the FREL: areas converted by tavy, though such conversions are temporary, and the conversion of secondary forests to non-forest land uses.

13. Activity data were obtained through combining a deforestation map of all four forest types (dry forests, humid forests, spiny forests and mangroves) with a stratified sampling assessment. Both of the sources used by Madagascar for preparing the land-use and deforestation map with the necessary stratification (see para. 9 above) have a spatial resolution of 30 m × 30 m. The data from both sources were merged by superimposing the Hansen et al. (2013) images onto the images generated from PERR-FH. This process produced simplified land-use classes for the years 2005, 2010, 2012 and 2015 that allowed determination of simple but relevant strata for the period 2005–2016. Lastly, the spatial resolution of the final map (30 m × 30 m) was re-sampled at 90 m × 90 m. A decision tree was applied to determine if an area is forest land or has been deforested. Based on this majority-rule decision tree: if there was at least one 30 m × 30 m pixel of deforestation within the 90 m × 90 m pixel, the area was classified as deforested; if there was at least one

and Etc Terra, and funded by the International Development Association and the Global Environment Facility.

¹⁷ Hansen MC, Potapov PV, Moore R, Hancher M, Turubanova SA, Tyukavina A, Thau D, Stehman SV, Goetz SJ, Loveland TR, Kommareddy A, Egorov A, Chini L, Justice CO and Townshend JRG. 2013. High-resolution global maps of 21st-century forest cover change. *Science*. 342: pp.850–853. Data are available online at <http://earthenginepartners.appspot.com/science-2013-global-forest>.

¹⁸ The inventory (in French, Inventaire Ecologique Forestier National) is the only ecological forest inventory to cover all inland ecosystems in Madagascar. Its main objective was to fill the gaps in information on the current state and the evolution of forestry resources in Madagascar, which is crucial information for sustainable and strategic management of natural forest resources at the national and regional level. Therefore, this inventory aimed to identify the location and geographical distribution of the different forest formations. The inventory was completed in 1996.

¹⁹ Jones TG, Ratsimba HR, Ravaoarinorotsihoarana L, Cripps G and Bey A. 2014. Ecological variability and carbon stock estimates of mangrove ecosystems in northwestern Madagascar. *Forests*. 5(1): pp.177–205.

²⁰ In its original submission of 2018, Madagascar defined deforestation as a direct anthropogenic conversion of continuous forest land of at least 0.36 ha to non-forest land.

30 m × 30 m pixel of reforestation within the 90 m × 90 m pixel, the area was classified as forested/reforested; and if there was at least one 30 m × 30 m pixel of forest within the 90 m × 90 m pixel, the area was classified as forest. Any remaining areas were classified as non-forest.

14. In the next step, Madagascar used the deforestation map as the basis for stratified sampling to derive estimates of the activity data and the uncertainties. For the labelling of the classes of each reference sample (forest or non-forest), data from Landsat and other high-resolution imagery were used. The classification of the reference samples was done through a systematic 5 × 5 point grid. If the majority of points (i.e. 12 out of 24, or more than 50 per cent) was on forest land, the unit was classified as forest. The AT noted that Madagascar provided a detailed description of the methodology used to obtain activity data in its modified submission (see chapter 4).

15. The emission factors were derived from several forest inventories for the four different forest types (see para. 9 above). Madagascar is in the process of conducting a national forest inventory as part of its stepwise approach for further developing its FREL. The emission factor for dry forests, as used in the modified submission, has been updated with information from the 2017 dry forest ecoregion inventory.

16. Separate emission factors were estimated for each of the four forest types. Estimates were based on the difference between biomass in a natural forest, as the sum of above-ground and below-ground biomass, deadwood and soil organic carbon, and biomass of the land cover after deforestation. With the exception of mangroves, the biomass estimates for natural forests were derived from single inventories for each forest type. The post-deforestation carbon stocks were obtained from Andriamananjara et al. (2016)²¹ for humid forests and Raharimalala et al. (2012)²² for dry and spiny forests.

17. Following the findings of Styger et al. (2007;²³ 2009²⁴), Madagascar identified that the most likely post-deforestation land uses for humid forests are fallow with trees, fallow with bushes and degraded land. The Party assumed that the post-deforestation biomass for humid forest corresponded to that of fallow with bushes (which contains the highest biomass values of the three identified post-deforestation land uses). In the case of dry and spiny forests, the assumption is that natural regeneration takes place after 11 to 20 years following deforestation (corresponding to the default transition period in the 2006 IPCC Guidelines). For mangroves, post-deforestation biomass values are assumed to be similar to that of open mangroves and were based on values obtained from Jones et al. (2014). Soil organic carbon data for all ecoregions were obtained from the SoilGrids database (spatial resolution 250 m) of the International Soil Reference and Information Centre (ISRIC).²⁵

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

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

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- ²¹ Andriamananjara A, Hewson J, Razakamanarivo H, Andrisoa RH, Ranaivoson N, Ramboatiana N, Razafindrakoto M, Ramifehiarivo N, Razafimanantsoa MP, Rabeharisoa L, Ramananantoandro T, Rasolohery A, Rabetokotany N and Razafimbelo T. 2016. Land cover impacts on above-ground and soil carbon stocks in Malagasy rainforest. *Agriculture, Ecosystems and Environment*. 233: pp.1–15.
- ²² Raharimalala O, Buttler A, Schlaepfer R and Gobat J-M. 2012. Quantifying biomass of secondary forest after slash and burn cultivation in Central Menabe, Madagascar. *Journal of Tropical Forest Science*. 24(4): pp.474–489.
- ²³ Styger E, Rakotondramasy HM, Pfeffer MJ, Erick CM, Fernandes ECM and Bates DM. 2007. Influence of slash-and-burn farming practices on fallow succession and land degradation in the rainforest region of Madagascar. *Agriculture, Ecosystems and Environment*. 119(3–4): pp.257–269.
- ²⁴ Styger E, Fernandes ECM, Rakotondramasy HM and Rajaobelinirina E. 2009. Degrading uplands in the rainforest region of Madagascar: fallow biomass, nutrient stocks and soil nutrient availability. *Agroforestry Systems*. 77(2): pp.107–122.
- ²⁵ SoilGrids is a system for automated soil mapping based on the compilation of global soil profile data and publicly available remote sensing data. SoilGrids 250 m (spatial resolution) is an output of this global system. See <ftp.soilgrids.org/data/recent/> for the most up-to-date version of SoilGrids data.

18. The AT noted that the modified submission includes an update to the emission factors for the dry forest ecoregion, a new methodology to improve the sampling of activity data and the inclusion of the soil organic carbon pool. However, the AT also noted that Madagascar did not provide a description of the changes made from the previous submission of 2017, as requested by decision 12/CP.17, annex, subparagraph (b), and decision 13/CP.19, annex, paragraph 2(e).

19. The AT took note of the areas for further improvement, in terms of the transparency completeness, consistency and accuracy of the data and information to be provided in future submissions, that were pointed out in the previous technical assessment report,²⁶ as well as the activities being undertaken by the Party to the same end.²⁷ The AT noted that some of these identified future improvements remain valid, including the planned and ongoing activities indicated by Madagascar in its 2017 submission.

20. Madagascar noted in the submission that it has not started to undertake a national GHG inventory, but the emissions and removals from the agriculture, forestry and other land use sector were included in an updated national GHG inventory in the Party's third national communication (2017).²⁸ Madagascar acknowledged that the methods, data and accounting scope of the national communication are not consistent with the FREL. According to decision 12/CP.17, paragraph 8, the FREL shall maintain consistency with the anthropogenic forest-related GHG emissions and removals in the national GHG inventory. In response to a question from the AT, Madagascar explained that the inconsistency arose owing to the use of different methodologies – the national GHG inventory uses methods from the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (hereinafter referred to as the Revised 1996 IPCC Guidelines). Madagascar stated that it will work on improving its institutional arrangements to ensure that consistency is maintained between its GHG inventory data and its FREL estimates. The AT acknowledges the efforts made by Madagascar on this matter and proposes that the Party continue with them to improve the consistency between future FRELS and national communications. The AT identified this as an area for future technical improvement.

21. The AT noted that information related to the total forest area was not included in the modified submission. The AT also noted that the total area of country reported in the original submission was significantly higher than that reported in the third national communication. Using the information in the modified submission, the AT estimated the total country area by summing the total land area of the four ecoregions and found this to be approximately 2 million ha less than the size of the country as reported by Madagascar in its third national communication (i.e. 56,518,092 ha compared with 58,650,000 ha). The AT considers as an area of future technical improvement that Madagascar increase the transparency of its reporting of the total country area and ensure the consistency of this area with other relevant international reporting. In addition, the AT encourages Madagascar to include annual land-use change matrices in an annex to future submissions, as was done in the original submission of 2018 (pp. 48–50).

22. Madagascar provided in its submission an updated emission factor for the dry forest ecoregion. This emission factor was derived from the forest inventory conducted in 2017 in that ecoregion, which provided new data on above-ground biomass and deadwood. In the 2017 submission, this emission factor was obtained from the 1996 IEFN, which is no longer representative of the current conditions in the ecoregion. The above-ground biomass estimate consequently increased from 58.01 to 63.16 t dry matter/ha, while the below-ground biomass increased from 16.52 to 17.73 t dry matter/ha. The deadwood carbon pool remained the same as in the 2017 submission (4.09 t dry matter/ha). The AT noted that the 2017 dry forest ecoregion inventory from which these biomass values were derived used fewer sample plots than the 1996 inventory, resulting in higher levels of uncertainty. The AT also pointed out that the submission does not provide information explaining how the new methodology produced more suitable estimates than the previous one. The AT was therefore unable to

²⁶ FCCC/TAR/2017/MDG, paragraphs 20, 21, 25 and 26.

²⁷ FCCC/TAR/2017/MDG, paragraphs 41 and 42.

²⁸ https://unfccc.int/sites/default/files/resource/682743015_Madagascar-NC3-1-MADAGASCAR%20Third%20National%20Communication%20of%20UNFCCC_0.pdf.

determine from the information provided in the submission whether the new methodology implies an overestimation or an underestimation of the biomass content of dry forests. During the TA week, Madagascar explained that the methodology applied in the 2017 dry forest ecoregion inventory is an improvement over that applied in the IEFN. The improvements include: measurements of deadwood and soil (in only the eastern part of the ecoregion) in degraded forests; permanent sample plots that are easy to revisit (each has a Global Positioning System location); provision to add extra sample plots in the future to lower the uncertainty; and extensive quality control procedures. The AT commends Madagascar for its efforts to update emission factors using a stepwise approach but notes that the transparency of the submission could have been enhanced by including a comparison of the methodologies used for the 1996 IEFN and the 2017 dry forest ecoregion inventory.

23. In its modified submission, Madagascar included new activity data that, together with the inclusion of soil organic carbon, resulted in a 60.45 per cent increase in the value of the FREL compared with that in the original submission (see para. 8 above and footnote 15). Based on its own estimates calculated from the data provided in the submission, the AT found that the new activity data were responsible for 44.15 per cent of the total increase of 60.45 per cent, while the inclusion of soil organic carbon accounted for the remaining 16.30 per cent. The AT commends Madagascar for its efforts to improve and update its activity data as part of the stepwise approach. However, given the significance of the increase in the FREL value owing to the use of the new activity data, the AT also considers the inclusion of an explanation of how the use of different methodologies led to this significant increase would have enhanced the transparency of the submission, in accordance with decision 12/CP.17, annex, subparagraph (b).

24. The decision tree used by Madagascar to estimate activity data (see para. 13 above) has a number of issues, including: (1) the consideration of forest loss in a 30 m × 30 m pixel representing only 0.81 ha as deforestation is not consistent with Madagascar's definition of forest and deforestation; and (2) the lack of a clear explanation from Madagascar regarding the inclusion or exclusion of afforested and reforested areas in the estimation of the FREL. The AT noted that the consideration of an area of 30 m × 30 m (or any forested area below 1 ha) as forest is also not consistent with the definition of forest as proposed by Madagascar. The AT also noted that the stratification of activity data included a stratum on "gains in new forest areas", and in the case of spiny forests, such gains have been included in the estimation of areas of deforestation (see tables 17 and 18 in the modified submission). Furthermore, the AT is of the view that the labelling protocol used to detect forest land, which is based on a majority rule of 50 per cent or more points in the sample grid falling on forest land and for which the forest definition establishes a minimum tree cover of 30 per cent, may result in inconsistencies, or at least reduce the accuracy of the FREL estimates. The AT considers that including appropriate explanations of how these issues will be addressed and an estimation of their effects on the uncertainty of the FREL would improve the transparency of future submissions. The AT considers this as an area for future technical improvement.

25. The AT noted that in the submission Madagascar described the results of the uncertainty assessment of activity data but did not provide an explanation of how the uncertainty of the activity data was estimated. In the chapter of the submission on uncertainty assessment (chapter 8), only general sources of uncertainties in the activity data were provided. Hence, the AT was not able to identify the specific or main causes of uncertainty in the activity data. The AT noted that the original version of the submission offered a more detailed analysis of the uncertainty of data.

26. The AT noted that Madagascar estimated above-ground biomass in post-deforestation areas and that it derived the carbon stocks on the basis of different studies for different forest types (see para. 16 above). The AT also noted that the secondary formations do not necessarily correspond to post-deforested areas and might instead correspond to regenerating young forests. In addition, carbon stocks on post-deforested land depend on the moment the conversion took place, and not all lands are likely to regenerate after 11–20 years. During the TA, the AT questioned whether the results of the studies referred to by Madagascar are applicable to deforested areas, in particular for dry and spiny forests, and whether including these values in the emission factors would result in an overestimation of the total removals in the deforested areas. Madagascar acknowledged that this observation by the AT is relevant

and that it will improve the information in its next submission. The Party noted that taking into account a 20-year period for the accumulation of carbon stocks on deforested land would not significantly change the estimation. The AT acknowledges the efforts made by Madagascar but sees the development of post-deforestation carbon stock emission factors, in particular in relation to management practices on non-forest lands such as grassland, cropland and settlements, as an area for future technical improvement.

27. The AT noted several inconsistencies or contradictions in the information provided in the submission. One such inconsistency concerns the use of the approach proposed by Olofsson et al. (2014),²⁹ which Madagascar mentioned in one paragraph was not used and in the following paragraph that it was used to estimate the adjusted areas (see p.122 of the modified submission). The second inconsistency relates to the level of confidence for activity data. Madagascar stated that the level of confidence for activity data at the national level is between 10 and 90 per cent, but later in the submission noted that at the national level, the confidence level to be adopted is 20–95 per cent (see the section “Activity data by ecoregion”, pp.40–56 of the modified submission). The AT considers that providing more transparent information on the estimation of uncertainty and correcting such inconsistencies in the submission would improve its transparency. This AT considers these as areas for future technical improvement.

28. The AT noted the inconsistent use of notations in the equations presented in the submission. For example, in equation 3 of the original submission (p.27), Madagascar used the notation “j” to represent the transition from one land use to another. In contrast, in equation 2 of the modified submission (p.26), “j” refers to the different reservoirs. While this works for the variable $E_{f,j}$, as it represents the emission factor for each reservoir, it does not make sense for the variable A_j , the area of forest converted to non-forest, because this would represent the area covered by each reservoir. Moreover, in equation 3, the text describing the variable $B_{\text{Aprés},j}$ continues to consider “j” as the land-use transitions taking place, making it inconsistent with the rest of the equation where “j” represents the reservoirs.

Description of relevant policies and plans, as appropriate

29. The AT noted that while Madagascar’s submission describes several areas of future improvement contained in an action plan, it does not include information on relevant policies and plans and whether these have been included in the construction of the FREL. The AT considers that including such information in future FREL submissions would increase the transparency of the FREL, particularly regarding the selection of the approach adopted for the construction of the FREL. The AT considers this as an area for future technical improvement, in accordance with decision 12/CP.17, annex, subparagraph (b).

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

30. According to decision 12/CP.17, annex, subparagraph (c), reasons for omitting a pool and/or activity from the construction of the FREL should be provided, noting that significant pools and/or activities should not be excluded.

31. The pools included in the FREL are above-ground biomass, below-ground biomass and deadwood. Litter and harvested wood products are not included. The AT commends Madagascar for its efforts to include the soil organic carbon pool in the modified submission, but noted that in table 3 there appears to be a contradiction in that the Party provides arguments justifying the exclusion of this carbon pool instead of its inclusion.

32. The AT considers that the exclusion of litter is adequately justified by Madagascar and commends the Party for its efforts to obtain better information on this pool in the future with the aim of including it as part of the stepwise approach. The AT concludes that emissions from litter are likely to be insignificant and their non-inclusion is therefore justified.

²⁹ Olofsson P, Foody GM, Herold M, Stehman SV, Woodcock CE and Wulder MA. 2014. Good practices for estimating area and assessing accuracy of land change. *Remote Sensing of Environment*. 148: pp.42–57.

33. Madagascar explained in its submission that the harvested wood products pool was not included as it is not mandatory reporting for Parties not included in Annex I to the Kyoto Protocol. The AT pointed out that decisions relating to the Kyoto Protocol fall outside the scope of the TA as well as the decisions under the Warsaw Framework for REDD-plus. In response to a question raised by the AT, Madagascar clarified that this pool was not included because of a lack of appropriate data.

34. In its submission, Madagascar provided information on how the post-deforestation land uses were identified in the different ecoregions, as well as data on above-ground and below-ground biomass and their emission factors. However, the AT could not find an explanation of how the post-deforestation soil organic carbon values were estimated. Table 49 shows data on soil organic carbon for forest and non-forest land-use classes, but there is no information in the submission on how the values of soil organic carbon of post-deforestation land use classes were calculated or from where they were obtained. Similarly, tables 54–57, which describe the emission factors by ecoregion, do not have data on emission factors associated with soil organic carbon and their sources. Based on the Excel files Madagascar shared with the AT, it seems that both the forest and the non-forest soil organic carbon estimates were extracted from the ISRIC global product³⁰ (i.e. SoilGrids 250 m). The AT found two transparency issues related to this approach. First, it is not clear how the ISRIC data were used to obtain the figures contained in table 49 of the modified submission. Second, the methodology applied to estimate soil organic carbon is not described in the submission and there is no reference to relevant chapters of the 2006 IPCC Guidelines. For the soils, Madagascar did not distinguish between mineral and organic. The AT noted that although it seems that a tier 3 methodology has been used for mineral soils, the soil organic carbon data are derived from a global product. Hence, it is not clear how soil organic carbon values taken from different locations (from the ISRIC map) can be comparable and used in a stock difference calculation, taking into account also that soil organic carbon gains or losses are spread over a default 20-year period. Moreover, the AT noted that Madagascar did not provide information on soil management practices after land-use change and the geographical locations where such changes occurred. As such information was not available to the AT, it could not fully understand how the associated post-deforestation soil organic carbon values have been assigned to specific areas.

35. Madagascar included in its FREL CO₂ emissions from deforestation and non-CO₂ emissions from burning on deforested land. The AT noted that non-CO₂ emission estimates in the FREL do not correspond to those in the national GHG inventory; such emissions should be equal to or lower than those estimated for the category “forest land converted to any other land” in the GHG inventory. The AT considers the treatment of non-CO₂ gases in the FREL in such a way as to maintain consistency with the GHG inventories included in future national communications as an area for future technical improvement.

36. The AT noted several inconsistencies arising from the definition of deforestation in the submission (see para. 24 above). In the AT’s view, this definition is not consistent with the definition of forest (see para. 39 below), as the latter does not include secondary formations. In addition, if deforestation is defined as a permanent land-use change, then tavy (which is included in the FREL) should be considered as a permanent land-use change rather than as a temporary conversion. Conversely, if deforestation is not defined as a permanent land-use change, then tavy should be excluded from the estimates of deforestation. As such, the AT noted that neither the definition of forest nor the definition of deforestation have been fully operationalized during the construction of the FREL. For example, the conversion of secondary formations is excluded from the forest definition but appears to be included in the calculations of deforestation, and tavy has been considered to result in a permanent land-use change. The AT considers that addressing these inconsistencies would considerably increase the transparency of the submission and identified this as an area for future technical improvement.

37. The AT acknowledges that Madagascar included the most significant activity (i.e. “reducing emissions from deforestation”) of the five activities identified in decision 1/CP.16, paragraph 70, in accordance with its national capabilities and circumstances. The AT noted

³⁰ World Soil Information, available at <http://www.isric.org/>. See also footnote 25 above.

that other activities could also be significant, in particular, “reducing emissions from forest degradation”. According to Madagascar’s submission, other activities have not been included owing to a potential overlap with deforestation. In response to a question from the AT, the Party clarified that a lack of data is the reason for this exclusion rather than an overlap of the activities.

38. The AT therefore noted that the current exclusion of some of the other activities in decision 1/CP.16, paragraph 70 (“reducing emissions from forest degradation”, “conservation of forest carbon stocks”, “enhancement of forest carbon stocks”) from the FREL appears to be conservative. Overall, the AT commends Madagascar for the information provided in its submission. The AT acknowledges the intention expressed by the Party to identify steps to improve future FREL/FRL submissions when new, adequate data and better information become available as part of the stepwise approach.

4. Definition of forest

39. Madagascar provided in its submission the definition of forest used in the construction of its FREL (i.e. minimum area of 1 ha, height of 5 m or more and at least 30 per cent canopy cover). The definition is not the same as the one the Party used for its reporting to the Food and Agriculture Organization of the United Nations Global Forest Resources Assessment (FRA) in 2015. Although Madagascar noted in its submission that the definition of forest is consistent with that used in its national GHG inventory, the AT noted that the Party did not actually provide a forest definition in the GHG inventory. Madagascar clarified in its submission that the definition used for FRA reporting will be modified in the future in order to have a consistent definition. The AT concludes that transparency would be increased if Madagascar ensures consistency in the forest definitions used across international reporting as well as in its GHG inventory report or provides an explanation for why and how the definition used for the construction of the FREL was chosen, as requested in decision 12/CP.17, annex, subparagraph (d). The AT considers this as an area for future technical improvement.

40. The forest definition described by Madagascar concerns only intact natural forest; it does not take into account other ecosystems such as secondary or very degraded formations or plantations. During the TA, Madagascar clarified that natural forests include both intact and degraded (secondary) forests. The Party also explained that forest plantations and agricultural plantations, such as palm oil, cacao and clove, as well as land on which tavy is practised, are not considered forests. However, there are cases where formations of clove and cacao, normally cultivated outside forest areas, are not distinguishable from forest land. Forest plantations are not common in Madagascar and are distinguished from forest land through geospatial delineation. Despite the clarifications provided by the Party during the technical exchange, the AT considers that the modified submission does not address the inconsistencies between the forest definition and its actual operationalization in the estimation of the FREL (see para. 36 above). Madagascar mentioned that the forest definition will be the subject of further national discussions, which will include addressing the question of whether or not to consider agricultural crops as forests, in order to confirm the new definition by June 2018. Recalling decision 12/CP.17, annex, subparagraph (d), the AT considers the inclusion of a more transparent definition of forest, describing how land on which tavy is practised and secondary formations have been distinguished from natural forests and how the definition is operationalized to estimate the FREL, as an area for future technical improvement.

41. In its submission, Madagascar acknowledged that in the case of spiny forests and mangroves, the trees do not naturally reach a height of 5 m but owing to a lack of data, the assumption that they will reach this height (i.e. that they qualify as forests) has been made for estimating the FREL. The AT noted that this approach may be interpreted as the country selectively choosing (sometimes referred to as “cherry-picking”) the types of vegetation and areas to be included in the FREL, irrespective whether or not they comply with the definition of forest. The AT considers that Madagascar could improve the transparency of its FREL by demonstrating that the share of spiny forests and mangroves that do not meet the definition of forest is not significant, modifying the definition of forest to include such vegetation types,

or excluding spiny forests and mangroves from the FREL estimations. The AT identified this as an area for future technical improvement.

III. Conclusions

42. The information used by Madagascar in constructing its FREL is complete, partially transparent and in overall accordance with the guidelines for submission of information on reference levels (as contained in the annex to decision 12/CP.17).

43. The FREL presented in the modified submission, for the reference period 2006–2015, corresponds to 34,342,327 t CO₂ eq/year (see para. 8 above).

44. The AT acknowledges that Madagascar included in the FREL the most significant activity and the most significant pools in terms of emissions from forests. In doing so, the AT considers that Madagascar followed decision 1/CP.16, paragraph 70, on activities undertaken, and paragraph 71(b), on elaboration of a national FREL, and decision 12/CP.17, paragraph 10, on implementing a stepwise approach. The AT commends Madagascar for the information provided on the ongoing work on the development of FRELS for other activities.

45. As a result of the facilitative interactions with the AT during the TA, Madagascar submitted a modified submission, which took into consideration some of the technical inputs of the AT. The AT notes that the completeness of information improved in the modified FREL submission and commends Madagascar for the efforts it made. The AT welcomes the information shared by the Party during the technical exchange, including the spreadsheet calculations, which facilitated the AT's reproduction of the FREL calculations.

46. The AT notes that, overall, the FREL does not maintain consistency, in terms of sources of activity data and emission factors,³¹ with the GHG inventory included in Madagascar's third national communication (see para. 20 above).

47. The AT notes that some of the areas identified for future technical improvement in the previous technical assessment report (see para. 19 above) remain valid and it commends Madagascar for its efforts made in addressing them as part of the stepwise approach. Pursuant to decision 13/CP.19, annex, paragraph 3, the AT identified a number of additional areas for future technical improvement:

(a) Ensure the consistency of data and information used in the construction of the FREL with those used in the national GHG inventory by including more information on land representation and on the different methodologies used in the GHG inventory (Revised 1996 IPCC Guidelines) and the FREL (2006 IPCC Guidelines) (see para. 20 above);

(b) Ensure the consistency and transparency of the national area values used for estimating the FREL with the emissions and removals reported in the GHG inventory in the national communication (see para. 21 above);

(c) Elaborate on the description of the methodology for deriving activity data on the basis of the adopted forest definition and on the accuracy assessment of the activity data, including the constraints and gaps in applying the methodology (see paras. 23 and 24 above);

(d) Provide a detailed explanation as to how the uncertainty estimates of the activity data were assessed, in addition to the results of the assessment (see para. 25 above);

(e) Include a description of relevant policies and plans (see para. 29 above);

(f) Address the inconsistencies in the definitions of forest and deforestation and, in particular, the operationalization of these definitions (see paras. 36, 40 and 41 above);

(g) Use a definition of forest that is consistent with those reported under other relevant international processes or provide an explanation for why different definitions are used, as requested in decision 12/CP.17, annex, subparagraph (d) (see para. 39 above);

(h) Improve the understanding of biomass dynamics of secondary formations, including land on which tavy is practised, as this information is crucial for the inclusion of

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

the activity “reducing emissions from forest degradation” (a likely significant source of emissions in Madagascar that has not been included in the present FREL owing to a lack of data) in future FRELs (see para. 37 above);

(i) Develop country-specific post-deforestation emission factors related to management practices on non-forest lands such as grassland, cropland and settlements (see para. 26 above);

(j) Improve the quality check of future submissions in order to correct errors in the text of the submission and to identify where more detailed methodological descriptions could provide greater clarity (see paras. 27 and 28 above).

48. In assessing the pools and gases included in the FREL, pursuant to decision 13/CP.19, annex, paragraph 2(f), the AT notes that the current omissions of pools and gases are likely to be conservative in the context of the FREL. Nevertheless, the AT identified the following additional areas for future technical improvement:

(a) Provide a more detailed explanation of the methodology, data and assumptions used to estimate emissions from mineral soils and soil organic carbon (see para. 34 above);

(b) Include non-CO₂ gases in order to maintain consistency with the national GHG inventory included in the national communications: (see para. 35 above).

49. The AT acknowledges and welcomes the intention expressed by Madagascar to:

(a) Include the activity “reducing emissions from forest degradation” in future submissions through further analysing drivers of deforestation in different forest types and monitoring eventual regeneration;

(b) Re-evaluate the forest definition and ensure its consistent operationalization when deriving activity data;

(c) Improve the representativeness of biomass data in post-deforested areas through new country-specific inventory data to be collected during the next national forest inventory, which is expected to include additional samples in post-deforested land-use areas;

(d) Ensure consistency between the national GHG inventory and the FREL through the establishment of a working group that will meet regularly to ensure methodological alignment for GHG emission estimates.

50. In conclusion, the AT commends Madagascar for showing a strong commitment to the continuous improvement of its FREL estimates, in line with the stepwise approach. A number of areas for future technical improvement of Madagascar’s FREL 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 Madagascar.

51. The table contained in the annex summarizes the main characteristics of Madagascar’s proposed FREL.

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 emission level based on information provided by Madagascar

<i>Main features of the FREL</i>		<i>Remarks</i>
Proposed FREL (in t CO ₂ eq/year)	34 342 327	The FREL was constructed by summing the annual emissions per strata of each ecoregion, resulting in the total annual GHG emissions over the 10-year reference period. The emissions are solely from deforestation (see para. 8 of this document)
Type and duration of FREL	FREL = historical emissions 2006–2015	New activity data were estimated for this modified reference period. Madagascar's 2017 assessed FREL covered the reference period 2005–2013 (see para. 8 of this document)
Adjustment for national circumstances	No	–
National/subnational	National	The four ecoregions of the country are covered (see paras. 6–7 of this document)
Activities included	Reducing emissions from deforestation	Madagascar defined deforestation as a direct and permanent anthropogenic conversion of a continuous area of forest of at least 1 ha to non-forest land, which includes areas converted by tavy and the conversion of secondary forests to non-forest land uses (see paras. 6 and 12 of this document)
Pools included	Above-ground biomass, below-ground biomass, deadwood, soil organic carbon	See paragraphs 31–34 of this document
Gases included	CO ₂ , CH ₄ , N ₂ O	CO ₂ emissions from deforestation and non-CO ₂ emissions from burning on deforested land (see para. 35 of this document)
Forest definition	Included	Defined as minimum area of 1 ha, height of 5 m or more and at least 30 per cent canopy cover. The definition is not the same as the one used for Madagascar's reporting to the Food and Agriculture Organization of the United Nations Global Forest Resources Assessment in 2015 (see para. 39 of this document)
Relationship with latest GHG inventory	Methods used for construction of the FREL are not consistent with those used for the latest GHG inventory (third national communication)	Madagascar explained that this inconsistency arose from using different methodologies for the 2017 national GHG inventory and construction of the FREL (see para. 20 of this document)
Description of relevant policies and plans	Not included	Several areas for future improvement were identified in an action plan but Madagascar did not include information on relevant policies and plans and whether these have been included in the construction of the FREL (see para. 29 of this document)

<i>Main features of the FREL</i>		<i>Remarks</i>
Description of assumptions on future changes in policies	Not applicable	–
Descriptions of changes to previous FREL	Not included	Madagascar did not provide a description of the changes made since the previous submission, as requested by decision 12/CP.17, annex, subparagraph (b), and decision 13/CP.19, annex, paragraph 2(e) (see para. 18 of this document)
Future improvements identified	Yes	Several areas for future technical improvement were identified (see paras. 47 and 48 of this document)

Abbreviations: CH₄ = methane, CO₂ = carbon dioxide, FREL = forest reference emission level, GHG = greenhouse gas, N₂O = nitrous oxide.