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## **Report on the technical assessment of the proposed forest reference level of the Sudan submitted in 2020**

### *Summary*

This report covers the technical assessment of the voluntary submission of the Sudan 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 the Sudan covers the activities reducing emissions from deforestation and enhancement of forest carbon stocks, which are among the activities included in decision 1/CP.16, paragraph 70. For its submission, the Sudan developed a subnational FRL, covering its Blue Nile, Gedarif and Sinnar States, with the aim of transitioning to a national forest reference emission level or FRL in the future. The FRL presented in the original submission, for the reference period 2006–2018, corresponds to 441,744 tonnes of carbon dioxide equivalent per year. As a result of the facilitative process during the technical assessment, the FRL was modified to 935,057 tonnes of carbon dioxide equivalent per year. The assessment team notes that the data and information used by the Sudan 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.



## Abbreviations and acronyms

AD	activity data
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
AT	assessment team
COP	Conference of the Parties
CO <sub>2</sub>	carbon dioxide
CO <sub>2</sub> eq	carbon dioxide equivalent
EF	emission factor
FAO	Food and Agriculture Organization of the United Nations
FNC	Forests National Corporation of the Sudan
FREL	forest reference emission level
FRL	forest reference level
GHG	greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
NFI	national forest inventory
REDD+	reducing emissions from deforestation; reducing emissions from forest degradation; conservation of forest carbon stocks; sustainable management of forests; and enhancement of forest carbon stocks (decision 1/CP.16, para. 70)
TA	technical assessment
2006 IPCC Guidelines	<i>2006 IPCC Guidelines for National Greenhouse Gas Inventories</i>

## I. Introduction and summary

### A. Overview

1. This report covers the TA of the voluntary submission of the Sudan on its proposed FRL,<sup>1</sup> submitted on 16 January 2020, in accordance with decisions 12/CP.17 and 13/CP.19. The remote TA<sup>2</sup> took place from 22 to 26 June 2020 and was coordinated by the secretariat.<sup>3</sup> The TA was conducted by two land use, land-use change and forestry experts from the UNFCCC roster of experts<sup>4</sup> (hereinafter referred to as the AT): Markus Didion (Switzerland) and Sangay Dorji (Bhutan). Although an expert from the Consultative Group of Experts was invited to participate during the remote session as an observer,<sup>5</sup> no representative was able to attend. The TA was coordinated by Jenny Wong (secretariat).

2. In response to the invitation of the COP and in accordance with the provisions of decision 12/CP.17, paragraphs 7–15 and annex, the Sudan submitted its proposed FRL on a voluntary basis. The proposed FRL is one of the elements<sup>6</sup> to be developed in implementing the activities referred to in decision 1/CP.16, paragraph 70. Pursuant to decision 13/CP.19, paragraphs 1–2, and decision 14/CP.19, paragraphs 7–8, the COP decided that each submission of a proposed FREL 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.

3. The Sudan's submission includes seven annexes, containing additional data and information used to support the development of the proposed FRL, which enhanced the transparency of the submission. The annexes provide a list of the satellite images used for estimating AD, afforestation and reforestation areas for 2000–2018 in the three States of Blue Nile, Gedarif and Sinnar, a description of the sample unit, the wood densities of dominant species, the form factors applied in constructing the FRL, 2017 NFI data and a list of the contributors to the submission.

4. The objective of the TA is to assess the degree to which the information provided by the Sudan is in accordance with the guidelines for submissions of information on reference levels<sup>7</sup> 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 the Sudan for the construction and future improvement of its FREL or FRL, as appropriate.<sup>8</sup>

5. The TA of the FRL submitted by the Sudan was undertaken in accordance with the guidelines and procedures for the TA of submissions from Parties on proposed FRELs and/or FRLs.<sup>9</sup> 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 the Sudan. The facilitative exchange during the TA allowed the Sudan to provide clarifications and additional information, which were considered by the AT in the preparation of this report.<sup>10</sup> As a result of the facilitative interactions with the AT during the TA, the Sudan provided a modified version of its submission on 9 September 2020, which took into consideration the technical input of the AT. The modifications improved the completeness, clarity and transparency of the submitted FRL without needing to alter the approach used to construct it. This TA report was prepared

<sup>1</sup> The submission of the Sudan is available at <https://redd.unfccc.int/submissions.html?country=sdn>.

<sup>2</sup> Owing to the circumstances related to the coronavirus disease 2019, the TAs of the FREL and FRL submissions of developing country Parties in 2020 had to be conducted remotely.

<sup>3</sup> As per decision 13/CP.19, annex, para. 7.

<sup>4</sup> As per decision 13/CP.19, annex, paras. 7 and 9.

<sup>5</sup> As per decision 13/CP.19, annex, para. 9.

<sup>6</sup> See decision 1/CP.16, para. 71(b).

<sup>7</sup> Decision 12/CP.17, annex.

<sup>8</sup> Decision 13/CP.19, annex, para. 1(a–b).

<sup>9</sup> Decision 13/CP.19, annex.

<sup>10</sup> As per decision 13/CP.19, annex, paras. 1(b), 13 and 14.

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.<sup>11</sup>

## **B. Proposed forest reference level**

7. 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 providing adequate and predictable support. The FRL proposed by the Sudan, on a voluntary basis for a TA in the context of results-based payments, covers the activities reducing emissions from deforestation and enhancement of forest carbon stocks, which are two of the five activities referred to in that paragraph. Pursuant to paragraph 71(b) of the same decision, the Sudan developed a subnational FRL, covering its Blue Nile, Gedarif and Sinnar States, with the aim of transitioning to a national FREL or FRL incorporating all forest land in the country in the future. The three States considered for the subnational FRL represent 7.2 per cent of the total area of the country and contain approximately 11 per cent of its forest land. For its submission, the Sudan applied a stepwise approach to developing its FRL in accordance with decision 12/CP.17, paragraph 10. The stepwise approach enables Parties to improve their FRELs or FRLs by incorporating better data, improved methodologies and, where appropriate, additional pools. The Sudan noted in its submission that it is aiming to test the methodologies and tools applied in constructing the subnational FRL; develop relevant knowledge, resources and expertise within national institutions; and improve data and expand the scope of its REDD+ implementation by adding more activities, pools and gases over time.

8. The subnational FRL proposed by the Sudan for the historical reference period 2006–2018 is the net emissions resulting from the annual average CO<sub>2</sub> emissions associated with gross deforestation (defined as the conversion of natural forest to other land uses) and the annual removals from enhancement of forest carbon stocks resulting from planting tree seeds and seedlings and related land preparation. The FRL includes the gross emissions from deforestation that are associated with clear-cuts and excludes any subsequent emissions and removals from deforested areas (i.e. post-deforestation land uses are not considered). The gross removals resulting from afforestation and reforestation activities do not include possible emissions due to tree mortality or fuelwood collection. In addition, the forests in the States assessed are among the most productive and are already strongly affected by human intervention, such as fuelwood collection and animal grazing; hence, the risk of displacement of emissions is low.

9. The AD used in constructing the FRL were extracted from several sources. For estimating the AD for the activity reducing emissions from deforestation, data were derived from spatial sample units stratified by a historical time series of land-cover maps for 2006, 2010, 2014 and 2018 for the three States that were developed by the Remote Sensing and Seismology Authority. The Sudan followed the Global Land Cover Network approach<sup>12</sup> for creating each land-cover map, which was also applied for developing the national land-cover map<sup>13</sup> for 2010 used in the 2012 Africover project. The AD for afforestation were estimated using the FNC records of planned afforestation and reforestation during the reference period.

10. The EFs for estimating emissions from deforestation were developed using the IPCC tier 2 approach with data from the most recent (2017) NFI and the EFs for estimating removals from enhancement of forest carbon stocks were developed using the IPCC tier 1 approach with default values for root-to-shoot ratios, mean annual increment and carbon fraction from the 2006 IPCC Guidelines together with country-specific wood densities for conversion of tree volume to biomass.

11. The FRL presented in the modified submission, with the aim of accessing results-based payments for REDD+ activities for 2006–2018, corresponds to net emissions of

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

<sup>12</sup> See <http://www.fao.org/geospatial/projects/detail/en/c/1035672>.

<sup>13</sup> Available at <http://www.fao.org/geospatial/resources/detail/en/c/1024736>.

935,057 t CO<sub>2</sub> eq/year, comprising emissions of 1,223,286 t CO<sub>2</sub> eq/year from deforestation and removals of 288,229 t CO<sub>2</sub> eq/year from enhancement of forest carbon stocks.<sup>14</sup>

12. The proposed FRL includes above-ground and below-ground biomass of vegetation (trees and large shrubs) that meets the forest definition. Regarding GHGs, the submission includes CO<sub>2</sub> only.

## **II. Data, methodologies and procedures used in constructing the proposed forest reference level**

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

#### **1. Information used by the Party in constructing its forest reference level**

13. For constructing its FRL, the Sudan used methodologies and default values from the 2006 IPCC Guidelines. The proposed FRL covers the activities reducing emissions from deforestation and enhancement of forest carbon stocks. AD were obtained from land-cover change maps that were based on remote-sensing data and national records of planted areas. EFs for deforestation were developed using data from the most recent (2017) NFI and IPCC default EFs were used for estimating carbon stock changes in removals from enhancement of forest carbon stocks.

14. For estimating areas of deforestation, the Party used satellite imagery for mapping land-cover change to identify areas that were cleared of tree cover and converted to other land uses. The Sudan defines enhancement of forest carbon stocks as removals from afforestation and reforestation activities that involve planting tree seeds and seedlings and related land preparation. Carbon stock gains resulting from natural regeneration on forest land remaining forest land and agricultural lands were excluded from the estimates.

15. To estimate the AD for deforestation, the Party first obtained satellite imagery for 2006, 2010, 2014 and 2018. With the exception of the 2006 data, Landsat data with a spatial resolution of 30 m were used. The 2006 data were obtained from the ASTER sensor,<sup>15</sup> which has a 15 m resolution. On the basis of the images, the Party developed land-cover maps for each of the four years using the land-cover classification system developed by FAO, which was also used to create the Sudan's national land-cover map for the Africover project. Using the maps, the Sudan created land-use and land-cover change maps for 2006–2010, 2010–2014 and 2014–2018 by overlaying the annual maps in order to identify overall forest cover loss for the reference period 2006–2018. Subsequently, 1,140 spatial sample units were distributed among the land-cover change map classes using a stratified random distribution following Olofsson et al. (2014). Accordingly, the error-adjusted deforestation area estimates were calculated and used for estimating the AD for deforestation.

16. The Sudan obtained AD on afforestation and reforestation areas from FNC, which maintains national records of all planned and implemented afforestation and reforestation activities. Robust AD on afforestation and reforestation available for 2000 onward, with interpolation used to fill gaps due to missing data for 2000, 2002 and 2003, were used in constructing the original FREL (see para. 31 below). On the basis of the technical exchanges with the AT, the Party revised its approach for the modified submission and considered afforestation and reforestation activities in 2006–2018 only, as full historical records of AD were available for those years. The Party explained that it used records of planted areas to

<sup>14</sup> In its original submission, the Sudan proposed a subnational FRL of 441,744 t CO<sub>2</sub> eq/year, resulting from 786,202 t CO<sub>2</sub> eq/year emissions from deforestation and 344,458 t CO<sub>2</sub> eq/year removals from enhancement of forest carbon stocks, for 2006–2018. The difference between the original and the modified submission is due mostly to revised biomass estimates affecting the EFs applied and, to a lesser degree, updated AD.

<sup>15</sup> The broad spectral coverage and high spectral resolution of ASTER, an imaging instrument on the National Aeronautics and Space Administration satellite Terra, provides critical information for surface mapping and monitoring dynamic conditions and temporal change.

establish AD for enhancement of forest carbon stocks instead of data from the land-cover change maps that were used to estimate AD for deforestation in order to exclude areas of natural regeneration on forest land remaining forest land as well as other naturally established forests. Such areas would be identified as areas of afforestation or reforestation in the land-cover change maps. The AT considered this justification of the Party's approach adequate.

17. The Sudan estimated EFs for deforestation using data from its most recent (2017) NFI, which was based on countrywide sampling, field data collection and remote sensing. The data on tree diameter at breast height and tree height from the inventory were used to estimate the total above-ground volume of trees and shrubs, including stumps, stems and branches, following a form factor approach. Form factors were developed using data from FAO and national sources. The AT commends the Sudan for transparently describing its NFI and providing additional information on data collection for the States included in the subnational FRL in its modified submission.

18. The AT notes that for obtaining tree volume the Sudan used the form factor method, which is one of two approaches used for the NFI. In the second approach, outlined in the NFI manual shared with the AT, the pantropical volume function developed by Chave et al. (2014) is used. While the AT notes that both approaches are valid, it considers that the inclusion of the rationale for selecting the form factor method would have enhanced the transparency of the submission.

19. For the Sudan's original submission, only trees of greater than 10 cm diameter at breast height were taken into consideration in developing the EFs. For the modified submission, trees of less than 10 cm diameter at breast height and trees greater than 1.3 m in height were also considered. The revised growing stock volume estimates reported in the modified submission were more similar to the estimates in the Sudan's second national communication (for 2013)<sup>16</sup> and in its country report for the FAO Global Forest Resources Assessment (for 2015).<sup>17</sup>

20. The Sudan converted above-ground tree volume to above-ground tree biomass using wood densities for the main tree species from literature (reported in annex 4 to the submission). The Party used the default root-to-shoot ratios from the 2006 IPCC Guidelines to obtain estimates of below-ground biomass and applied equations 2.15–2.16 and the default carbon fraction of 0.47 from the 2006 IPCC Guidelines (vol. 4) for estimating losses of carbon stock due to deforestation. For the reference period, the Sudan assumed that, for deforestation, biomass stocks after forest conversion to other land uses (mainly conversion to cropland) were zero; and that, for enhancement of forest carbon stocks, the annual decrease in biomass carbon stocks due to losses from harvesting, fuelwood gathering and disturbances on land converted to forest land was zero.

21. The Sudan developed the EFs for estimating removals from enhancement of forest carbon stocks by estimating the mean annual increment. The estimates were based on default values for the mean annual increment of merchantable volume for the category "productive semi-natural forests" from the 2006 IPCC Guidelines for the four most commonly planted species in plantations in the Sudan. The AT commends the Party for transparently reporting its use of the mean annual increment values from the 2006 IPCC Guidelines (vol. 4, table 4.11b) in its modified submission.

22. Volume increment on plantations was converted to biomass increment using country-specific wood densities for the four most commonly planted tree species. Default root-to-shoot ratios from the 2006 IPCC Guidelines were also used to account for below-ground increment. In order to obtain an overall estimate of carbon sequestered by the average annual growth of above-ground and below-ground biomass, the species-specific estimates were weighted on the basis of their fraction of the area planted and converted to carbon using the IPCC default carbon fraction of 0.47.

23. In estimating removals from plantations under enhancement of forest carbon stocks, the Sudan assumed a survival rate of 60 per cent for all plantations regardless of the year of establishment on the basis of the survival rate of 55–65 per cent recorded by FNC. The AT

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<sup>16</sup> Available at <https://unfccc.int/documents/144628>.

<sup>17</sup> Available at <http://www.fao.org/forest-resources-assessment/past-assessments/fra-2015/country-reports/en>.

notes that the Sudan may wish to consider elaborating on the accuracy of the estimate of the survival rate and its representativeness of plantations of different ages, and to possibly consider this as a source of uncertainty for its FRL.

24. The approaches used to estimate the EFs for deforestation and the EFs for enhancement of forest carbon stocks differed (i.e. the former was based on country-specific NFI data and for the latter IPCC default values were applied). The Sudan clarified during the TA that the latter approach was expected to achieve more accurate estimates of EFs for enhancement of forest carbon stocks. The AT notes that this is a plausible explanation and the approach is justified as volume increment cannot be estimated because there is currently only one NFI available.

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

### **(a) Methodological information, including description of data sets, approaches and methods**

25. The AT notes that the AD and EFs applied in constructing the FRL were not consistent with those in the GHG inventory owing to differences between the methodologies and data used in each process. The AT also notes that the differences were well justified given the national political circumstances (e.g. the separation of South Sudan) and the availability of more recent NFI data applied in constructing the FRL.

26. To estimate AD for deforestation for the reference period, the Sudan used the land-cover change map developed for the reference period to stratify 1,140 spatial sample units (see para. 15 above). The original submission presented an accuracy assessment directly derived from the land-cover change maps for 2006–2010, 2010–2014 and 2014–2018 that were used to develop the land-cover change map for the entire reference period. In the modified submission, improvements to the land-cover change map for the reference period were made, such as including spatial stratification and sample-based accuracy estimates, allowing for the correction of land-cover classification errors in the map. The accuracy assessment of the overall land-cover change map for the reference period 2006–2018 was based on the method proposed by Olofsson et al. (2014). In the technical exchanges with the AT, the Party indicated that the initial land-cover maps produced for 2006, 2010, 2014 and 2018 were subject to a quality assurance and quality control process, but the AT notes that the results of the process were not reported in the submission. The AT commends the Sudan on its efforts to improve its AD documentation in general, and for reporting the outcomes of the accuracy and uncertainty assessment in its modified submission. The AT also commends the Sudan for transparently documenting the methodology used for assessing the accuracy and uncertainty of the land-cover change map for the reference period.

27. The AT notes that the overall 83 per cent accuracy of the map products was good. However, the accuracy assessment indicated only moderate accuracy of the forest-cover loss estimates: the producer's accuracy was 24 per cent and the user's accuracy was even lower, at 19 per cent. The Sudan identified challenges in improving the accuracy of map data derived from publicly available medium-resolution imagery. The AT also notes that the Sudan may wish to explore using alternative imagery based on higher-resolution data to improve the producer's and user's accuracies for detecting forest-cover loss in order to minimize incorrect classification of land-cover change.

28. The AT notes that, in the original submission and in the additional document on the accuracy of the detection of land-cover change for identifying areas of deforestation that was shared during the TA, information on the quality of the classification of land cover for the mapping years 2006, 2010, 2014 and 2018 was lacking. Since the quality of the identification of land-cover changes for 2006–2010, 2010–2014 and 2014–2018 depends strongly on the quality of the land-cover maps for the four mapping years, the AT considers that it would be valuable to provide such information in order to enhance the transparency of future submissions. For example, the information describing the approach to handling the different spatial resolutions of the images used for detecting land-cover change (i.e. the 15 m resolution of the ASTER images for 2006 and the 30 m resolution of the Landsat images for the other years of the reference period) could be expanded with additional details, and the implications

of using imagery of different resolutions for the consistency of the land-cover change classifications could be identified more transparently. Alternatively, the Sudan may wish to consider using higher-resolution satellite imagery, for example ASTER images, for all mapping years.

29. The AD on afforestation and reforestation activities were derived from FNC records. During the TA, the Sudan explained that these records are based on annual reporting by State-level FNC offices and on reports on regular supervisory field visits to assess the success of the annual afforestation and reforestation activities. During the TA, the Sudan further explained that it currently has no system in place for monitoring forest harvesting activities on afforestation and reforestation areas based on land-cover mapping. The AT commends the Party for its efforts to develop a system for forest monitoring based on land-cover mapping within the framework of the REDD+ Readiness Programme.

30. The Sudan did not report on the outcomes of the quality assurance and quality control of the AD on afforestation and reforestation activities in its submission. The Party assumed that the records on the afforested areas are accurate and no uncertainty assessment was conducted. The AT notes the provision of information on the accuracy of those records as an area for future technical improvement as part of enhancing the transparency of the submission.

31. For its original submission, for estimating removals due to afforestation and reforestation activities, the Sudan included in the reference period the removals resulting from afforestation and reforestation plantations that were established between 2000 and 2005. The Party justified this approach by referring to the guidance in the 2006 IPCC Guidelines (vol. 4, chap. 4.3) on tracking afforested land converted to forest land over a default transition period of 20 years. The AT discussed the implications of this approach with the Party (e.g. for consistency, plantations that date back to 1985 would need to be considered). For the modified submission, the Sudan revised its approach by including in the reference period only the removals from plantations that were established between 2006 and 2018. The AT notes that the revised approach is more transparent and results in a consistent time series of removals from afforestation and reforestation activities within the reference period.

32. The AT noted that, in the original submission, the Sudan used the term “strata” to refer to the land-cover change classifications as well as to the classifications used in the NFI, and that the inconsistent use of this term resulted in ambiguities in various sections of the submission. The AT commends the Party for providing clear definitions of the terms used in the modified submission, which improved clarity and transparency.

33. In the original submission, the reported mean above-ground volume of growing stocks was in the range of 2.9–11.9 m<sup>3</sup>/ha (or 2–8 t dry matter/ha on the basis of the wood densities used by the Sudan) in the three States analysed. These estimated values are low compared with the defaults given in the 2006 IPCC Guidelines (vol. 4, table 4.7), which are in the range of 20–200 t dry matter/ha for tropical shrublands in Africa. The AT commends the Sudan for addressing the issues raised during the TA regarding the accuracy of the NFI growing stock data in the original submission, noting that the revised estimates of growing stock included in the modified submission (i.e. 6.4–22.1 m<sup>3</sup>/ha or 4.5–15.5 t dry matter/ha) are closer to the IPCC default values for the relevant forest types and regions. The AT commends the Sudan for investigating the reason behind the still comparatively low estimates and explaining in its modified submission that the estimated growing stock is low due mainly to the factors causing deforestation and forest degradation, such as unsustainable extraction of wood, agriculture expansion and overgrazing by large herds of livestock in this region.

34. According to the Sudan’s forest definition, shrubland areas that meet the forest definition are considered forest land (see para. 45 below) and they were consequently included in the estimation of the FRL. The AT notes that the Sudan may wish to provide a more comprehensive explanation of how representative the volume estimation developed for trees is of shrubs. The AT considers that a potentially more accurate approach would be to stratify forest land into tree-dominated areas and shrubland.

35. The Sudan applied the same root-to-shoot ratio of 0.56 to both trees and shrubs in estimating their below-ground biomass and hence the relevant EFs. The 2006 IPCC



Guidelines (vol. 4, table 4.4) provide a default ratio value for shrubs (0.40 for tropical shrubland) that differs from the ratio for trees (0.56 for tropical dry forest). The AT notes that the Sudan may wish to consider applying separate root-to-shoot ratios for trees and shrubs to improve the accuracy of the EF estimates, and possibly to develop country-specific ratios or consider other estimation methods such as using allometric equations.

36. The methodology and sources of uncertainty used to estimate the confidence intervals for emissions from deforestation were not fully transparent in the submission. In addition, an overall accuracy assessment of the estimates of removals from afforestation and reforestation was not reported. The AT suggests that the Party identify the sources of uncertainty and list them in its FRL submission, even if the uncertainty cannot be estimated or is unknown (e.g. the default mean annual increment for enhancement of forest carbon stocks for which the 2006 IPCC Guidelines do not provide an uncertainty estimate). The AT is of the view that clearly showing the sources of uncertainty and whether they are considered in estimating the confidence intervals for emissions from deforestation would enhance transparency and could serve as an indication of what further improvements may be needed; for example, reducing the uncertainty of the AD on afforestation and reforestation (see para. 30 above) or collecting further information on the survival rate of plantations (see para. 23 above).

**(b) Description of relevant policies and plans, as appropriate**

37. The Sudan selected the reference period for the FRL with the intention of covering major recent events in the country. Significant developments include the adoption of a new Forest Act in 2002 and the separation of South Sudan in 2011, a geographical region with rich forest resources. These developments resulted in the need to modify the forest definition. In its submission, the Party noted the possibility of future reforms to its current forest policy and related national policies. The AT commends the Sudan for its extensive plans to further improve its FRL, which were also highlighted during the TA.

**3. Pools, gases and activities included in constructing the forest reference level**

38. According to decision 12/CP.17, annex, paragraph (c), reasons for omitting a pool or activity in constructing the FRL should be provided, noting that significant pools and/or activities should not be excluded.

39. The pools included in the Party's FRL are above-ground and below-ground biomass. In the original submission, the Sudan explained that the omission of the deadwood, litter and soil pools was due to lack of good-quality and reliable national data. In the case of deadwood, the pool is not significant in the context of the selected REDD+ activities. The soil organic carbon pool is typically a significant carbon pool, in which the carbon stocks are susceptible to disturbance, and the AT considers that it would be valuable to explore options for considering this pool for future submissions.

40. In view of the Party's intention to consider additional pools in the future, the AT requested clarification of the reasons for omitting the deadwood pool from the current submission. In response, the Sudan explained that the NFI included measurements of parameters that could be used for estimating deadwood and litter, and that the data are being analysed. Furthermore, the Party noted that the volume of deadwood in the regions included in the FRL is difficult to estimate with reasonable accuracy because the rural communities in the regions collect deadwood to meet their energy needs, but the volume collected is not captured in official records. The Sudan is aware that deadwood could be a significant carbon pool and noted its intention to review and improve the data on deadwood using the results of its 2017 NFI and to consider including the pool in future FREL or FRL submissions. The AT notes that, considering the Party's intention to continue analysing deadwood data and to include forest degradation in future submissions, the omission of the pool from the current submission is justified. The AT commends the Sudan for providing additional information in the modified submission on limitations on data collection for deadwood and for its efforts to obtain better information on this pool. The AT considers the treatment of emissions from the other carbon pools, namely deadwood, litter and soils, as an area for future technical improvement of the FRL.

41. With regard to GHG emissions, the Sudan included only CO<sub>2</sub> in the submission. The exclusion of emissions of non-CO<sub>2</sub> gases is well justified as data are lacking or considered unreliable. Considering that methane and nitrous oxide emissions were reported in the Party's second national communication, the AT considers the treatment of non-CO<sub>2</sub> gases as an area for future technical improvement to enhance the comprehensiveness and accuracy of future FREL or FRL submissions as well as to maintain consistency with the national GHG inventory. The Sudan noted that disturbances such as forest fires are not currently considered potential sources of emissions, explaining that the dominant acacia species in natural forests and plantations are less susceptible to forest fires than other species, such as eucalyptus. The AT commends the Sudan's ongoing work on monitoring forest fires with the aim of preparing forest fire maps for 2000–2018. Such maps will facilitate visualization and identification of forest fire hotspots and could allow the Sudan to include emissions from forest fires in future submissions. The AT considers that the treatment of emissions of non-CO<sub>2</sub> gases, such as methane, nitrous oxide, carbon monoxide and nitrogen oxides, would enhance the accuracy of the FRL.

42. The AT acknowledges that the Sudan included two of the most significant activities, reducing emissions from deforestation and enhancement of forest carbon stocks, of the five activities identified in decision 1/CP.16, paragraph 70, in accordance with its national capabilities and circumstances. The AT notes that other activities could also be significant, in particular reducing emissions from forest degradation, considering that fuelwood collection could result in forest degradation.

43. The Party noted in its submission that emissions from forest degradation could be significant. However, the satellite imagery used to detect and assess land-use change due to deforestation was considered inadequate for detecting forest degradation. On the basis of the information provided by the Party, the AT considers the exclusion of the activity reducing emissions from forest degradation from the current submission to be reasonable, as a system for monitoring and identifying forest degradation will need to be developed before the activity can be included. The Party also noted in its submission that it is considering including two other REDD+ activities, conservation of forest carbon stocks and sustainable management of forests, in future national FREL or FRL submissions. The AT acknowledges and commends the Party's intention to include, as part of the stepwise approach, additional activities in future FREL or FRL submissions when new and adequate data and better information become available.

#### **4. Definition of forest**

44. The Sudan provided in its submission the definition of forest used in constructing its FRL. The Party defines forest as an area of land spanning a minimum area of 0.4 ha with trees that have reached, or have the potential to reach, at least 2 m in height and a minimum tree canopy cover of 10 per cent. The definition includes wind breaks and/or shelter belts with a minimum width of 20 m. During the TA, the Party noted that the definition is different from the one that it used for its second national communication (2013) and its reporting to FAO for the Global Forest Resources Assessment (2015) as the forest definition had to be revised after the separation of South Sudan, which reduced the Sudan's forest resources by approximately 60 per cent.

45. The Sudan's forest definition refers to trees only, without defining what a tree is. The AT noted that, although they are not explicitly mentioned, the Party also considers shrubs meeting the definition of forest to be forest. The AT notes that the Sudan may wish to consider adding an explicit reference to shrubs (e.g. types of shrub) in its forest definition to improve its transparency.

46. The Sudan indicated in its submission that the national forest definition used in constructing its FRL corresponds to the definition used for its 2017 NFI and that the same definition will be used for its third national communication and first biennial update report, both of which are currently being prepared. The AT commends the Sudan for ensuring that the same forest definition is applied across its reporting.

### III. Conclusions

47. The information used by the Sudan in constructing its FRL for reducing emissions from deforestation and enhancement of forest carbon stocks is transparent and complete and in overall accordance with the guidelines for submissions of information on reference levels.

48. The subnational FRL presented in the modified submission, for the reference period 2006–2018, corresponds to 935,057 t CO<sub>2</sub> eq/year, resulting from 1,223,286 t CO<sub>2</sub> eq/year emissions from deforestation and 288,229 t CO<sub>2</sub> eq/year removals from enhancement of forest carbon stocks.

49. The AT acknowledges that the Sudan included in its FRL the most significant activities, the most important forest types in the subnational area considered in the submission and the most significant pools in terms of emissions from forests. The AT considers that, in doing so, the Sudan followed decision 1/CP.16, paragraph 70, on activities undertaken, and paragraph 71(b), on elaborating a subnational FRL as an interim measure, and decision 12/CP.17, paragraph 10, on applying the stepwise approach. The AT commends the Sudan for providing information on its ongoing work to develop FRELs or FRLs for other activities, as well as for other areas in the country, as a step towards constructing a national FREL or FRL.

50. As a result of the facilitative interactions with the AT during the TA, the Sudan provided a modified submission that took into consideration the technical input of the AT. The AT notes that the transparency and completeness of the information provided were significantly improved in the modified FRL submission and commends the Sudan on its efforts. The new information provided in the modified submission increased the reproducibility of the FRL estimates.

51. The AT notes that the separation of South Sudan made it difficult for the Party to maintain consistency between its FRL submission and the GHG inventory included in the second national communication.<sup>18</sup> The AT acknowledges the Party's efforts and commitment to maintaining consistency, in terms of sources of AD and EFs used in constructing its FRL, with the land use, land-use change and forestry estimates to be included in the national GHG inventory included in the third national communication and first biennial update report, which are currently being prepared.

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

(a) Provision of the rationale for using the form factor approach from the NFI for estimating tree volume rather than the approach based on the pantropical equation from Chave et al. (2014) also used in the NFI (see para. 18 above);

(b) Identification of forest type and plantation conditions (e.g. age class, survival rates) in order to improve the accuracy of the estimates of tree volume increment and to address the associated uncertainties (see para. 23 above);

(c) Exploration of opportunities for improving the low accuracy of the estimates of land-cover change (see para. 27 above);

(d) Provision of a more detailed description of the approach used to harmonize the land-cover map for 2006, which has a spatial resolution of 15 m, with the maps for 2010, 2014 and 2018, which have a resolution of 30 m (see para. 28 above);

(e) Inclusion of additional information on and an accuracy assessment of the land-cover maps that served as the basis for estimating land-cover changes (see para. 28 above);

(f) Consideration of obtaining and using higher-resolution satellite imagery (see para. 28 above);

(g) Provision of information on the accuracy of the records on the afforested areas (see para. 30 above);

<sup>18</sup> In reference to the scope of the TA, as per decision 13/CP.19, annex, para. 2(a).

(h) Consideration of possible emissions from disturbances due to harvesting, fuelwood collection and grazing that are causing deforestation and forest degradation (see para. 33 above);

(i) Stratification of forest land into areas dominated by trees and areas of shrubland to improve the accuracy of the above-ground volume estimates, and use of separate root-to-shoot ratios for trees and shrubs for estimating below-ground biomass, or consideration of other estimation methods such as using allometric equations (see paras. 34–35 above);

(j) Development of country-specific parameters and values for volume increment in plantations (see para. 22 above) and for root-to-shoot ratios for trees and shrubs (see para. 35 above);

(k) Improvement of the documentation of sources of uncertainty (see para. 36 above);

(l) Refinement of the forest definition to include shrubs and shrubland that meet the definition (see para. 45 above).

53. Pursuant to decision 13/CP.19, annex, paragraph 2(f), in assessing the pools and gases included in the FRL, the AT noted that the pools and gases excluded by the Sudan are likely to be insignificant in the context of the FRL. Nevertheless, pursuant to decision 13/CP.19, annex, paragraph 3, the AT identified the following additional areas for future technical improvement regarding the exclusion of pools and gases from the FRL:

(a) Treatment of emissions from the deadwood, litter and soil pools (see paras. 39–40 above);

(b) Treatment of emissions of non-CO<sub>2</sub> gases (to maintain consistency with the national GHG inventory) (see para. 41 above).

54. The AT acknowledges and welcomes the Party's intention to undertake the following for its future FREL or FRL submissions:

(a) Improvement of AD by using advanced remote-sensing technologies with higher-resolution imagery for mapping and estimating biomass;

(b) Improvement of EFs by using data from a permanent sample plot network, and development of country-specific allometric equations and country-specific values for wood density and root-to-shoot ratios for dominant tree species;

(c) Inclusion of other REDD+ activities, in particular reducing emissions from forest degradation, when new and adequate data and better information become available;

(d) Inclusion of other forest biomes as part of efforts to construct a national FREL or FRL;

(e) Inclusion of emissions from deadwood and forest fires.

55. In conclusion, the AT commends the Sudan for showing strong commitment to continuously improving its FRL estimates in line with the stepwise approach. A number of areas for the future technical improvement of the Sudan'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 providing adequate and predictable support.<sup>19</sup> The AT also acknowledges that the TA was an opportunity for a rich, open, facilitative and constructive technical exchange of information with the Sudan.

56. The table contained in annex I summarizes the main features of the Sudan's proposed FRL.

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<sup>19</sup> As per decisions 13/CP.19, annex, para. 1(b); and 12/CP.17, para. 10.

## Annex I

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

	<i>Main features of the FRL</i>	<i>Remarks</i>
Proposed FRL	935 057 t CO <sub>2</sub> eq/year	The FRL corresponds to the net emissions resulting from 1 223 286 t CO <sub>2</sub> eq/year emissions from deforestation and 288 229 t CO <sub>2</sub> eq/year removals from enhancement of forest carbon stocks (see para. 11 of this document)
Type and reference period of FRL	FRL = annual average of historical emissions and removals in 2006–2018	The reference period was defined and justified (see para. 8 of this document)
Application of adjustment for national circumstances	No	
National/subnational	Subnational	The FRL covers the Blue Nile, Gedarif and Sinnar States, representing 7.2 per cent of the total area of the country and containing approximately 11 per cent of its forest land (see paras. 7–8 of this document)
Activities included	Reducing emissions from deforestation Enhancement of forest carbon stocks	See paragraph 7 of this document
Pools included	Above-ground biomass Below-ground biomass	The omission of the deadwood, litter and soil pools was due to lack of reliable national data (see paras. 12, 39 and 40 of this document)
Gas included	CO <sub>2</sub>	The submission includes CO <sub>2</sub> only as data for other gases are lacking or not reliable (see paras. 12 and 41 of this document)
Forest definition	Included	Defined as land with a minimum area of 0.4 ha, minimum tree height of 2 m (or potential to reach this height) and minimum tree canopy cover of 10 per cent. Includes wind breaks and/or shelter belts with a minimum width of 20 m (see paras. 44–45 of this document)
Consistency with latest GHG inventory	Methods used for estimating the FRL are not consistent with those used for the latest GHG inventory (for 2013)	Following the separation of South Sudan and the development of the NFI, methodologies were revised and improved, thus justifying the differences from the 2013 GHG inventory (see paras. 25 and 51 of this document)
Description of relevant policies and plans	Included	Recent political events (separation of South Sudan) affecting forest resources

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<i>Main features of the FRL</i>		<i>Remarks</i>
		and related policies were described (see para. 37 of this document)
Description of assumptions on future changes to domestic policies, if included in the construction of the FRL	Not applicable	
Description of changes to previous FREL/FRL	Not applicable	
Identification of future technical improvements	Included	Several areas for future technical improvement were identified (see paras. 52–53 of this document)

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## Annex II

### Documents and information used during the technical assessment

#### A. Reference documents

“Guidelines and procedures for the technical assessment of submissions from Parties on proposed forest reference emission levels and/or forest reference levels”. Annex to decision 13/CP.19. Available at

<https://unfccc.int/sites/default/files/resource/docs/2013/cop19/eng/10a01.pdf#page=36>.

“Guidelines for submissions of information on reference levels”. Annex to decision 12/CP.17. Available at

<https://unfccc.int/sites/default/files/resource/docs/2011/cop17/eng/09a02.pdf#page=19>.

IPCC. 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. S Eggleston, L Buendia, K Miwa, et al. (eds.). Hayama, Japan: Institute for Global Environmental Strategies. Available at <http://www.ipcc-nggip.iges.or.jp/public/2006gl>.

Original and modified FRL submission of the Sudan. Available at

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

Second national communication of the Sudan. Available at

<https://unfccc.int/documents/144628>.

#### B. Other documents

The following references have been reproduced as received:

Charles T. Scott. Estimation Using Ratio-to-Size Estimator Across Strata and Subpopulations. 20 April 2020.

Chave J, Réjou-Méchain M, Búrquez A, et al. 2014. Improved allometric models to estimate the aboveground biomass of tropical trees. *Global Change Biology*. 20(10): pp.3177–3190. Available at <https://doi.org/10.1111/gcb.12629>.

FAO. 2015. *Global Forest Resources Assessment 2015*. Rome: Food and Agriculture Organization of the United Nations. Available at <http://www.fao.org/forest-resources-assessment/past-assessment/fra-2015/en/>.

Improvement and accuracy assessment of change map (2006–2018) for the subnational FRL of Sudan.

National Forestry Corporation and the Food and Agriculture Organization of the United Nations. 2020. Sudan National Forest Inventory (2017): Calculation Procedures.

National Forest Inventory results for the FRL region.

Olofsson P, Foody G, Herold M, et al. 2014. Good practices for estimating area and assessing accuracy of land change. *Remote Sensing of Environment*. 148: pp.42–57. Available at <https://doi.org/10.1016/j.rse.2014.02.015>.