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SUPPLEMENTARY INFORMATION

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The key role of forests in meeting climate targets requires science for credible mitigation

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Table of Contents

1. Main countries not included in our mitigation analysis 3
2. (I)NDC analysis: country examples 6
3. Uncertainty analysis: levels and trends 11
4. Supplementary FIGURES and TABLES. 13
Supplementary Information – References 25

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1. Main countries not included in our mitigation analysis

Part of our analysis (LULUCF net emissions over time) covered all 195 UNFCCC countries, with assumptions in some case (see Methods). However, the estimation of the LULUCF mitigation contribution was possible only for 68 countries (41 (I)NDCs), covering 83% of global forest area (based on FAO-FRA 2015[1]). The modality of inclusion of LULUCF in the (I)NDCs of these countries is summarised in Supplementary Table 1. Other countries were not included either because LULUCF was not clearly included in the target or because the LULUCF contribution was not entirely clear or directly quantifiable.

In this section we discuss the qualitative, or partially quantitative, information on LULUCF mitigation (essentially from forests) from the (I)NDCs[2] of the most important forest countries not included in our mitigation analysis. In some cases, where information on area was included in the (I)NDC, a preliminary estimate of the impact in terms of emissions is included based on the carbon density from FAO-FRA reports[1]. In several cases, the contribution of LULUCF is not clear, e.g. the (I)NDC target apparently does not include LULUCF, but then actions in the forest sector are mentioned. Altogether, those countries cover an additional 12% of the global forest area.

Overall, this information shows that the estimate of the LULUCF mitigation contribution included in the paper is conservative because several relatively small potential contributions have been excluded.

Argentina (27 Mha forest): An unconditional economy-wide target to reduce GHG emissions by 15% (101 $MtCO_2e/y$) in 2030 relative to Business-as-usual (BAU) emissions (670 $MtCO_2e/y$). The goal includes actions linked to the promotion of sustainable forest management; although their contribution to the total target is not reported.

Bolivia (55 Mha forest): Unconditional forest-related targets include: 1) zero illegal deforestation by 2020; 2) an additional 1.5 Mha of forest cover by 2030 (which, from FAO-FRA data can be estimated to store about 6 $MtCO_2e/y$); 3) increased forest areas with integrated and sustainable community management approaches up to 16.9 Mha by 2030; 4) 'strengthened environmental functions' on about 29 Mha by 2030. The conditional forest related target is 6 Mha of new afforestation by 2030 (which, from FAO-FRA data, can be estimated to take up 24 $MtCO_2e/y$).

Cameroon (19 Mha forest): A conditional economy-wide target (but excluding LULUCF) to reduce GHG emissions by 32% (33 $MtCO_2e/y$) in 2030 relative to BAU emissions without LULUCF (104 $MtCO_2e/y$). The NDC also mentions actions to increase carbon sequestration from the forestry sector

through reforestation and rehabilitation of degraded forests, as well as sustainable forest management and reduced deforestation.

Cote d'Ivoire (10 Mha forest): An unconditional/conditional economy-wide target (but excluding LULUCF) to reduce GHG emissions by 28% (10 $MtCO_2e/y$) in 2030 relative to BAU emissions without LULUCF (34 $MtCO_2e/y$). The INDC also mentions actions for increasing carbon sequestration from the forestry sector by 5 $MtCO_2e/y$ in 2030. The conditional goal includes REDD+ activities (reduction of deforestation and forest degradation).

Iran (11 Mha forest): The unconditional economy-wide target is to reduce GHG emissions by 4% in 2030 relative to BAU. The conditional target is to reduce by an additional 8%. The conditional goal includes undefined actions in the forest sector.

Malaysia (22 Mha forest): An unconditional economy-wide target (although non-forest land excluded) to reduce the GHG emissions intensity of GDP by 35% by 2030 with respect to 2005. The conditional target is to reduce by an additional 10%. There is no clear indication of actions to be taken in the forest sector, although activities regarding sustainable forest management of some regions have been listed as early actions already in implementation.

Mongolia (13 Mha forest): The unconditional/conditional economy-wide target (but excluding LULUCF) is to reduce GHG emissions by 14% (7 $MtCO_2e/y$) in 2030 relative to BAU (51 $MtCO_2e/y$). In addition, a reduction of 2% in 2020 and 5% by 2030 is envisaged for the forest sector through actions for reducing emissions from deforestation and forest degradation.

Mozambique (38 Mha forest): The conditional targets relate to energy, forest and waste sectors. The targets are a total GHG emissions reduction of about 76,5 $MtCO_2e$ during the period from 2020 to 2030, with 23 $MtCO_2e$ in 2024 and 53 $MtCO_2e$ from 2025 to 2030. REDD+ activities are an integral part of actions to achieve those targets.

Myanmar (29 Mha forest): The conditional contribution is composed of a set of policies and measure for mitigation and adaptation. Those measures include the expansion of the protected forest area up to 30% of total country territory, and a decrease of the deforestation rate.

Papua New Guinea (34 Mha forest): Conditional economy-wide target of zeroing GHG emissions in the energy sector in 2030 relative to BAU (18 $MtCO_2e/y$). REDD+ is also reported as a means to achieve mitigation although no information is reported on specific REDD+ targets and on how REDD+ would contribute to the energy sector target, if at all.

Paraguay (11 Mha forest): The unconditional/conditional economy-wide target is to reduce GHG emissions by 20% in 2030 relative to BAU. The goal includes increasing forest area, enhancing sustainable forest management and reducing deforestation.

Peru (74 Mha forest): The unconditional economy-wide target is to reduce GHG emissions by 20% (28 $MtCO_2e/y$) in 2030 relative to BAU (139 $MtCO_2e/y$). The conditional target is to reduce by an additional 10%. No information on specific mitigation actions is reported, although the LULUCF sector contributes to half of the country's total net GHG emissions.

Sudan (19 Mha forest): Conditional targets relate to the energy, forest and waste sectors. However, no BAU level is included in the (I)NDC. To note, in the second National Communication, the mitigation potential is reported as a net emissions reduction of 28% (7 $MtCO_2e/y$) in 2030 relative to the BAU. The conditional goal includes an increase in total afforested area of 4 Mha (which from FAO-FRA data can be estimated as a sink of 20 $MtCO_2e/y$), as well as a reduction of emissions from deforestation and forest degradation.

Suriname (15 Mha forest): The unconditional/conditional contribution is composed of a set of policies and measures for mitigation and adaptation. Unconditional measures include sustainable forest management, while conditional ones include avoided deforestation though conservation.

Thailand (16 Mha forest): The unconditional economy-wide target (but excluding LULUCF) is to reduce GHG emissions by 20% (111 $MtCO_2e/y$) in 2030 relative to BAU (555 $MtCO_2e/y$). The conditional target is to reduce by an additional 5%. The unconditional and conditional goals do not include mitigation actions in forestry, although the inclusion of REDD+ activities is still under consideration.

Venezuela (47 Mha forest): The unconditional economy-wide target is to reduce GHG emissions by 20% (68 $MtCO_2e/y$) in 2030 with respect to projected BAU emissions for that year (340 $MtCO_2e/y$). The unconditional goal includes actions for sustainable management of forest of 4 $MtCO_2e/y$.

Vietnam (15 Mha forest): An unconditional economy-wide target to reduce GHG emissions by 8% (63 $MtCO_2e/y$) in 2030 relative to BAU (787 $MtCO_2e/y$). The conditional target is to reduce by an additional 17%. The unconditional goal includes, inter alia, the increase of forest area up to 45% of the total country's area (however, according to FAO-FRA data, 48% of the country's area is currently covered by forest).

2. (I)NDC analysis: country examples

Six country cases are discussed in detail below, chosen because of their relevance in terms of the size of emissions or removals, and because they are representative of the various (I)NDC cases analysed (see Supplementary Table 2).

The data sources used in this analysis include the country (I)NDC[2], 2015 GHG inventories[3] (GHGI 2015), the latest National Communications[4] (NC), Biennial Reports[5] (BR, for developed countries) or Biennial Update Reports[6] (BUR, for developing countries) and the Forest Reference Emission Level (FREL)[7], complemented by additional country-specific sources indicated below. Our analysis is based on countries' documents submitted up to the end of February 2016. However, below we also briefly discuss any relevant recalculations made by countries after that date (e.g. Brazil, Indonesia and USA).

(I)NDC case 1 (absolute target relative to 2005, LULUCF treated the same as any other sector).

Brazil. *NDC all sector emission target: indicative -43% relative to 2005 levels in 2030 (37% below 2005 in 2025).* The NDC includes some information on the future LULUCF mitigation potential, including the expected enhanced sink by "conservation units and indigenous lands" (footnote 1 of NDC) and the aim to "achieve, in the Brazilian Amazonia, zero illegal deforestation by 2030 and compensating for emissions from legal suppression of vegetation by 2030". The data we used for this analysis were Brazil's 2014 GHG emission estimates[8], the 2nd NC (2010), the BUR (2014), the Copenhagen pledge[9], the Brazil submission on FREL and the NDC presented in October 2015[10]. To ensure consistency with the NDC, all estimates were adjusted to reflect the Global Warming Potential based around 100 years time frame (GWP-100) from IPCC AR5 as used in the NDC. This analysis suggests that: (i) In 2005, LULUCF emissions (1.2 $GtCO_2e/y$) represented about 58% of Brazil's total emissions; (ii) a significant drop in emissions from deforestation already occurred from 2005 to 2010 (about -0.9 $GtCO_2e/y$, equal to about 43% of 2005 GHG emissions); (iii) LULUCF emissions will likely further decrease, getting close to zero in 2030, and the estimated "Country perspective on emissions reduction in the INDC" (perspective C in the main text) is equal to about -1.1 $GtCO_2e/y$, or about -55% relative to 2005 emissions; (iv) the LULUCF NDC trajectory appears a significant deviation from the alternative scenarios included in ref[8] for 2020 (and here assumed to stay constant in 2030), i.e. the pre-NDC Cancun pledges (about 0.5 $GtCO_2e/y$ in 2020) and the 'country-BAU' (1.4 $GtCO_2e/y$ in 2020). The LULUCF NDC trajectory appears a significant deviation also from the FREL for the Amazonia biome (0.9 $GtCO_2e/y$ for results in the period 2011–2015, based on mean annual emissions for the period 1996–2010). Overall, this analysis confirms the great importance of LULUCF mitigation in Brazil's NDC. The 3rd NC[4], submitted in May 2016 and not included in this analysis, includes an upward revision of historical LULUCF GHG estimates for the year 2005 (i.e. 1.9

$GtCO_2e/y$, i.e. an increase of about 0.7 $GtCO_2e/y$ compared to 2nd NC and ref[8] used in our analysis) while data for the year 2010 remains essentially unchanged. These recalculations, largely consistent with independent analysis (http://seeg.eco.br/en/), suggest an even greater reduction of historical LULUCF emissions over time, and opens new questions on the possible implications for the NDC and on how and when data consistency between NDC, REDD+ and the GHG data included in the NC will be ensured.

USA. *NDC all sector emission target: -26 to -28% relative to 2005 levels in 2025*. LULUCF is treated the same as any other sector, with the exception of the possible exclusion of emissions from natural disturbances, consistent with available IPCC guidance. This analysis used information from the NDC complemented by the GHGI (2015), the NC (2014), the BR (2014) and the "Building blocks for Climate Smart Agriculture and Forestry"[11]. According to the latest NC (2014), the expected LULUCF sink in 2025 ranges from -0.53 $GtCO_2e/y$ (low sequestration scenario) to -0.88 $GtCO_2e/y$ (high sequestration scenario). In both cases, the LULUCF sink is expected to decrease compared to 2005 (-0.97 $GtCO_2e/y$ as reported in the NC). Given that the 'high sequestration' scenario is the one considered to be 'with policies and measures' in the BR, we used this for both the "country BAU" and "Pre-NDC" scenario cases. Projections from the NC and BR were calibrated for the year 2010 with the GHGI of 2015 to keep consistency with historical data (note that the latest GHGI 2015 revised the sink downward for the entire time series). In addition, the recent USDA document[11] expects that a new set of voluntary programs and initiatives in agriculture and forestry will 'reduce net emissions and enhance carbon sequestration by 0.12 $GtCO_2e/y$ in 2025'. Here, we assumed that half of this amount will come from LULUCF (i.e., the "deviation from pre-NDC" is equal to 0.06 $GtCO_2e/y$ in 2025). Overall, this analysis suggests that the 2025 net sink will likely remain close to or lower than the 2005 levels (with large uncertainties), and therefore the "Country perspective on emissions reduction in the NDC" as defined in this analysis is close to zero. The revision of data in the 2016 GHG inventory[3] (May 2016) compared to the 2015 GHG inventory data used in this analysis shows a marked reduction of the sink for the year 2005 (now reported at -0.70 $GtCO_2e/y$). However, since new projections (http://unfccc.int/files/focus/long-term_strategies/application/pdf/mid_century_strategy_report-final_red.pdf, November 2016) indicate for the "benchmark" scenario a future land sink comparable to the current one, the preliminary conclusions above do not seem strongly affected.

(I)NDC case 2 (reduction relative to BAU, LULUCF treated the same as any other sector).

Indonesia. (*I)NDC all sector emission target: -29% (unconditional) and -41% (conditional) relative to a 2030 BAU emission of 2.8 $GtCO_2/y$*. This analysis used information from the (I)NDC, complemented by: (i) the sectorial AFOLU data underlying the (I)NDC for the period 2000-2030

(presented at the COP-21[12]), including emissions in 2005 (1.01 $GtCO_2e/y$, representing about 65% of total GHG emissions) and the expected emissions in 2030 for the BAU (1.08 $GtCO_2e/y$), the unconditional (0.55 $GtCO_2e/y$) and the conditional (0.42 $GtCO_2e/y$) scenarios. This data refers to AFOLU (Agriculture, Forestry and other Land Use), including peat decomposition and peat fires, but since Agriculture is a rather constant source of about 0.1 $GtCO_2e/y$ (R. Boer, personal communication), the vast majority of AFOLU emissions come from LULUCF; (ii) the information from the 2nd NC (2011) for the period before 2000. For peat fire emissions before 1997, we assumed an average of 0.3 $GtCO_2e/y$, based on the average of post-1997 fire emissions in 2nd NC and ref[12]; (iii) the Indonesia FREL (0.58 $GtCO_2e/y$ as average for the period 2013-2020), based on data of deforestation, forest degradation and peat decomposition (but not peat fires) from 1990 to 2012[13] and (iv) other official presentations by Indonesia[14]. Overall, the above information shows the great importance of LULUCF within the Indonesia's (I)NDC: the "Country perspective on emissions reduction in the (I)NDC*"* (perspective C in the main text) is equal to about -0.53 and -0.66 $GtCO_2e/y$ in 2030 for the unconditional and conditional (I)NDC targets, respectively (equal to -18% to -23% of 2030 total BAU emissions, i.e. between half and two-thirds of the (I)NDC emission reduction target relative to BAU). In November 2016 Indonesia has submitted its first NDC (after having ratified the Paris Agreement), including an update of the (I)NDC data used in this analysis and a disaggregation between Agriculture and LULUCF. The LULUCF estimates in the NDC reflect the data from the first BUR[5] (March 2016), where the historical LULUCF emissions have been revised downward relative to 2nd NC (due to a recalculation of past deforestation rates), e.g. LULUCF emissions for the year 2005 are now estimated at 0.70 $GtCO_2e/y$. Since a similar downward revision of LULUCF emissions occurred also for the BAU (0.71 $GtCO_2e/y$), the unconditional (0.22 $GtCO_2e/y$) and the conditional (0.06 $GtCO_2e/y$) scenarios, the overall conclusions above on the relative importance of LULUCF do not change.

(I)NDC case 3 (absolute target relative base year, LULUCF with special accounting rules)

Russian Federation. (*I)NDC all sector emission target: -25% to -30% relative to 1990 levels in 2030*. Since the INDC is "subject to the maximum possible account of absorbing capacity of forests", this analysis assumes a so-called "gross-net accounting" for forests (i.e. the full sink in 2030, not the change in the sink, is accounted toward the target). Taking into account the GHGI (2015), the decline of forest sink projected in the NC 2014 (scenario 3 was assumed as "(I)NDC") and additional information from Romanovskaya and Federici[15], this analysis suggests a "Country perspective on emissions reduction in the (I)NDC" (perspective C in the main text) equal to about -0.5 $GtCO_2e/y$ in 2030 (12 % of 1990 emissions, or about two-fifths to the total (I)NDC emission reduction). It should be considered that a large uncertainty exists due to: (i) projected scenarios; (ii) accounting assumptions: if Russia would account the forest sink vs. 1990 (as in the Forest Management Reference

Level for Kyoto Protocol Commitment Period 2[16]), or if cropland and grassland would be included, the LULUCF contribution to (I)NDC would be about 5% or 20% of 1990 emissions, respectively; (iii) whether or not LULUCF is included in the base year: since LULUCF was a source of 0.2 Gt CO_2e/y in 1990, its inclusion could increase the GHG allowances in 2030.

Canada. *NDC all sector emission target: -30% relative to 2005 levels in 2030*. In Canada, estimating LULUCF emissions and removals is very complex and uncertain due to the great importance of emissions from natural disturbances (ND), which according to the NDC will be excluded from the accounting. The country's projections in the NC (2014) are without ND and therefore cannot be directly compared to historical data. To make this comparison possible, we reconstructed a proxy time series without ND since 1990, based on country information on area affected by insect and fires and on the temporal dynamics of corresponding direct and indirect emissions (e.g. GHGI 2015, NC, Canada's submission on Forest Management Reference Level and its technical assessment[16]). Based on the above, it is estimated a "Country perspective on emissions reduction in the NDC", as defined in this analysis, of about -0.05 $GtCO_2$e/y in 2030. This is somewhat higher than the LULUCF accounting expected in Canada's NC for the Kyoto Protocol Commitment Period 2 (about -0.028 $GtCO_2$e/y in 2020); given the harvest rate in 2005 (base year of the NDC) and in the Forest Management Reference Level (basis for Commitment Period 2 accounting), this difference is plausible. Large uncertainties exist due to: (i) the impact of ND; (ii) whether or not LULUCF is included in the base year: if included, then emissions from ND could be expected to be excluded from the base year, and this may affect considerably the GHG allowances in 2030.

<u>(I)NDC case 4 (intensity target).</u>

China. *NDC all sector emission target in 2030: 60 to 65% CO_2 emission intensity (per unit GDP) reduction, and other specific targets, including the 20% non-fossil fuels in primary energy consumption, and the 'increase the forest stock volume by 4.5 billion m^3 on the 2005 level'*. By using the ratio of Carbon stock/growing stock from China's FAO-FRA 2015 country report[1] (which already incorporates the Biomass Expansion Factor, the root/shoot ratio and the Carbon density), we estimated an average sink of about -0.25 $GtCO_2$/y for the period 2015-2030. This represents a decline of the sink compared to 2005 (i.e. -0.44 $GtCO_2$e/y, based on the NDC, the China's report under FAO-FRA 2015[1] and the China's NC (2012)). This apparently contrasts with the young age structure of forests, which could suggest a good potential for a stable or increasing sink (e.g. refs. [17,18,19]). It should be noted that recently China has already adopted a 'prudent' forest projection. As stated in the NDC: "In 2009, China announced internationally that by 2020 it will increase the forest stock volume by 1.3 billion cubic meters compared to the 2005 levels" and "By 2014 the forest stock volume increased by 2.2 billion cubic meters compared to the 2005". Therefore, in 2014 China apparently already largely

overachieved (+70%) the target for 2020 announced in 2009. Since the INDC's target is expressed as '*increase of C stock*' (i.e., a sink), in this analysis the "Country perspective on emissions reduction in the NDC" for China is estimated as equal to the expected full sink in 2030 (i.e. about -0.25 $GtCO_2/y$).

3. Uncertainty analysis: levels and trends

The estimation of LULUCF uncertainty may depend on many factors, including the level of aggregation and the different coverage of land uses, carbon pools and gases. Based on available information from countries' reports to UNFCCC, complemented by expert judgment, we performed analyses of the uncertainties for LULUCF absolute GHG net emissions (level) and for the associated trends. When a total estimate for LULUCF was not available in countries' report, the uncertainty of the most important category (typically forest land in developed countries and deforestation in developing ones) or the most important carbon pool (typically biomass) was used. Supplementary Table 7 shows the values of uncertainties used in this analysis.

Overall, the aggregation of available information indicates values of uncertainties of 16% for developed countries and 24% for developing countries. However, since the available information is incomplete in terms of land categories, carbon pools and gases covered, based on expert judgment we increased the above values to 25% for developed countries and 40% for developing countries, making this analysis more conservative and robust than just using the single aggregation of available information. We then applied these increased values of uncertainty separately to LULUCF estimates of developed and developing countries, and then summed them up to obtain global level uncertainties in single years.

Supplementary Figure 2 shows the global estimates of uncertainty for single years from 1990 to 2010, along with the linear trend estimate and its equation. The lower absolute uncertainties after 2005 relative to the 1990s reflect the decrease of emissions from developing countries, where the values of uncertainties are higher. The linear trend emerging from this figure (-0.083±11.6, significantly different from zero at $p>0.95$) is strongly affected by inter-annual variability, and does not consider the impact of possible temporal correlation among errors[20]. Of particular relevance is the question whether changes in net emissions in specific present and future periods, are statistically discernable from the net emissions in other periods.

These limits are addressed in the results shown in Supplementary Figure 3, showing:

(a) Data aggregated in different periods up to 2030 (Supplementary Figure 3a). For the year 2030, we assumed that the uncertainty of GHG emissions calculations for developed and developing countries estimated for the past will hold for the future (an obviously conservative assumption), but we did not assess the uncertainty related to the implementation of policies. Global LULUCF net emissions are 1.28 ± 1.14 $GtCO_2e/y$ for the period 1990-2010 and are expected to reach -0.41 ± 0.68 $GtCO_2e/y$ and -1.14 ± 0.48 $GtCO_2e/y$ for the unconditional and the conditional (I)NDC cases, respectively.

(b) The uncertainty of the trend (Supplementary Figure 3b), i.e. the uncertainty of the difference between specific periods (at the 95% confidence interval, CI) using the methods described in IPCC[21],

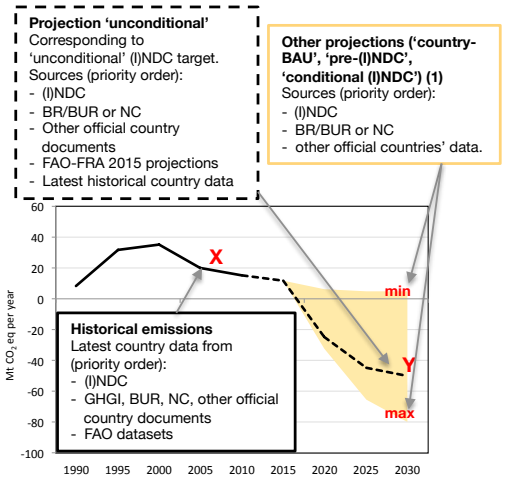
Volume 3, chapter 3 (Table 3.2). Given that an estimate of net emission is the result of Activity Data (AD, e.g. deforested area) multiplied by the relevant Emission Factor (EF, e.g. loss of carbon per unit of deforested area), the uncertainty of the trend is dependent on whether or not the errors of AD and EF are correlated over time[20]. An analysis of fully uncorrelated AD and EF errors could be done by comparing visually the uncertainties ranges of Supplementary Figure 3a: if the ranges do not overlap, the emissions of corresponding periods may be considered statistically different, e.g., emissions in the 2030 unconditional INDC case are statistically different from those in the 1990s, but not necessarily from those in the 2000s. However, a complete absence of temporal correlation is unrealistic: the basic assumption in IPCC[21] is that for LULUCF errors of AD are not correlated and errors of EF are fully temporally correlated. This typically leads to uncertainties of the differences over time which are lower than the uncertainty[20] of the annual estimates. For the purpose of this analysis, we applied the basic IPCC assumption on correlation and assumed aggregated values of uncertainty of 15% for AD and 20% for EF in developed countries, and of 20% for AD and 35% for EF in developing countries (Supplementary Table 7). These values are consistent with the aggregated (AD x EF) values of emission uncertainties discussed above (25% of developed countries, 40% for developing ones).

The differences between the periods 1996-2000 and 1990-1995 in Supplementary Figure 3(b), or between the periods 2001-2005 and 1996-2000, are not significantly different from zero. By contrast, the difference between the periods 2006-2010 and 2001-2005 (-0.96 ± 0.84 $GtCO_2e/y$) is significantly different from zero at the 95% CI. The trend over these latter two periods is mostly due to the well-documented reduction of deforestation in Brazil[3]. The difference between the pre-(I)NDC case and the period 1990-2010 (-0.92 ± 1.78 $GtCO_2e/y$) is not significantly different from zero. By contrast, the differences between the unconditional (I)NDC case and the period 1990-2010 (-1.69 ± 1.00 $GtCO_2e/y$) and between the conditional (I)NDC case and the period 1990-2010 (-2.43 ± 1.25 $GtCO_2e/y$) are both significantly different from zero at the 95% CI.

Overall, we conclude that the trend of reduced LULUCF net emissions assumed by the (I)NDCs relative to the historical period 1990-2010, as shown in this analysis, is statistically robust.

4. Supplementary FIGURES and TABLES.

2030 (I)NDC *vs.* 2005 and *vs.* alternative scenarios (perspectives 'A' and 'B', respectively) estimated as:



Country perspective on emissions reduction in the (I)NDC (perspective 'C') estimated as:

(LULUCF at target year) – (LULUCF at reference point), combined with accounting rules (if any)

Reference point: base year *or* BAU scenario for target year (2025 or 2030)

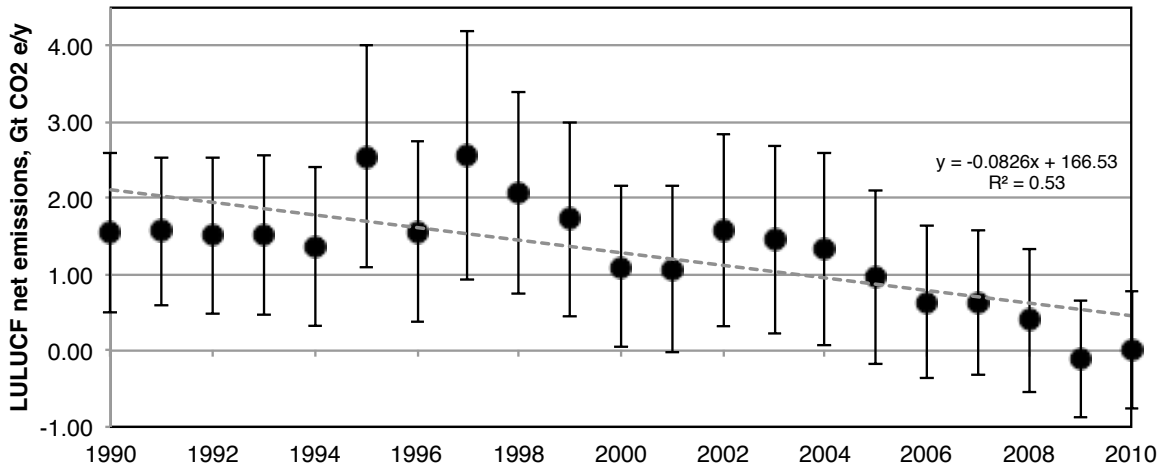
INDC CASE	Type of mitigation target	LULUCF within the (I)NDC	Calculation of perspective 'C"
1	Absolute target relative to base year	Treated as any other sector	Y - X
2	Reduction relative to BAU		Unconditional: Y – min Conditional: max – min
3	Absolute target relative to base year	Specific accounting rules	Y – a quantity determined by the accounting rule (2)
4	Intensity	Various approaches	Y – min (based on (I)NDC information)

(1) For developed countries: 'country-BAU' is assumed equal to 'pre-(I)NDC' and corresponds to the NC projection 'with existing measures'; 'conditional (I)NDC' is not relevant.

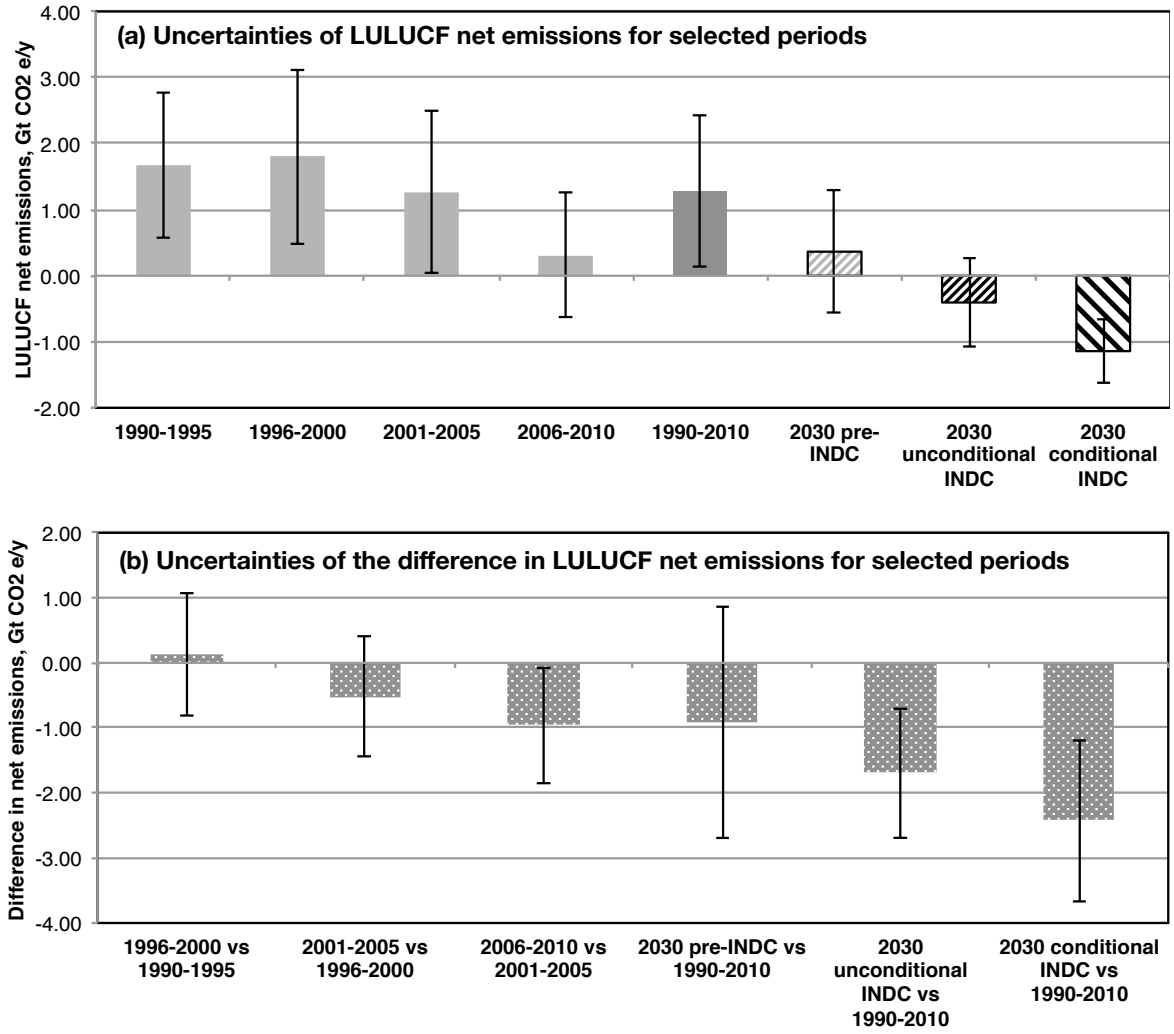
For most developing countries: 'country-BAU' and the 'conditional (I)NDC' are explicitly indicated in the (I)NDC; 'pre-(I)NDC' is taken from country-specific information when available (e.g. Copenhagen pledges for 2020, assumed constant in 2030) or otherwise it is assumed equal to 'unconditional (I)NDC'.

(2) For countries in (I)NDC case 3 (see Supplementary Table 2), if no specific quantitative information was indicated in the (I)NDC, the following approach was taken: For the LULUCF activities expected to continue with the current LULUCF rules, the numbers considered in LULUCF accounting in the KP Commitment Period 1 were used. In case Forest Management is expected to be accounted against a projected reference level, in the absence of better information, zero credits are assumed.

Supplementary Figure 1. Approach to collect and estimate the three different LULUCF mitigation perspectives (Supplementary Table 3) for the four (I)NDC cases identified in Supplementary Table 2.



Supplementary Figure 2. Global estimates of net emissions uncertainty for single years from 1990 to 2010, along with the linear trend and its equation.



Supplementary Figure 3. Uncertainties for (a) LULUCF net emissions in selected periods and (b) the difference in LULUCF net emissions between selected periods. Bars express the 95% confidence interval. For (b), following IPCC, the activity data (AD) is assumed uncorrelated and the emissions factor (EF) is assumed fully correlated. Based on available information on uncertainty in countries' reports to UNFCCC, complemented by expert judgment, the following values of aggregated uncertainty were used: 15% for AD and 20% for EF in developed countries; 20% for AD and 35% for EF in developing countries. See text for additional information. Note that the levels of uncertainty for the periods in panel (a) are similar to those for the corresponding single years in Supplementary Figure 2.

Supplementary Table 1. Overview of country-specific information from the 41 (I)NDCs analyzed (68 countries)

COUNTRY	General information based on the (I)NDCs					Comments on LULUCF accounting (based on (I)NDCs)
	Type of target	year	%, min - max relative to RP (conditional targets in parenthesis)		Reference point (base year or BAU)	
Angola	Relative to BAU	2030	-35%	(-50%)	BAU 2030	LULUCF included as any other sector.
Australia	Absolute	2030	-26%	-28%	2005	LULUCF included as any other sector.
Benin	Relative to BAU	2030	-7%	(-39%)	BAU 2030	LULUCF (forestry) has specific conditional and unconditional targets (here summed to other sectors).
Brazil	Absolute	2025 / 2030	-37%	-43%	2005	See "Country case studies"
Cambodia	Relative to BAU	2030		(-27%)	BAU 2030	LULUCF included in (I)NDC, apparently with separate targets
Canada	Absolute	2030	-30%	-30%	2005	See "Country case studies"
Central Afr. Rep.	Relative to BAU	2030	-3%	(-4%)	BAU 2030	LULUCF included as any other sector.
Chad	Relative to BAU	2030	-18%	(-71%)	BAU 2030	Land use and forestry included as any other sector.
Chile	Relative to BAU	2030		*(1)*	2007	LULUCF has separate target.
China	Relative to BAU	2030		*(2)*	2005	See "Country case studies"
Colombia	Relative to BAU	2030	-20%	(-30%)	BAU 2030	LULUCF (as AFOLU) included as any other sectors.
Congo	Relative to BAU	2025/2035	-48%	(-54%)	BAU 2025/2035	LULUCF included as any other sector.
Dem. Rep. Congo	Relative to BAU	2030		(-17%)	BAU 2030	LULUCF (forests) included as any other sector.
Ecuador	Relative to BAU	2030	-23%	(-42%)	BAU 2025	Forests has specific objectives
Ethiopia	Relative to BAU	2030		(-64%)	BAU 2030	Forestry included as any other sector.
EU28	Absolute	2030	-40%	-40%	1990	Accounting is not decided yet (NDC: "policy on how to include LULUCF will be established as soon as technical conditions allow"). Here assumed continuation of Kyoto Protocol (KP) rules for forest activities.
Gabon	Relative to BAU	2025	-62%	-62%	BAU 2025	Land Use changes included as any other sectors (forestry is excluded).
Ghana	Relative to BAU	2030	-15%	(-45%)	BAU 2030	LULUCF included as any other sectors.
Guyana	Absolute	2025		*(3)*		Forestry included as any other sector.
India	Relative to BAU	2030		*(4)*	2005	Forests have a separate target
Indonesia	Relative to BAU	2030	-29%	(-41%)	BAU 2030	See "Country case studies"
Japan	Absolute	2030	-26%	-26%	2013	Accounting as under KP
Lao's PDR	Absolute	2030		*(3)*		A number of forest actions are mentioned in (I)NDC
Kazakhstan	Absolute	2030	-15%	-25%	1990	LULUCF assumed to be included with KP-like rules.
Kenya	Relative to BAU	2030		(-30%)	BAU 2030	LULUCF included as any other sectors.
Madagascar	Relative to BAU	2030	(-42%) with sinks		BAU 2030	LULUCF included as any other sectors.
Malawi	Relative to BAU	2030		(-40%)	BAU 2030	LULUCF (mainly forests) included as any other sector.
Mali	Relative to BAU	2030			BAU 2030	LULUCF (mainly forests) apparently has own targets
Mexico	Relative to BAU	2030	-22%	(-36%)	BAU 2030	LULUCF (mainly forestry and land use changes) included as any other sector.
Morocco	Relative to BAU	2030	-13%	(-32%)	BAU 2030	LULUCF (mainly forests) included as any other sector.
Namibia	Relative to BAU	2030		(-89%)	BAU 2030	LULUCF (mainly forests) included as any other sector.
New Zealand	Absolute	2030	-30%	-30%	2005	Assumed the continuation of KP rules.
Norway	Absolute	2030	-40%	-40%	2030	Accounting is not decided yet. Here assumed continuation of KP rules.
Russian Fed.	Absolute	2030	-25%	-30%	1990	See "Country case studies"
Senegal	Relative to BAU	2030	-5%	(-22%)	BAU 2030	Forests included as any other sector.
Switzerland	Absolute	2030	-50%	-50%	1990	Assumed continuation of KP rules.
Turkey	Absolute	2030	-21%	-21%	BAU 2030	Accounting is not decided yet. Here assumed KP-like rules, with 'gross-net' accounting for forests.
Uganda	Relative to BAU	2030		(-22%)	BAU 2030	Forestry included as any other sector.
Ukraine	Absolute	2030	-40%	-40%	1990	Accounting is not decided yet. Here assumed continuation of KP rules.
USA	Absolute	2025	-26%	-28%	2005	See "Country case studies"
Zambia	Relative to BAU	2030		(-47%)	BAU 2030	Forest management included as any other sectors.

(1) Chile: Reduce the emissions intensity of its GDP by 30-45 % by 2030 from 2007 level. Specific LULUCF targets.

(2) China: Peaking CO_2 emissions around 2030; 60-65% CO2 emission intensity reduction; 20% non-fossil fuels in primary energy consumption & increased forest stock volume (see country cases)

(3) The (I)NDCs of Guyana and Laos' people Democratic Republic (PDR) do not specify a reduction target, but

identify specific forestry actions. In this analysis, we quantified these actions based on (I)NDC information.

(4) India: 33% to 35% emissions intensity reduction; 40% non-fossil fuel electricity; additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030

Supplementary Table 2. Identification of the four '(I)NDC cases' and classification of the 68 countries where (I)NDCs were analysed (or 41 (I)NDCs, including the EU representing a group of 28 countries)

(I)NDC CASE	Type of mitigation target	Inclusion of LULUCF within the (I)NDC	Countries with enough LULUCF information for this analysis
1	Absolute target relative to base year	LULUCF (or part of it) explicitly (or assumed to be) treated as any other sector	Brazil, United States of America(2)
2	Reduction (including "unconditional" and "conditional" targets) relative to BAU scenario		Angola, Benin, Cambodia, Central African Republic, Chad, Colombia, Congo, Democratic Republic of the Congo, Ecuador, Ethiopia, Gabon, Ghana, Guyana, Indonesia, Lao's People Democratic Republic, Kenya, Madagascar, Malawi, Mali, Mexico, Morocco, Namibia, Senegal, Uganda, Zambia
3	Absolute target relative to base year	Special accounting rules	Australia, Canada, EU, Japan, Kazakhstan, New Zealand, Norway, Russian Federation, Switzerland, Turkey, Ukraine
4	Intensity target (1)	Various approaches	Chile, China, India

(1) When an (I)NDC is expressed in terms of 'intensity targets' (e.g. (I)NDCs of China and India include for 2030 a reduction of emission intensity per unit of GDP), the total GHG emissions for the 2030 BAU scenario were taken from Ref [22].

(2) A possible exception to LULUCF being treated as other sectors is that the (I)NDCs of USA include the possibility to exclude emissions from natural disturbances, consistent with available IPCC guidance.

Supplementary Table 3. The 'LULUCF mitigation perspectives' used in this analysis and summary of the estimated global results for the unconditional and conditional (I)NDC scenarios (negative numbers indicate a mitigation contribution)

LULUCF mitigation perspective		Questions addressed	Results from this analysis ($GtCO_2e/y$)	
			Unconditional (I)NDCs	Conditional (I)NDCs
A. 2030 ((I)NDC) vs. 2005: emissions and removals expected in 2030 for unconditional and conditional (I)NDC targets relative to a historical base year. In this analysis we refer to 2005, chosen as the most historically reliable in terms of data.		What are the current and future emissions and removals from LULUCF? What will be the effect on anthropogenic emissions to and removals from the atmosphere as a consequence of (I)NDC implementation? (i.e. the actual change in net emissions to the atmosphere).	-1.2	-1.9
B. 2030 (I)NDC vs. two 2030 alternative scenarios (see next column).	1. Country BAU, as expressed in the (I)NDC or in other country document	What is the *additional* contribution from LULUCF mitigation in the (I)NDC relative to a given scenario?	-2.4	-3.1
	2. Pre-(I)NDC, which considers policies in place prior to COP-21 based on country documents, including information on 'Copenhagen pledges' when available[8].		-0.8	-1.5
C. Country perspective on emissions reduction in the (I)NDC in 2030. This perspective considers the *way that each country has proposed to express its (I)NDC* (relative to a reference point, i.e. base year or a BAU scenario year) and the *way LULUCF is included* (treated as any other sector or with special accounting rules).		What are countries "accounting" as their emissions reduction in the land sector? If a country commits to reduce its overall emissions by *x*% relative to *y* (reference point: base year or BAU-scenario), what fraction of *x* is attributable to LULUCF? Depending on each countries' (I)NDC, perspective C may be the same as perspective A or B above, or may be different.	-3.1	-3.8

Supplementary Table 4: Overview of the sources of LULUCF country data used for the historical period in Fig. 1 of the paper.

		Developed countries	Developing countries
LULUCF historical		Priority order: (I)NDC, GHGI	Priority order: (I)NDC, GHG data in NC and BUR, other official country data, FAO-based datasets
Alternative selection of country data	**LULUCF upper range**	GHGI	FAO-based datasets
	LULUCF lower range	GHGI	GHG data in NC

Supplementary Table 5. Overview of country-specific LULUCF trends for the historical period (1990-2010) and up to 2030 (as expected for unconditional (I)NDC targets and for the additional conditional LULUCF contribution). The country sources used in this analysis include the (I)NDC[1], 2015 GHG inventories[2], GHG data in the latest National Communications[3](NC), Biennial Reports[4] (BR, for developed countries) or Biennial Update Reports[5] (BUR, for developing countries), the Forest Reference Emission Level (FREL)[6], FAO-FRA 2015 country reports[16], complemented by additional country-specific sources indicated below.

COUNTRY	Historical LULUCF emissions (+) and removals (-), Gt CO_2e/y						Expected LULUCF emissions (+) and removals (-) in 2030 (1), Gt CO_2e/y		
	1990	1995	2000	2005	2010	main sources of information	with unconditional (I)NDC (2)	impact of *additional* conditional measures (3), if any	main sources of information
Angola	0.04	0.04	0.04	0.04	0.04	FAO-FRA 2015	0.03	-0.04	(I)NDC
Australia	0.10	0.04	0.06	0.07	0.03	GHGI 2015	0.02	0.00	2020 is from NC. 2030 assumed = 2020.
Benin	-0.02	-0.02	-0.01	-0.01	0.03	FAO-FRA 2015	0.02	-0.01	(I)NDC
Brazil	0.84	1.99	1.38	1.21	0.32	MCTI[7], NC, BUR, FREL[8]	0.02	0.00	See "Country case studies"
Cambodia	-0.02	-0.02	-0.03	-0.02	-0.02	NC	-0.01	-0.01	(I)NDC
Canada	-0.09	0.20	-0.08	0.02	0.08	GHGI 2015	-0.03	0.00	See "Country case studies"
Central African Republic	0.10	0.10	0.10	0.10	0.10	(I)NDC	0.10	0.00	INDC, tab. 1
Chad	-0.01	-0.01	-0.01	-0.01	-0.01	(I)NDC	-0.02	-0.01	INDC, tab. 4
Chile	-0.05	-0.05	-0.06	-0.04	-0.05	(I)NDC, NC	0.00	0.00	(I)NDC
China	-0.37	-0.37	-0.37	-0.44	-0.41	(I)NDC, NC, FAO-FRA 2015	-0.25	0.00	See "Country case studies"
Colombia	0.09	0.09	0.09	0.07	0.09	(I)NDC, NC, FREL, presentation[9]	0.08	-0.01	(I)NDC, NC, FREL, presentation[9]
Congo	0.02	0.02	0.02	0.02	0.02	(I)NDC	0.02	-0.03	(I)NDC
Dem. Rep. Congo	0.20	0.20	0.20	0.20	0.24	(I)NDC	0.40	-0.11	(I)NDC, Fig. 2
Ecuador	0.04	0.04	0.04	0.03	0.03	FAO-FRA 2015, FREL	0.02	-0.01	(I)NDC (afforestation area) and FREL (C stock/ha)
Ethiopia	0.06	0.06	0.06	0.06	0.06	(I)NDC	0.09	-0.13	(I)NDC
EU28	-0.26	-0.28	-0.31	-0.32	-0.31	GHGI 2015	-0.28	0.00	2030: Ref [10], calibrated at 2010 with GHGI 2015 to keep consistency with historical data.
Gabon	0.08	0.08	0.08	0.09	0.11	(I)NDC	0.06	0.00	(I)NDC, fig. 2. LULUCF contribution assumed unconditional.
Ghana	0.00	0.00	0.00	0.00	0.00	GHGI 2015	0.01	-0.02	Country projection in FAO-FRA 2015, BUR.
Guyana	0.01	0.01	0.01	0.01	0.01	NC	0.01	-0.05	(I)NDC, FREL
India	0.01	-0.13	-0.27	-0.28	-0.25	NC, BUR, FAO-FRA 2015	-0.30	0.00	(4)
Indonesia	0.79	0.79	0.66	1.01	0.87	NC, Indonesia[11]	0.55	-0.13	See "Country case studies"
Japan	-0.06	-0.07	-0.09	-0.09	-0.07	GHGI 2015	-0.04	0.00	(I)NDC
Lao's PDR	0.04	0.04	0.04	0.04	0.04	NC	0.04	-0.01	(I)NDC, tab. 1
Kazakhstan	-0.02	0.00	0.01	-0.01	0.00	GHGI 2015	0.00	0.00	2030 assumed = 2010.
Kenya	0.02	0.02	0.02	0.02	0.02	FAO-FRA 2015	0.01	-0.04	Government of Kenya[12]
Madagascar	-0.22	-0.22	-0.28	-0.28	-0.22	(I)NDC, NC	-0.19	-0.06	(I)NDC
Malawi	0.02	0.02	0.02	0.02	0.02	(I)NDC, FAO-FRA 2015	0.00	0.00	(I)NDC
Mali	-0.26	-0.26	-0.26	-0.26	-0.24	(I)NDC (5)	-0.13	-0.02	(I)NDC (5)
Mexico	0.11	0.10	0.07	0.05	0.05	NC, FREL	-0.01	0.00	(I)NDC, (6)
Morocco	0.00	0.00	0.00	0.00	0.00	NC	0.00	0.00	(I)NDC
Namibia	-0.01	-0.01	-0.01	-0.03	-0.03	BUR	0.01	-0.02	(I)NDC
New Zealand	-0.03	-0.03	-0.03	-0.03	-0.03	GHGI 2015	0.00	0.00	NC
Norway	-0.01	-0.02	-0.01	-0.03	-0.02	GHGI 2015	-0.02	0.00	(I)NDC
Russian Fed.	0.20	-0.06	-0.31	-0.35	-0.45	GHGI 2015	-0.37	0.00	See "Country case studies"
Senegal	-0.01	-0.01	-0.01	-0.01	-0.02	(I)NDC, NC	-0.03	0.00	(I)NDC
Switzerland	0.00	0.00	0.00	0.00	0.00	GHGI 2015	0.00	0.00	NC
Turkey	-0.04	-0.05	-0.05	-0.05	-0.06	GHGI 2015	-0.06	0.00	2030 assumed = 2010.
Uganda	0.01	0.01	0.01	0.01	0.01	(I)NDC, NC	0.01	-0.02	(I)NDC

Ukraine	-0.04	-0.05	-0.05	-0.05	-0.06	GHGI 2015	-0.04	0.00	2030 from NC, calibrated at 2010 with GHGI 2015.
USA	-0.78	-0.70	-0.58	-0.91	-0.87	GHGI 2015	-0.89	0.00	See "Country case studies"
Zambia	0.04	0.04	0.04	0.05	0.05	NC	0.07	-0.03	(I)NDC
TOTAL 40 INDC analysed (67 countries)	0.49	1.48	0.08	-0.17	-0.97		-1.10	-0.70	
Other 128 countries	1.05	1.07	1.02	1.01	0.97		0.70	-0.04	
TOTAL	**1.54**	**2.55**	**1.10**	**0.84**	**0.01**		**-0.41**	**-0.74**	

(1) For the few countries having a target year in 2025 (see Supplementary Table 1), we assumed that in 2030 the LULUCF net emissions are = to 2025.

(2) This column corresponds to the "(I)NDC unconditional" in Fig. 1 of the article. While developed country (I)NDC targets are unconditional, many developing countries expressed at least part of their targets as conditional to the provision of climate finance, technology transfer or capacity-building support. Where the (I)NDC did not contain any explicit information on the conditional nature of the target, we assumed the target to be unconditional.

(3) This column corresponds to the difference between "(I)NDC conditional" and "(I)NDC unconditional" in Fig. 1 of the article.

(4) The India BUR (2016) reports a sink of 0.25 $GtCO_2/y$ for 2010, of which 0.2 $GtCO_2$ from forests. From the NC, it can be inferred that about 0.13 $GtCO_2/y$ of the forest sink is from "land converted to forest land" (L-FL) and 0.07 $GtCO_2/y$ is from and "forest remaining forest". For 2030 we assume that the "additional forest sink of 2.5 to 3 billion CO_2" mentioned in the (I)NDC is cumulated between 2015 and 2030 (average of 0.18 $GtCO_2/y$). To be conservative, we did not considered "additional" to the current sink but "total" of L-FL. Assuming the existing sink constant in the future, the deviation from pre-(I)NDC considered in our analysis is therefore 0.18-0.13=0.05 $GtCO_2e/y$

(5) The forest sink included in Mali's (I)NDC, and used by default in this analysis, is very high (-0.24 $GtCO_2e/y$ in 2010), and considerably higher than the sink from NC (-0.06 $GtCO_2/y$ in 2000). This may be explained by possible errors or by inclusion of some unmanaged areas.

(6) The expected "LULUCF contribution to overall (I)NDC" in Mexico in 2030 (-0.046Gt CO2/y) is the difference between what Mexico considers BAU (source of +0.032 $GtCO_2/y$) and the expected unconditional sink (-0.014 $GtCO_2/y$).

Supplementary Table 6. Summary of global LULUCF estimates, disaggregated between developed and developing countries (i.e. UNFCCC Annex I and Non-Annex I, respectively), for the historical period (1990, 2000 and 2010) and for 2030 according to the four scenarios analysed. The main countries contributing to the difference between Country-BAU and Unconditional (I)NDC scenarios are mentioned in the last column.

	1990	2000	2010	2030				
				Country-BAU	Pre-INDC	Unconditional INDC	Conditional INDC	Comment
	LULUCF emissions (+) and removals (-), Gt CO2e/y							
Developed countries	-1.02	-1.44	-1.77	-1.51	-1.51	-1.71	-1.71	The most important country in explaining the difference between Country-BAU and Unconditional INDC is USA (see refs 17)
Developing countries	2.56	2.54	1.78	3.45	1.87	1.30	0.56	The most important countries in explaining the difference between Country-BAU and Unconditional INDC are Brazil (≈1.4 GtCO2e/y), Indonesia (≈0.5 GtCO2e/y), Gabon (≈0.1 GtCO2e/y) and Mexico (≈0.05 GtCO2e/y). See "Country examples" for more details.
TOTAL	**1.54**	**1.10**	**0.00**	**1.94**	**0.36**	**-0.41**	**-1.14**	

Supplementary Table 7. Values of uncertainties used in this analysis.

	Total emissions for the period 1990-2010 ($GtCO_2e/y$)	Aggregated value of % uncertainty [3]	Value of % uncertainty used in this analysis [4]		
			Activity Data [5]	Emission Factor [5]	Aggregated [6]
Developed countries [1]	-1.42	16	15	20	25
Developing countries [2]	2.70	24	20	35	40
All countries	1.28	54			89 [3]

(1) Based on available information from GHG inventories[2] of Australia, Canada, EU, Japan, New Zealand, Norway, Russian Federation, Turkey, USA (individual countries' uncertainty ranging from 13% to 71%).

(2) Based on available information from Brazil[3] and Indonesia[15] (uncertainty of about 35% each) and expert judgment (uncertainty of 50%) for other countries.

(3) Aggregation at global level done with eq. 3.2 (additional and subtraction) in IPCC[21], Vol. 1, Chapter 3

(4) Based on expert judgment, we set these values higher than the previous column to take into account the incomplete information on uncertainties from countries' report, in terms of land categories, carbon pool and gases covered.

(5) These values are used for the analysis of uncertainty of the trend, through equations in table 3.2 in IPCC[21], Vol. 1, Chapter 3. See text for more details.

(6) These values correspond to the combination of values from the previous two columns, through eq. 3.1 (multiplication) in IPCC[21], Vol. 1, Chapter 3.

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