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Quantifying the contribution of the Land Use sector to the Paris Climate Agreement

The LULUCF sector within the Intended Nationally Determined Contributions

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Abstract
Quantifying the contribution of the Land Use sector to the Paris Climate Agreement
This analysis highlights that the full implementation of all INDCs would significantly decrease LULUCF net GHG emissions in 2030 compared to historical levels. In order to reduce the current high level of uncertainty, additional efforts to improve monitoring and reporting are needed.

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FAO-FRA-2015 data were elaborated by Sandro Federici.

Disclaimer

The views expressed are purely those of the writers and may not in any circumstances be regarded as stating an official position of the European Commission.

To the best of our efforts this analysis reflects the data and information provided by individual countries on the mitigation role of the LULUCF sector. However, we did not aim to assess country policies nor the quality of country data relative to independent sources. Due the occasional need of expert judgment, and the complexity of information collected, our analysis may in some cases differ from the countries' own calculations. Should we receive updates or better information, it will be considered for future publications.

Please send any further suggestions or comment to giacomo.grassi@jrc.ec.europa.eu

Executive summary

In preparation for the COP-21 in Paris, December 2015, more than 175 countries (representing around 95% of global GHG emissions in 2010) have submitted their emission reduction targets in the Intended Nationally Determined Contributions (INDCs). Nearly 100 countries explicitly mention a mitigation role of the Land Use, Land Use Change and Forestry (LULUCF) sector.

This analysis aims to reflect, to the best of our ability, information provided by countries on the mitigation role of the LULUCF sector till the year 2030. The purpose is to help assessing the specific role of LULUCF within the INDCs and the degree to which we are on track for the below 2°C target. This analysis does not aim to assess country policies or the quality of country data in comparison to independent sources.

This report is entirely based on countries' official information (augmented with limited expert judgment) including:

(i) *Countries' historical data and projections*: primarily from INDCs, 2015 GHG inventories, National Communications, Biennial (Update) Reports, complemented by other official country documents and gap-filled with FAO-FRA 2015 data;

(ii) The type of mitigation target: absolute or intensity (e.g. relative to GDP); the 'reference point' (base year or BAU scenario); the target 'unconditional' or 'conditional' (i.e. related to finance, technology or capacity-building support);

(iii) *The way LULUCF is included within the INDC*, e.g., treated as any other sector or through special accounting rules.

The mitigation role of LULUCF may be quantified from different perspectives. For this reason, this analysis assessed the following '*LULUCF mitigation perspectives*':

A) **LULUCF INDC trend** of net emissions, in particular 2030 relative to 2005, including **unconditional** and **conditional** INDC measures. Fig. 1 shows that the global LULUCF estimates transition from an estimated net source of +0.6 $GtCO_2e/y$ in 2005 to a net sink of -0.2 $GtCO_2e/y$ (unconditional) or -1.0 $GtCO_2e/y$ (conditional) in 2030. The difference between 2030 and 2005, ranging from **-0.8 (unconditional) to -1.6 $GtCO_2e/y$ (conditional)**, can be considered as "*what the atmosphere will see over time*" (i.e. the actual change in net emissions with INDC implemented, in contrast to what is 'accounted', which is addressed by perspective 'C'). A large contribution to this trend is given by the reduction of emissions from deforestation in Brazil between 2005 and 2010.

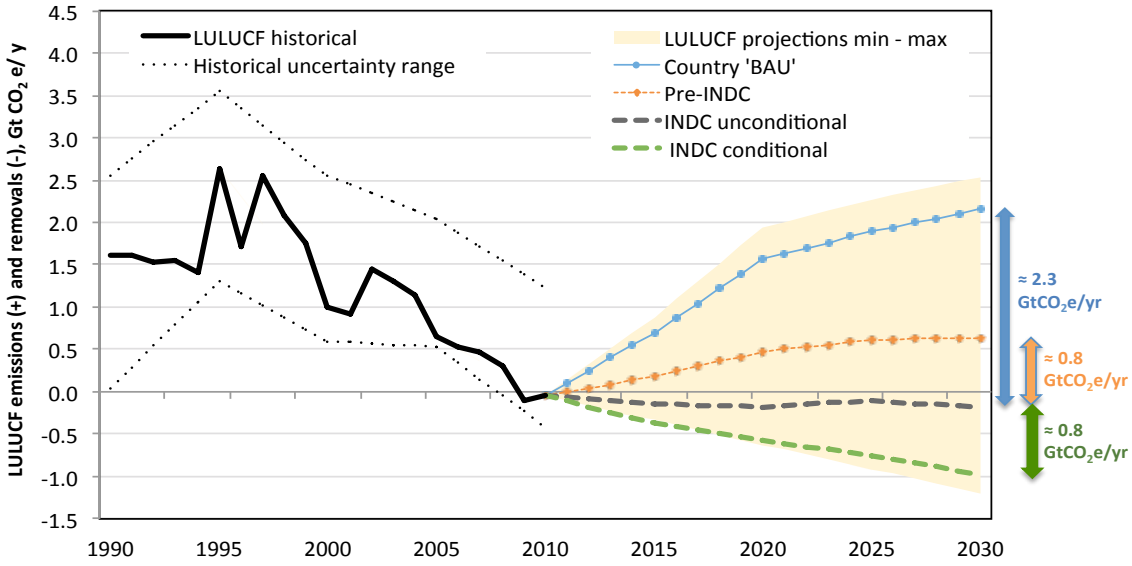


Figure 1. Global LULUCF trend of emissions and removals, and future scenarios analyzed.

B) **LULUCF INDC trend *vs* alternative scenarios**[1], i.e. **'country BAU'** (business-as-usual) and **'pre-INDC'** (e.g. Cancun pledges). We note that several countries apparently use the term 'BAU' to indicate a 'no measures' scenario (i.e. ignoring policies that are already in place). This 'country BAU' scenario would lead to an increase in emissions by 1.5 $GtCO_2e/y$ compared to 2005 or 2.3 $GtCO_2e/y$ compared to the unconditional INDC. Unconditional INDCs would improve the carbon balance by 0.8 $GtCO_2e/y$ compared to 'pre-INDC' case. The wide range of results, **+0.8 to +2.3 $GtCO_2e/y$ relative to unconditional INDCs** (Fig. 1), reflects the high sensitivity to the assumptions for the alternative scenarios.

C) **LULUCF contribution to meeting the INDC**[1]. This perspective represents the countries' view on what they consider as mitigation (i.e. INDC 'accounting'), based on the *way that each country has proposed to express its INDC as a whole* (relative to a reference point that is base year or a BAU scenario year) and the *way LULUCF is included* (treated as any other sector or with special accounting rules). Depending on each countries' INDC, perspective 'C' may be equal to 'A', 'B, country-BAU' or be determined by accounting rules. Thus it cannot be displayed explicitly in Figure 1, although it is implicit in the results as shown**.** Summing the contribution for each country based on this perspective, the estimated unconditional LULUCF contribution to the overall mitigation in the INDCs is -2.9 $GtCO_2e/y$ in the target year (2030 or 2025). The negative sign indicates that LULUCF assists in meeting the INDCs. Nearly half of this contribution comes from Brazil, followed by Indonesia and Russia. By adding the estimated conditional measures (-0.8 $GtCO_2e/y$), the total LULUCF contribution to INDCs becomes **-3.7 $GtCO_2e/y$**, with large uncertainty due to *countries' projections* and *accounting rules*.

Finally, the LULUCF mitigation effort is compared to all-sectors emissions. It emerges that **the LULUCF mitigation contribution relative to the emissions from all sectors is between 20% and 25%,** for both perspectives 'B' and 'C'.

When our results are compared to the land-related CO_2 net emissions from IPCC AR5, we show that differences in absolute levels are explainable by partly different definitions used by IPCC vs. country submissions to UNFCCC (used in this analysis). Furthermore, we show that **the overall trend (2030-2005) emerging from this report is qualitatively consistent with IPCC AR5 scenarios and with the UNFCCC INDC synthesis report** (UNFCC 2015a).

Overall, this analysis highlights a **high uncertainty on both the historical levels and the projections of LULUCF emissions and removals**. Nevertheless, we estimate that **the full implementation of all INDCs** (including conditional) **would significantly decrease LULUCF net emissions in 2030 compared to historical levels**. Furthermore, from this analysis it emerges that **countries expect a significant contribution from LULUCF in meeting INDCs.**

The INDCs represented an important new source of LULUCF information. To reduce the current high level of uncertainty and, ultimately, increase mutual trust on LULUCF estimates and mitigation potential, the implementation of INDCs would require additional efforts to improve monitoring and reporting, and further guidance to enhance the transparency on accounting rules.

[1] Estimated explicitly for 74 countries (80% of global emissions in 2010 excl. bunkers; % estimated using EDGAR 2015 for non-LULUCF sectors and this analysis for LULUCF) where enough information was available from INDCs and from other official country documents. For the remaining countries, perspectives 'B' and 'C' were conservatively quantified to be equal to zero.

1. Introduction

According to the IPCC (2014), and broadly confirmed by more recent analysis of the IPCC datasets (Tubiello et al., 2015) and FAO-FRA 2015 data (Federici et al. 2015), *net emissions from land use changes* represented ≈ 10-12% of total GHG emissions around the year 2005. Beyond the mitigation potential related to reducing emissions from land use changes, the LULUCF sector may also provide a relevant contribution through the conservation and enhancement of the carbon sink (e.g. forest management, forest expansion) and through the substitution of energy and materials.

This analysis quantifies the mitigation role of LULUCF, based on the Intended Nationally Determined Contributions (INDCs)[2] submitted by UNFCCC Parties in preparation of the Paris Climate Conference, complemented with information from other countries' official documents. **This analysis aims to reflect, to the best of our ability, LULUCF data and information from country-specific information.** It does not aim assess specific country policies or the quality of country data in comparison with independent sources.

The quantification of the mitigation role of LULUCF may be carried our using different methodological approaches, reflecting different perspectives. **This analysis assessed the perspectives listed in Table 1, each answering to different questions**. Whereas estimates for perspective 'A' could be provided for all 195 UNFCCC countries, the information needed for perspectives 'B' and 'C' was available only for 74 countries, representing about 80% of global emissions in 2010 (incl. LULUCF, excl. bunkers). For the remaining countries, the additional mitigation in perspectives 'B' a 'C' were conservatively quantified to be equal to zero.

Table 1. The 'LULUCF mitigation perspectives' used in this analysis.

LULUCF mitigation perspective	Questions addressed
A. LULUCF INDC trend: emissions and removals expected in 2030 for **unconditional** and **conditional** INDC targets relative to historical period (in this analysis we refer to 2005).	What are the current and future emissions and removals from LULUCF? In other words, "*what the atmosphere will see over time*" as a consequence of INDC implementation (i.e. the actual change in emissions, in contrast to what is 'accounted', which is included in 'C').
B. LULUCF INDC trend *vs* two alternative scenarios[3]: 1. **Country BAU**, as expressed in INDC or in other country's document. 2. **Pre-INDC**, estimated from Cancun pledges or other country's documents.	What is the *additional* contribution from LULUCF mitigation in the INDC relative to a given scenario? What is the contribution of LULUCF toward closing the emission gap?
C. LULUCF contribution to meeting the INDC, based on the *way that each country has proposed to express its INDC* (relative to a reference point that is base year or a BAU scenario year) and the *way LULUCF is included* (treated as any other sector or with special accounting rules).	If the INDC expresses a "*all-sectors reduction of X% relative to Y (base year or BAU scenario year)*", what is the contribution of LULUCF to X? This approach includes the effect of accounting rules. In other words, "*what the countries consider as mitigation from LULUCF*"

Section 2 of this document contains a short description of the approach used. Section 3 illustrates the results at global level, and for specific 'INDC cases'. Boxes 1 and 3 provide in-depth analyses of 'Datasets for historical LULUCF emissions and removals' and 'Comparison of this analysis with IPCC AR5 scenarios', respectively. Country examples are included in Box 2. Given the complexity of the issue, the uncertainty of the data used, and the relative scarcity of reliable information, the results presented in this analysis should be considered as preliminary.

[2] http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx

[3] We note a high uncertainty associated with these scenarios, due to underlying assumptions. E.g. several countries apparently use the term 'BAU' to indicate a 'no measures' scenario (i.e. ignoring existing policies).

2. Approach

The approach applied in this analysis required collecting information on:

(i) *Country's historical data* and *projections*[4] (for all 195 UNFCCC countries), used with the following priority: INDCs; 2015 GHG inventories (GHGI); National Communications (NC) and Biennial Reports (BR) or Biennial Update Reports (BUR), complemented by other official country's documents and gap-filled with FAO-Forest Resource Assessment (FRA 2015, complemented by FAOSTAT non-forest emissions). When possible, projections were classified as: "*with INDC measures*" (i.e. to be implemented according to the '*unconditional'* INDC), "*without INDC measures*" (including 'country BAU' or 'pre-INDC') or "*with additional measures"* (often linked to INDC's '*conditional'* to external support). For historical data, see Box 1 for more details.

(ii) *Type of mitigation target*[5], i.e. absolute or intensity, relative to a base year or to a BAU scenario (i.e. 2025 or 2030 scenario year), target 'unconditional' or 'conditional' (i.e. related to the provision of finance, technology or capacity-building support);

(iii) *Modality of inclusion of LULUCF within the INDC*, i.e. LULUCF treated as any other sector or with special accounting rules;

Based on (ii) and (iii) above, the INDCs were classified in four cases. Based on (i), i.e. on the availability of country LULUCF information (in the INDC and in other official country documents), enough information was found to assign 74 countries to these different "**INDC cases**" (Table 2) and quantify the mitigation role of LULUCF.

Table 2. Identification of the four 'INDC cases' and classification of the 74 countries where INDC was analysed.

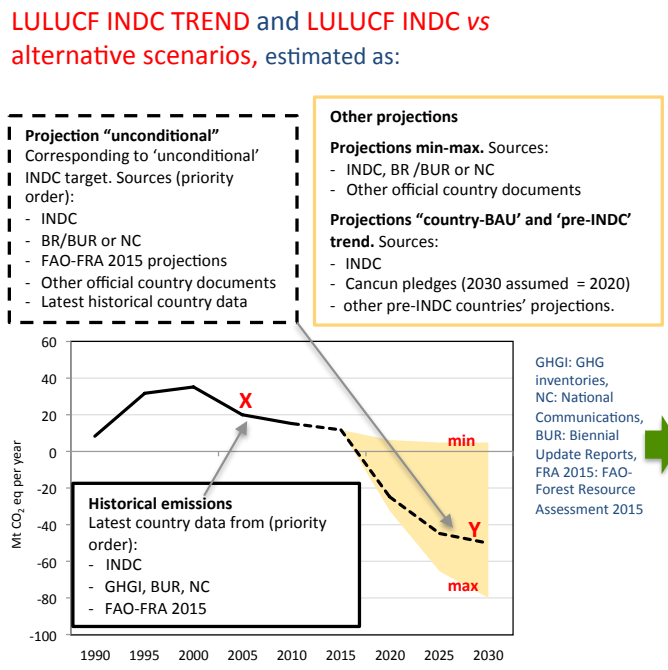
INDC CASE	Type of mitigation target	Inclusion of LULUCF within the INDC	Countries with enough LULUCF information for this analysis*
1	Absolute target relative to base year	Treated as any other sector	Australia, Brazil, United States of America
2	Reduction (including "unconditional" and "conditional" targets) relative to BAU scenario		Afghanistan, Argentina, Benin, Cambodia, Central African Republic, Chad, Colombia, Congo, Democratic Republic of the Congo, Ecuador, Ethiopia, Gabon, Ghana, Guatemala, Guyana, Honduras, Indonesia, Kenya, Madagascar, Malawi, Mali, Mexico, Morocco, Namibia, Paraguay, Peru, Senegal, Uganda, Viet Nam, Zambia
3	Absolute target relative to base year	Special accounting rules	Canada, EU, Japan, Kazakhstan, New Zealand, Norway, Russian Federation, Switzerland, Turkey, Ukraine
4	Intensity target[5]		Chile, China, India

*46 INDCs (= 74 countries, ≈ 80% of global emissions in 2010, including LULCUF and excl. bunkers)

[4] For all NCs, a careful country-by-country assessment was done. In case only NC prior to 2010 were available, we generally replaced them with the more recent FAO FRA 2015 data (complemented by FAOSTAT non-forest emissions). Overall, for the historical period we used FAO FRA 2015 only to fill the gaps (for many, but typically small countries). For projections, FRA 2015 data (if available from the countries, as elaborated by S. Federici) were used only if no projection was available in the INDC or in BR/BUR/NC.

[5] When an INDC is expressed in terms of 'intensity targets' (e.g. INDCs 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 Admiraal et al (2015). INDCs expressing only 'policies and measures' (i.e., no quantitative targets) are not taken into account.

Based on the four INDC cases above, using country information (generally with limited expert judgment) this analysis estimated the 'LULUCF mitigation perspectives' described in table 1 following the method illustrated in Figure 2.



LULUCF CONTRIBUTION to INDC estimated as:

(LULUCF in target year) – (LULUCF in 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 INDC	Calculation of LULUCF contribution to INDC
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 **
4	Intensity		Y – min (based on INDC information)

* For few countries in INDC case 2, where the INDC clearly indicated a planned reduction of emissions from LULUCF relative to a BAU scenario, but no direct quantitative assessment was possible, this analysis estimated the *LULUCF contribution to INDC* indirectly, assuming that emission reductions in the INDC is shared between LULUCF sectors and other sectors proportionally to the share of emissions in 2005 (i.e. if LULUCF is X% of total emissions in 2005, it is assumed to be X% of the emission reduction in INDC).

** For countries in INDC case 3, if no specific quantitative information was indicated in the INDC, 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 preliminary assumed.

Figure 2. Approach to collect and estimate the various LULUCF mitigation perspectives (table 1), according to the four INDC cases identified in table 2.

BOX 1: Datasets for historical LULUCF emissions and removals

Different LULUCF-related historical datasets are available (including those shown in Fig. 3), and the choice of the most appropriate source may depend on the scope of the analysis.

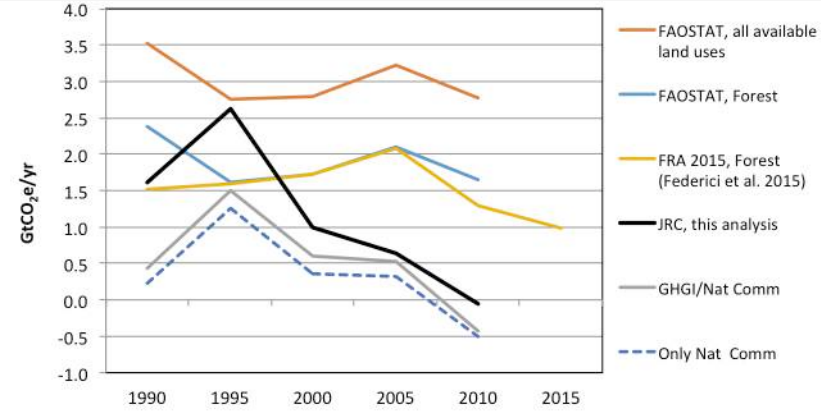


Figure 3. Different LULUCF-related historical datasets (at 5 years intervals; for FAO and NC data points represent 5-yrs averages). The JRC analysis in this report used the following source (in order of priority): INDCs; 2015 GHGIs; recent NCs (> 2010); other official country's documents; FRA 2015 (from Federici et al. 2015) complemented by FAOSTAT non-forest emissions. Note that, at the time of writing this report, net emissions from 'forest land' in FAOSTAT used FRA2010 data; this explains the differences with Federici et al. (2015), which is based on FRA 2015. See http://faostat3.fao.org/download/G2/*/E for methodologies used by FAOSTAT.

The difference between FAO-FRA data and country reports to UNFCCC (i.e. GHGIs and NCs) is not always straightforward to explain, and is significant also for large countries (e.g., USA and Russia). Possible reasons for differences include: different definition of forest, different coverage of areas (UNFCCC only deals with 'managed' areas), of carbon pools and of non-forest lands, different methods in estimation and different reporting agencies (see Federici et al. 2015 for further discussion). In general, it should be considered that the FAO-FRA reports (i.e. the source of forest data in FAOSTAT estimates) are not primarily aimed to report on CO_2 emissions and removals from forests, and are not subject to a formal review process. In contrast, GHGIs and NCs specifically aim at reporting on emissions and removals in the LULUCF sector, and GHGIs are formally reviewed annually. This motivates the order of priority of INDCs, GHGIs and NCs in assessing LULUCF in this analysis. FRA and FAOSTAT data was used for gap filling (in 57, generally small countries), allowing to obtain world-level estimates for all 195 countries.

Figure 4 illustrates an expert-judgment estimate of 'realistic ranges' of LULUCF emissions and removals (min-max), based on the different countries' datasets.

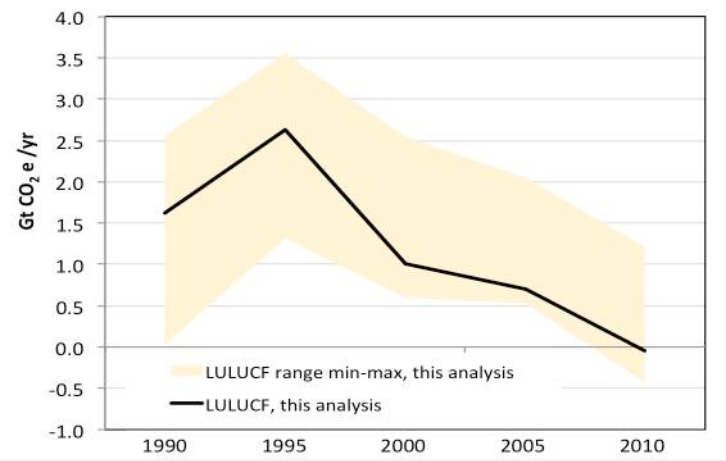


Figure 4. Range of historical LULUCF emissions and removals estimated in this analysis. The upper range reflects GHGIs, complemented by FRA2015 (forest) and FAOSTAT (non forest-land); the lower range reflects GHGIs complemented by NCs.

3. Results

The global trend of LULUCF emissions and removals emerging from this analysis, entirely based on country data and information, is shown in Fig. 5.

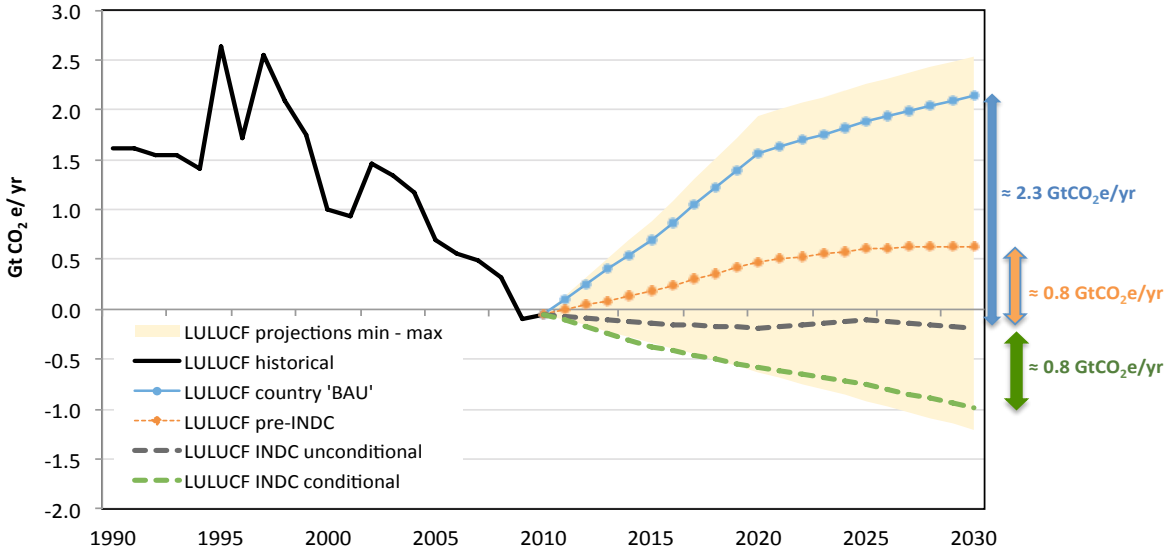


Figure 5. Global LULUCF trend of emissions and removals from 1990 to 2030 (195 countries). The historical LULUCF data use 1-yr intervals. For the projected period, the yellow band represents the full range 'min-max' of countries' projections used in this analysis; the colored lines correspond to the various scenarios analyzed.

The historical period (1990-2010) shows a significant decrease in emissions. This trend is influenced by several patterns, including: (i) deforestation in Brazil, with peak years in 1995 and 2002-2004 followed by a steep decline (reduction of emissions by ≈ 1.3 $GtCO_2e/y$ from 2004 to 2010); (ii) high deforestation rates (1997-1999) and peak years in peat fire emissions (e.g., 1997) in Indonesia; (iii) an increasing sink in most temperate and boreal countries (increased sink by ≈ -0.8 $GtCO_2e/y$ from 1990 to 2010).

For the projected period (2010-2030) estimates widely differ for the four scenarios. For the **countries 'BAU'** scenario (in most cases explicitly indicated in the INDC) a sharp increase in emissions is foreseen. However, when the **pre-INDC** scenario (e.g. including Cancun pledges) is considered, only a moderate increase of global emissions emerges, leading to a level of emissions in 2030 similar to 2005. For the **unconditional INDC** scenario the global trend is rather stable, despite opposite trends in specific countries. An additional reduction of net emissions by ≈ 0.8 $GtCO_2/y$ in 2030 is estimated for the **conditional INDC** scenario, half of which is explicitly indicated in INDCs and the rest estimated based on other country specific information. Overall, the **implementation of INDCs would produce a decrease of emissions from 2005 to 2030 of ≈ 0.8 and 1.6 GtCO2e/y** (for the unconditional and the conditional scenarios, respectively), in line with estimates from the UNFCCC synthesis report (UNFCCC 2015a, footnote 40).

The results above can be better interpreted by disaggregation in the four INDC cases identified (see Fig. 6), corresponding to the countries in table 2. The level and trend of net emissions in the various INDC cases are dominated by relatively few countries: Brazil and USA (case 1); Indonesia and Mexico (Case 2); Russia, Canada and EU (case 3); China and India (case 4). A selection of representative countries examples in Box 2 further elucidates these trends.

The contribution of LULUCF to INDC (perspective 'C') for the case 1 countries amounts to 42%, mainly driven by reduction of deforestation in Brazil. For case 2, the countries that compare to BAU, realize about 25% (unconditional) to 48% (conditional) of their INDC efforts in the LULUCF sector. However, compared to 2005, the unconditional INDC reflects stable net emissions from LULUCF. For case 3, the countries that compare to a

historical year with specific accounting rules, the overall carbon uptake is slightly declining, and LULUCF contributes with about 13% of the total INDC effort. Also for case 4 countries, based on intensity, LULUCF provides a somewhat diminishing sink, but a positive contribution toward meeting the INDC. Overall, the largest contribution of LULUCF to INDCs stems from the case 1 and 2 countries.

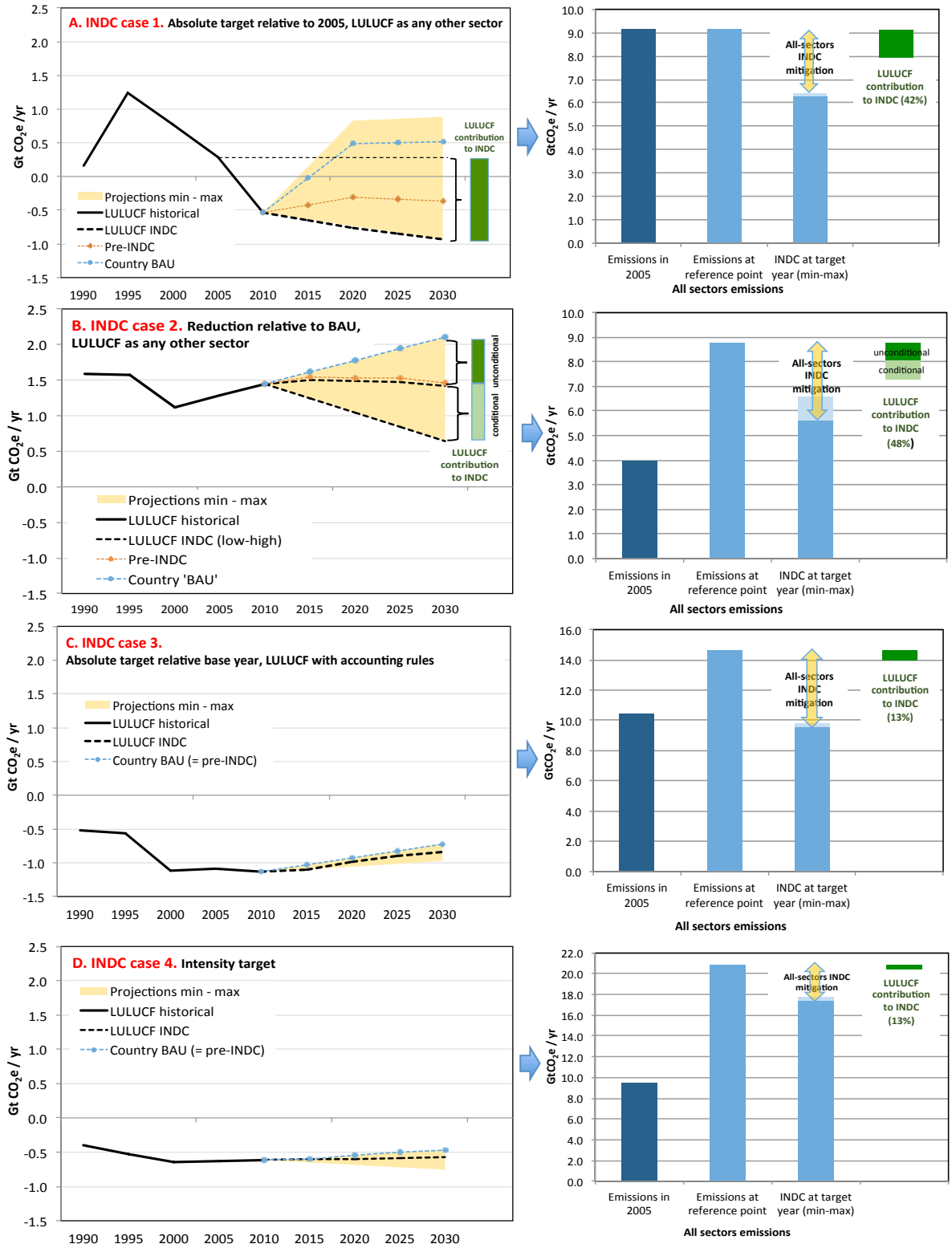


Figure 6. Trend of LULUCF emissions and removals (left) and the corresponding 'LULUCF contribution to INDC' relative to other sectors (right) for the four INDC cases described in table 2.

BOX 2. LULUCF trend and contribution to INDC: country examples

INDC case 1 (absolute target relative to 2005, LULUCF as any other sector).

Brazil. *INDC emission target: -43% in 2030 vs. 2005.* The INDC includes some information on the future LULUCF mitigation potential, including the expected enhanced sink by "conservation units and indigenous lands" (footnote 1 of INDC) 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". In addition, the most recent country's GHG emission estimates (MCTI, 2014), the NC (2010), the BUR (2014), the Cancun's pledges by Brazil (UNFCCC, 2011), the Brazil's submission on Forest Reference Emissions Level (2014) and the Brazil's INDC presentation in October 2015* were also used in this analysis. To ensure consistency with the INDC, all estimates were adjusted to reflect the GWP-100 from IPCC AR5 used in the INDC. Taken the above into account, this analysis suggests that: (i) In 2005, LULUCF emissions (≈1.2 $GtCO_2e/y$) represented ≈ 58% of total emissions; (ii) a significant drop in emissions from deforestation already occurred from 2005 to 2010 (≈-0.9 $GtCO_2e/y$, equal to ≈43% of 2005 GHG emissions); (iii) LULUCF emissions will likely further decrease, getting close to zero in 2030 (estimated *LULUCF contribution to INDC* ≈-1.1 $GtCO_2e/y$, or ≈-55% relative to 2005 emissions); (iv) the LULUCF INDC trajectory appears more ambitious than the pre-INDC Cancun pledges (≈0.5 $GtCO_2e/y$ in 2020) and far more ambitious that the 'country-BAU' (≈1.4 $GtCO_2e/y$ in 2020). Overall, this analysis confirms the outmost importance of LULUCF in Brazil's INDC.

USA. *INDC emission target: -26 to -28% in 2025 vs. 2005*. This analysis used information from the NC (2014), the BR (2014) and the "Building blocks for Climate Smart Agriculture & Forestry" (USDA, 2015. http://www.usda.gov/documents/climate-smart-fact-sheet.pdf). According to NC6, the expected LULUCF sink in 2025 ranges from -0.53 $GtCO_2e/y$ (low sequestration scenario) to -0.88 GtCO2e/y (high sequestration scenario). In both cases, the LULUCF sink is expected to decrease compared to 2005 (-0.97 $GtCO_2e/y$, NC6). Given that the 'high sequestration' is the scenario considered 'with measures' in BR, we considered it as 'BAU' (and equal to pre-INDC). To obtain the most updated LULUCF trend, the absolute level of net emissions from NC was scaled to the latest data from GHGI 2015. In addition, the recent USDA document 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 figure will come from LULUCF (i.e., 'deviation from pre-INDC'). 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 '*LULUCF contribution to INDC'* is close to zero.

INDC case 2 (reduction relative to BAU, LULUCF as any other sector).

Indonesia. *INDC emission target: -29% (unconditional) and -41% (conditional) vs. a 2030 BAU emission of 2.8 $GtCO_2/y$*. This analysis used the sectorial BAU data underlying the INDC (http://ranradgrk.bappenas.go.id/rangrk/english/publication), the NC (2012) and the Indonesia's INDC presentation in October 2015*. For the future LULUCF trend, this analysis combined the information from LULUCF BAU and the two mitigation scenarios included in the NC. Mitigation scenario 1 is what Indonesia has already planned as part of its previous "non-binding emissions reduction target", which we assume being the pre-INDC Cancun pledge and therefore corresponding to the 'unconditional' INDC target. Mitigation scenario 2 is a "progressive target with a higher rate of planting", which we preliminary assume corresponding to the 'conditional' INDC target. Note that both scenarios assume a deviation from the BAU scenario of peat emissions (including fires) and of the sink, but the same level of deforestation emissions as in the BAU. Given that BAU in NC and INDC slightly differ, a slight adjustment to NC data was done; furthermore, since NC provides only a projection up to 2025, here we assumed that 2025=2030. Overall, this analysis suggests that: (i) In 2005, LULUCF emissions (≈0.9 $GtCO_2e/y$) represented ≈ 65% of total emissions; (ii) The *LULUCF contribution to INDC* is relevant, with an estimated emissions reduction ranging from ≈-0.4 to ≈-0.7 $GtCO_2e/y$ in 2030 for the unconditional and conditional targets, respectively (equal to -15% to -24% of 2030 total BAU emissions).

Other countries under 'INDC case 2' where a relevant *LULUCF contribution to INDC* was directly quantifiable from the INDC (or other country documents) include: Ethiopia (≈-0.13 $GtCO_2e/y$, conditional); Gabon (≈-0.1 $GtCO_2e/y$); Mexico (≈-0.05 $GtCO_2e/y$, unconditional); Guyana, Kenya, Madagascar, Mali, Congo and Democratic Republic of Congo (each one with estimated conditional LULUCF contribution to INDC ranging from -0.03 to -0.06 $GtCO_2e/y$).

BOX 2 (continued)

INDC case 3 (absolute target relative base year, LULUCF with accounting rules).

Russian Federation. *INDC emission target: -25% to -30% in 2030 vs. 1990*. Since the INDC is "subject to the maximum possible account of absorbing capacity of forests", this analysis assumes a gross-net accounting for forests (i.e. the full sink, not the change, is in 2030 accounted toward the target). Taking into account the latest GHGI LULUCF estimates (2015), the decline of forest sink projected in the NC 2014 (scenario 3 was assumed as "INDC") and additional information from Romanovskaya and Federici (2015), this analysis suggests a *LULUCF contribution to INDC* of ≈-0.4 $GtCO_2e/y$ in 2030 (11% of 1990 emissions). It should be considered that a large uncertainty exists due to: (i) projections scenarios; (ii) accounting assumptions: if Russia would account the forest sink vs. 1990 (as in the Forest Management Reference Level for KP Commitment Period 2), or if cropland and grassland would be included, LULUCF contribution to INDC 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 $GtCO_2/yt$ in 1990, its inclusion could increase the GHG allowances in 2030.

Canada. *INDC emission target: -30% in 2030 vs. 2005*. LULUCF is very complex and uncertain due to the great importance of emissions from natural disturbances (ND), which according to the INDC 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 (2011) and its technical assessment). Based on the above, it is estimated a *LULUCF contribution to INDC* of ≈-0.05 $GtCO_2e/y$ in 2030. This is higher than the LULUCF accounting expected by Canada in KP Commitment Period 2 (≈-0.028 $GtCO_2e/y$ in 2020, NC6); given the harvest rate in 2005 (base year of the INDC) 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.

INDC case 4 (intensity target).

China. *INDC emission target in 2030: 60 to 65% CO2 emission intensity reduction and other specific targets, including the 'increase the forest stock volume by 4.5 billion m3 on the 2005 level'.* By using the ratio C stock/growing stock from China's FAO-FRA 2015 country report (which already incorporates BEFs, root/shoot ratio and C density), we estimated an average sink of ≈-0.25 $GtCO_2/y$ for the period 2015-2030. This represents a decline of the sink compared to 2005 (≈-0.44 $GtCO_2e/y$, based on INDC, FAO-FRA 2015 and NC (2012)). This apparently contrasts with the young age structure of forests, which could suggest a good potential for a stable or increasing sink. It should be noted that recently China has already adopted a 'prudent' forest projection. As stated in the INDC: "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 *LULUCF contribution to INDC* for China is preliminary estimated equal to the expected full sink in 2030 (≈-0.25 $GtCO_2/y$).

India. *INDC emission target in 2030: 33% to 35% emissions intensity reduction and other specific targets, including the 'additional sink of 2.5-3.0 Billions tCO_2 by 2030'*. Starting from the current sink (≈-0.15 $GtCO_2/y$ in 2005, based on the INDC and NC2), we assume the INDC target as additional (i.e. on top of the current sink) and *cumulative* over the period 2015-2030. This translates in ≈-0.30 to ≈0.35 $GtCO_2/y$ (on average for the period 2015-2030), i.e. more than doubling the current sink, which seems an ambitious goal for LULUCF. Since the INDC's target is expressed as '*additional sink'*, in this analysis the *LULUCF contribution to INDC* for India is estimated as difference between the sink in 2030 and in 2015 (i.e. -0.15 to -0.20 $GtCO_2/y$).

* UNFCCC Events on INDCs. http://unfccc.int/focus/indc_portal/items/9182.php

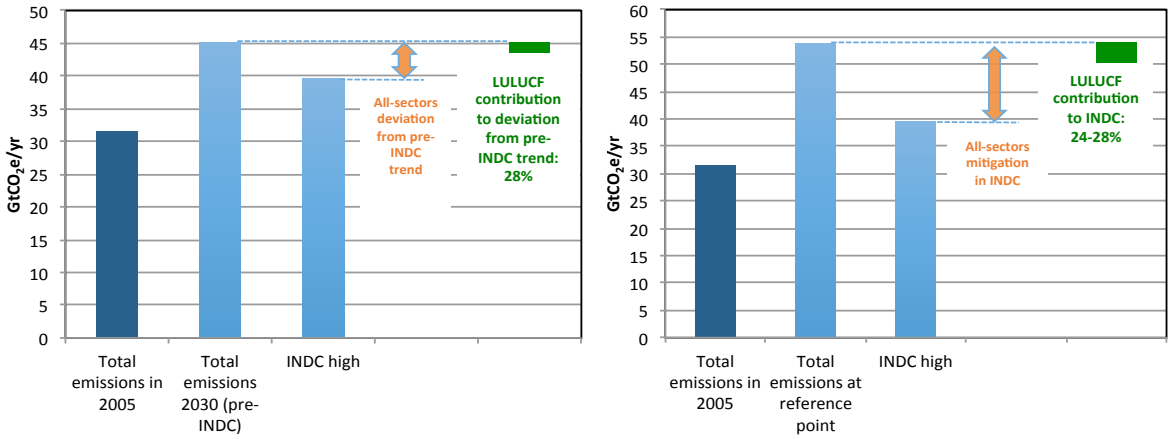


Figure 7. Aggregation of results from the 4 INDC cases (74 countries, covering 80% of global emissions) for the mitigation perspective 'B' (LULUCF INDC *vs.* pre-INDC, left panel) and 'C' (LULUCF contribution to INDC, right panel), in relation to mitigation efforts from other sectors. INDC high represents the maximum targets expressed in the INDC (including conditional measured). The reference point may represent a base year or future BAU year.

Globally, for the 74 countries directly analyzed, the **LULUCF contribution to the overall mitigation in the INDCs** (perspective 'C') is estimated as **-2.9 $GtCO_2e/y$ (conditional) and -3.7 $GtCO_2e/y$ (including conditional measures).** The negative sign indicates that LULUCF assists in meeting the INDCs. Large uncertainty should be considered, due to *countries' projections* and *accounting rules*.

Finally, Fig. 7 shows the total results for mitigation perspectives 'B' (LULUCF INDC *vs.* pre-INDC) and 'C' (LULUCF contribution to INDC) in relation to the efforts expected in all sectors (based on country data). Relative to the emissions from all sectors, the estimated contribution from LULUCF is about 28% for perspective 'B' and 26% (24% to 28%) for perspective 'C' (the range is due to uncertainty in accounting rules). When these results (for 74 countries, covering 80% of global emissions) are scaled at global level[6], the contribution from LULUCF is about 23% for perspectives 'B' and 21% for perspective 'C'. Overall, this suggests that **the LULUCF mitigation contribution relative to the emissions from all sectors is between about 20% and 25%** for both perspectives 'B' and 'C'.

IPCC AR5 provides an authoritative evaluation of emissions and removals from terrestrial ecosystems. In Box 3 we suggests that the absolute differences (i.e. level of current net emissions) between IPCC AR5 and this report are explainable by partly different definitions used by IPCC vs. country submissions to UNFCCC. Furthermore, we show that the trend (2030-2005) emerging from this report is qualitatively consistent with IPCC AR5 scenarios and with the UNFCCC INDC synthesis report (UNFCC 2015a).

In conclusion, this analysis highlights a **high uncertainty on both the historical levels and the projections of LULUCF emissions and removals**. Despite these uncertainties, we estimate that **the full implementation of all INDCs would significantly decrease LULUCF net emissions in 2030 compared to historical levels**. Consistently with the common assumption that LULUCF may be a "low hanging fruit" in climate mitigation, from this analysis it emerges that **countries assume a significant contribution from the LULUCF sector in meeting their INDCs.**

[6] The scaling at global level was done as follows. For both perspectives 'B' and 'C' it was conservatively assumed that, for the countries not directly covered in INDC analysis, the LULUCF mitigation contribution is equal to zero. Then, for perspective 'B', the LULUCF deviation from pre-INDC trend (1.6 $GtCO_2e/y$, this analysis) was compared with data from UNEP (2015) on the all-sectors difference in 2030 between current policy trajectory and conditional INDC, i.e. 60 – 53 = 7 $GtCO_2e/y$. Similar results are obtained using data from CAT (2015) or Admiraal et al (2015). For perspective 'C', the LULUCF contribution to INDC (3.7 $GtCO_2e/y \pm 0.3$ $GtCO_2e/y$, this analysis) is compared to total emissions at reference point (Fig. 7, right panel) empirically multiplied by 1.25 (to consider that counties analysed here covered 80% of global emissions).

BOX 3: Comparison of this analysis with IPCC AR5 scenarios

Historical period

The IPCC AR5 reported on emissions and removals from terrestrial ecosystems using partly different definitions than the country submissions to UNFCCC.

Table 3 in this box suggests that differences in IPCC AR5 and this report are explainable, i.e.:

- For land use changes (LUC) this analysis estimates slightly lower emissions than IPCC AR5, but well within the IPCC uncertainty ranges.

- For "non-LUC" our estimate of sink in 'managed' lands (based on country definitions, and mainly due to increasing carbon stocks in existing forests) is much lower than the 'residual sink' in IPCC AR5; this is expected and logic, because IPCC AR5 includes both managed and unmanaged areas (the latter not included in countries' reports and in this analysis).

Tab. 3. Emissions and removals from land use changes (LUC) and non-LUC in IPCC AR5 and in this analysis, for the period 2000-2010 (in $GtCO_2e/y$)

	Land Use Changes (LUC)	**Non-LUC**	
		'residual terrestrial sink'	**'managed' lands only**
IPCC AR5*	+4.0 ± 2.9	-9.5 ± 4.4	
This analysis**	≈ +3.3		≈ -2.7

* WG3, table 11.1 (same data as in WG1, table 6.1). Note that, while table 6.1 refers to "LUC", table 11.1 refers to "FOLU" (which could be interpreted as the whole LULUCF sector). Since the +4.0 $GtCO_2e/y$ come from a variety of sources (see Houghton et al., 2012), most of which refer to LUC only, here we assume this number as referring *essentially* to *net emissions from LUC*. This approach seems reinforced by the fact that other relevant literature (Pan et al. 2010, Global Carbon Project 2015) use the term 'LUC' referring to the same or very similar number for the same period. This analysis therefore suggests that the +4.0 $GtCO_2e/y$ (IPCC) should be compared only with the LUC component of country reports (+3.3 $GtCO_2e/y$), and not with the whole LULUCF sector (+0.6 (=3.3-2.7) $GtCO_2e/y$). The approach explained above is consistent with the UNFCCC INDC synthesis report (UNFCCC 2015a), whose Technical Annex (UNFCCC 2015b, para 17) clarifies that the difference between IPCC and country data is "largely a definitional issue in terms of which CO_2 removals are considered to be anthropogenic, which in the case of the IPCC is limited to net emissions from land-use change"

** Preliminary estimates. While the separation of LUC from non-LUC was straightforward in GHGIs, it required assumptions in some NCs of developing countries.

Projected period

The comparison shown in figure 8 in this box suggests that the *future trend* of land-related net emissions from this analysis is broadly similar to IPCC AR5 scenarios. This is in line with the *qualitative* observation by the UNFCCC INDC synthesis report (UNFCCC 2015a, paragraph 106) on similar 'INDC trend' vs. 'IPCC trend', which from a global perspective is mostly relevant for the 2°C target. However, in contrast with UNFCCC 2015a, this analysis did not need to 're-scale' country data to let it match with IPCC datasets (see fig. 1 of UNFCCC 2015b); this is due to the criteria adopted in this analysis to select country data and to the split between LUC and non-LUC done in this box. While estimates for LUC from this analysis match well with IPCC (Fig. 8, left panel), estimates for total LULUCF from this analysis (right panel) are different from IPCC 'all lands': as explained above, this is expected due to different coverage of non-LUC (i.e. the difference between the red line and other lines is mainly due to unmanaged areas).

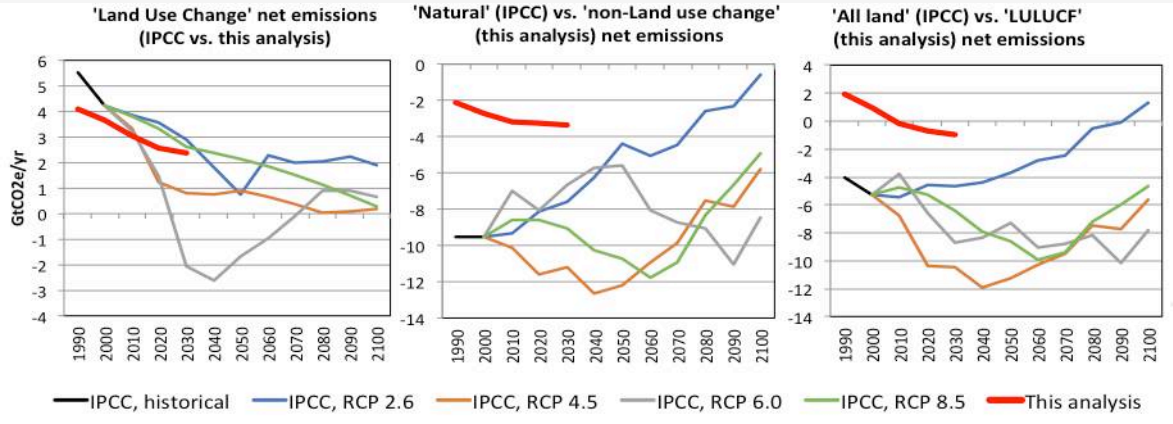


Figure 8. Comparison of IPCC AR5 land-related emissions from various scenarios (IPCC AR5, WGI, Tab AII.3.1a) with estimates from this analysis (red lines). 'Natural' (IPCC) corresponds to 'residual sink' of Tab. 3. To make estimates from this analysis comparable with IPCC, 10-years averages are shown (2010: average of 2005-2014).

Appendix – Historical LULUCF emissions and removals

Tab. 4. General information on the 74 countries (46 INDCs) where enough LULUCF was available in the INDC, and historical LULUCF emissions and removals from LULUCF compiled in this analysis based on country sources.

	General information based on the INDCs					Historical LULUCF emission (+) and removals (-)					
	Type of target	Reference point (RP), *year or BAU*	Target			1990	1995	2000	2005	2010	Sources
PARTY			*year*	*%, min - max relative to RP*		$GtCO_2e/yr$					
Afghanistan	Relative to BAU	BAU 2030	2030	-14%	-14%	0.01	0.01	0.01	0.01	0.01	INDC
Argentina	Relative to BAU	BAU 2030	2030	-15%	-20%	0.06	0.06	0.07	0.08	0.10	FAO-FRA 2015
Australia	Absolute	2005	2030	-26%	-28%	0.10	0.04	0.06	0.07	0.03	GHGI 2015
Benin	Relative to BAU	BAU 2030	2030	-7%	-39%	-0.02	-0.02	-0.01	-0.01	0.03	FAO-FRA 2015
Brazil	Absolute	2005	2025 / 2030	-37%	-43%	0.84	1.99	1.38	1.21	0.32	MCTI (2014), NC (2010), BUR (2014), FREL (2014)
Cambodia	Relative to BAU	BAU 2030	2030	-27%	-27%	-0.02	-0.02	-0.01	-0.01	0.00	NC
Canada	Absolute	2005	2030	-30%	-30%	-0.09	0.20	-0.08	0.02	0.08	GHGI 2015
Central African Rep	Relative to BAU	BAU 2030	2030	-3%	-4%	0.10	0.10	0.10	0.10	0.10	INDC
Chad	Relative to BAU	BAU 2030	2030	-18%	-71%	-0.01	-0.01	-0.01	-0.01	-0.01	INDC
Chile	Relative to BAU	2007	(1)			-0.05	-0.05	-0.06	-0.04	-0.05	INDC, NC (2011)
China	Relative to BAU	2005	(2)			-0.37	-0.37	-0.37	-0.44	-0.41	INDC, NC, FAO-FRA 2015
Colombia	Relative to BAU	BAU 2030	2030	-20%	-30%	0.07	0.07	0.07	0.07	0.07	INDC, NC (2010), FREL (2015), presentation Bonn (Oct 2015)
Congo	Relative to BAU	BAU 2025/2035	2025/2035	-48%	-51%	0.02	0.02	0.02	0.02	0.02	INDC
Dem Rep Congo	Relative to BAU	BAU 2030	2030	-17%	-17%	0.20	0.20	0.20	0.20	0.20	INDC
Ecuador	Relative to BAU	BAU 2025	2030	-23%	-42%	0.04	0.04	0.04	0.03	0.03	FAO-FRA 2015, FREL 2015
Ethiopia	Relative to BAU	BAU 2030	2030	-64%	-64%	0.06	0.06	0.06	0.06	0.06	INDC
EU	Absolute	1990	2030	-40%	-40%	-0.26	-0.28	-0.31	-0.32	-0.31	GHGI 2015
Gabon	Relative to BAU	BAU 2025	2025	-62%	-62%	0.08	0.08	0.08	0.09	0.11	INDC
Ghana	Relative to BAU	BAU 2030	2030	-15%	-45%	0.01	0.01	0.01	0.01	0.01	GHGI 2015 (NC)
Guatemala	Relative to BAU	BAU 2030	2030	-11%	-23%	0.02	0.02	0.02	0.02	0.02	FAO-FRA 2015
Guyana	Relative to BAU	BAU 2025	2025	0%	0%	0.01	0.01	0.01	0.01	0.01	NC (2012)
Honduras	Relative to BAU	BAU 2030	2030	-15%	-15%	0.00	0.00	0.00	0.00	0.00	FAO-FRA2015
India	Relative to BAU	2005	(3)			0.01	-0.10	-0.22	-0.15	-0.15	INDC, NC (2012), FAO-FRA 2015
Indonesia	Relative to BAU	BAU 2030	2030	-29%	-41%	1.09	1.09	0.68	0.91	0.93	NC (2012), FAO-FRA 2015 http://ranradgrk.bappenas.go.id/rangrk/english/publication
Japan	Absolute	2013	2030	-26%	-26%	-0.06	-0.07	-0.09	-0.09	-0.07	GHGI 2015
Kazakhstan	Absolute	1990	2030	-15%	-25%	-0.02	0.00	0.01	-0.01	0.00	GHGI 2015
Kenya	Relative to BAU	BAU 2030	2030	-30%	-30%	0.02	0.02	0.02	0.02	0.02	FAO FRA 2015, Kenya Climate change action plan (2013)
Madagascar	Relative to BAU	BAU 2030	2030	-42%	-42%	-0.22	-0.22	-0.28	-0.28	-0.22	INDC, NC (201)
Malawi	Relative to BAU	BAU 2030	2030	-40%	-40%	0.02	0.02	0.02	0.02	0.01	INDC, FAO-FRA 2015
Mali	Relative to BAU	BAU 2030	2030	16%	192%	-0.26	-0.26	-0.26	-0.26	-0.25	INDC
Mexico	Relative to BAU	BAU 2030	2030	-22%	-36%	0.11	0.10	0.07	0.05	0.05	NC (2015), FREL (2015), Presentation in Bonn June 2015
Morocco	Relative to BAU	BAU 2030	2030	-13%	-32%	0.00	0.00	0.00	0.00	0.00	NC (201)
Namibia	Relative to BAU	BAU 2030	2030	-89%	-89%	-0.01	-0.01	-0.01	-0.03	-0.03	BUR (2014)
New Zealand	Absolute	2005	2030	-30%	-30%	-0.03	-0.03	-0.03	-0.03	-0.03	GHGI 2015
Norway	Absolute	2030	2030	-40%	-40%	-0.01	-0.02	-0.01	-0.03	-0.02	GHGI 2015
Paraguay	Relative to BAU	BAU 2030	2030	-10%	-20%	0.07	0.07	0.07	0.07	0.07	FAO FRA 2015
Peru	Relative to BAU	BAU 2030	2030	-20%	-30%	0.09	0.09	0.11	0.09	0.09	INDC
Russian Federation	Absolute	1990	2030	-25%	-30%	0.20	-0.06	-0.31	-0.35	-0.45	GHGI 2015
Senegal	Relative to BAU	BAU 2030	2030	-5%	-22%	-0.01	-0.01	-0.01	-0.01	-0.02	INDC, NC (2010)
Switzerland	Absolute	1990	2030	-50%	-50%	0.00	0.00	0.00	0.00	0.00	GHGI 2015
Turkey	Absolute	BAU 2030	2030	-21%	-21%	-0.04	-0.05	-0.05	-0.05	-0.06	GHGI 2015
Uganda	Relative to BAU	BAU 2030	2030	-22%	-22%	0.01	0.01	0.01	0.01	0.01	INDC, NC (2014)
Ukraine	Absolute	1990	2030	-60%	-60%	-0.04	-0.05	-0.05	-0.05	-0.06	GHGI 2015
USA	Absolute	2005	2025	-26%	-28%	-0.78	-0.70	-0.58	-0.91	-0.87	GHGI 2015
Viet Nam	Relative to BAU	BAU 2030	2030	-8%	-25%	0.02	0.02	0.02	-0.02	-0.02	BUR (2014)
Zambia	Relative to BAU	BAU 2030	2030	-25%	-45%	0.04	0.04	0.04	0.05	0.05	NC (2014)
TOTAL 46 INDC analysed (74 countries)						1.00	2.01	0.41	0.10	-0.62	
Other 121 countries						0.62	0.62	0.59	0.53	0.56	Latest NC or FAO-FRA 2015 to gap-fill
TOTAL 195 counties						**1.62**	**2.63**	**1.00**	**0.63**	**-0.05**	

(1) Chile: Reduce the emissions intensity of its GDP by 30-45 % by 2030 from 2007 level.
(2) China: Peaking CO2 emissions around 2030; 60-65% CO2 emission intensity reduction; 20% non-fossil fuels in primary energy consumption & increased forest stock volume.
(3) India: 33% to 35% emissions intensity reduction; 40% non-fossil fuel electricity; Increase carbon sink volume

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Links to Parties' documents submitted to UNFCCC, quoted in this document:

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  http://unfccc.int/bodies/awg-kp/items/5896.php
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  http://redd.unfccc.int/submissions.html
- Greenhouse Gas Inventories (GHGI):
  http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/8812.php
- National Communications (NC):
  http://unfccc.int/national_reports/annex_i_natcom/submitted_natcom/items/7742.php
  http://unfccc.int/national_reports/non-annex_i_natcom/submitted_natcom/items/653.php
- Biennial Reports (BR) and Biennial Update Reports (BUR):
  http://unfccc.int/national_reports/biennial_reports_and_iar/submitted_biennial_reports/items/7550.php
  http://unfccc.int/national_reports/non-annex_i_natcom/reporting_on_climate_change/items/8722.php

List of abbreviations and definitions

BAU: business-as-usual

BR: Biennial Reports; BUR: Biennial Update Reports

FAO-FRA: Forest Resource Assessment by the Food and Agriculture Organization

GHGI: Greenhouse gas inventories

LULUCF: Land Use, Land Use Change and Forestry sector

INDC: Intended Nationally Determined Contributions

IPCC: Intergovernmental Panel on Climate Change

IPCC AR5: Fifth Assessment Report by IPCC

KP: Kyoto Protocol

NC: National Communications

UNFCCC: United Nation Framework Convention on Climate Change

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