LUC Impact tool

Update description - Version 2021

Title LUC Impact tool
Date 20-5-2021
Place Gouda, NL
Author Lisanne de Weert - Blank Consultants

Blonk Consultants
Groen van Prinsterersingel 45
2805 TD Gouda
(+31) 0182 579970
www.blonkconsultants.nl
tools@blonkconsultants.nl

blonk consultants

1. Introduction

Deforestation is one of the major issues caused by the global agriculture production system, with as much as 8% of global CO_2 emissions being attributable to land use change. Many publications have focused on this issue and have provided solid global or country specific estimations of CO_2 emissions due to land use change based on available statistics and/or satellite imagery.
A big challenge for practitioners of Life Cycle Assessments (LCA) is to translate this impact of land use change to specific crops from specific countries while little primary data is available. Calculation methodologies are often not straightforward, even in case detailed information is available. The calculation becomes even more challenging when no specific information is available for the crop of interest. Our 'LUC Impact tool' aims to provide insights into the impact of land use change of a wide variety of crop-country combinations and is specifically designed to support LCA practitioners and other professionals or academics.

1.1. Three functionalities

The 'LUC Impact tool' is an Excel tool, which provides a predefined way of calculating greenhouse gas emissions from direct land use change (dLUC). The tool has three basic functionalities, based on three different approaches related to what data is available for the user.

1. **Country known & land use unknown:** this approach is described in the PAS 2050-1 published by BSI (BSI, 2012) and is made operational in the tool using various FAO and IPCC data sources. The calculation is based on country-level statistics of the expansion and contraction of forestland, grassland, annual cropland, and perennial cropland (FAO). The land use change of a selected crop is based on country-level statistics on the relative expansion of the selected crop (FAOSTAT).
2. **Country & land use unknown:** The 'average' LUC GHG emissions for a selected crop are determined by taking the weighted average of all producing countries, based on cultivated area. The GHG emissions for each relevant country are determined through the methodology as described in 'country know & land use unknown'.
3. **Country & land use known:** In case the country and both the current and the previous land use is known, the carbon stock change of a selected crop is calculated using IPCC defaults and methodology.

The 'LUC Impact tool' has grown in past years based on the PAS 2050 and specifically the PAS 2050-1 frameworks. This basic methodology is now widely referenced in LCA guidelines, such as the Product Environmental Footprint (PEF) guidelines & Envifood protocol.

1.2. Update to version 2021

In this update of the 'LUC Impact tool' (previously called the Direct Land Use Change Assessment Tool, or short dLUC tool), we incorporated the latest data from FAO, up to and including 2018. New estimations of biomass carbon stock in forests are obtained from the Forest Resource Assessment (FRA) 2020 (FAO, 2020). In 2019, IPCC published refinements to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2019b). Soil carbon stock change factors are adapted accordingly. Some insights into the changes compared to the previous versions of the LUC Impact tool are presented below.

MAIN DRIVERS OF CHANGE

When interpreting the data (differences), it is important to realize where (changes in) dLUC emissions originate from. The changes in direct land use change emissions compared to previous years for a crop-country combination in the "country known, previous land use unknown"-scenario are mainly driven by four questions:

- *Did the total forest area in a country contract over the last 20 years?*
  Conversion from forest area to cropland results in the largest loss of carbon stock, compared to conversion from grassland or changes between annual and perennial croplands. Therefore, if the total forest area in a country did not reduce compared to 20 years ago, the emissions factors due to direct land use change will generally be low.
- *Did the total area for crop cultivation increase in a country?*

If there is no increase in the total area used for crop cultivation, according to the PAS-2050-1, it can be assumed that no contractions of forest or grass land are caused by an increase of cropland. Therefore, the emissions factors for that country will generally be low.

- *Did the total harvested area for the crop under investigation expand?*
  If the area harvested for a crop under investigation did not increase over the last 20 years, there is no land use change connected to that crop. If there is an increase, the emissions due to land use change will be mainly driven by the factors mentioned above. For crops that are rapidly expanding, this can result in large changes in emissions factors between the chosen 20 year interval.
- *Is the forest carbon stock change very different in FRA 2020 compared to FRA 2015?*
  Due to the availability of newer and better data, the estimated carbon stock in forest changed significantly for several countries in FRA 2020 compared to the FRA 2015. A change in carbon stock in forest area will directly translate to a change in dLUC emissions and is especially important for crop-country combinations where expansion of the crop mainly goes at the expense of forest.

KEY DATA CHANGES

Crop data now include statistics from the FAO up to 2018 (most recent data available in 2021), IPCC stock change factors are updated, and the FRA 2020 datasets are included. Several specific changes in the data sources (based on the main drivers for change as described above) are discussed to explain differences between the current and previous dataset.

Changes in forest and grassland area

Changes in the data can be due to the change of scope (inclusion of two additional years) or as the result of updated statistics. The latter can be the result of other data-sources or assessment models and can highly influence results.

For forest area, some notable differences are found for Côte d'Ivoire, where forest area is much lower in the recent FAO data compared to the previously used data, especially for recent years. This results in higher dLUC emissions compared to the previous dataset. Kenya also shows lower forest area values for recent years in the latest FAO data, which will also result in higher dLUC emissions. For Nicaragua, forest land is higher in the latest FAO data, however, as the recent years show a smaller increase compared to data from 20 years ago, dLUC emissions still increase. For grassland, Samoa shows much larger areas in recent years in the new FAO data. Guyana and Gabon show much smaller grassland areas for all years in the new FAO data. How changes in grassland area result in changes in dLUC emissions differs per crop-country combination, as grassland does not always have a higher or lower carbon stock compared to the expanding crop.

Changes in total cultivated area

The global cultivated area expanded from 1.38*10^9 ha in 2016 (dLUC tool v2018) to 1.42*10^9 ha in 2018 (LUC Impact tool v2021). This is an expansion of crop area of 3% compared to the previous dataset (2018). When the expansion is calculated over a 20-year period for both the old and the new dataset, the increase is from +17% to +19%.

Changes in cultivated area of investigated crop

As in the case of the other data sources: changes in the data can be due to the change of scope (inclusion of two additional years) or as the result of updated statistics. For conciseness, we will not discuss changes for specific crop-country combinations. Contact us in case of specific questions that cannot be explained within this document.

Changes in forest carbon stock

In the FRA 2020 datasets, the forest carbon stock (sum of living and dead biomass carbon) increased and therefore influences results for Ethiopia; Suriname; Philippines; Myanmar; Antigua and Barbuda and to a lesser extend for Cameroon and the Democratic Republic of the Congo. In the FRA 2020 datasets, the forest carbon stock vastly decreased and therefore highly influences results for Côte d'Ivoire; the United Republic of Tanzania; Paraguay; Ghana; Nicaragua; Samoa; Angola; Nigeria; Papua New Guinea and to a lesser extend for Pakistan; Niue; Kenya; Zambia; Indonesia; Dominica; Sierra Leone; Burkina Faso; Guinea; Togo and Belize.

Changes in IPCC soil carbon stock change factors

The stock change factors changed significantly compared to 2006 through enhanced databases, refined techniques of data analysis and enhanced computational capacity over the last 15 years. Changes in these

factors influence the soil carbon stock of the expanding crop and the reference situation of annual and perennial cropland. An increase in carbon stock of the expanding crop relates to lower dLUC emissions, a decrease relates to higher dLUC emissions.
Soil carbon stock increases for annual cropland in tropical regions and paddy rice cultivation in every climate region. Soil carbon stock decreases strongly for perennial cropland in every climate region except tropical regions and decreases slightly for reduced and no-tillage practices on cropland in all regions with a stronger decrease in tropical regions.

TOTAL EMISSIONS FROM LAND USE CHANGE

The global average calculated emissions from direct land use change have slightly lowered in the latest update including crop data of 2017 and 2018: from 2.3 to 1.9 ton CO_2 eq./ha. For the total dataset under consideration, this adds up to the emission of roughly 2.6 Gt CO_2/year. Although the cultivated area expansion is larger compared to the 2018 tool version, total emissions are lower than the figure found in the previous version: 3.2 Gt CO_2/year.

FAOSTAT calculated global GHG emissions resulting from lang management activities, these values are also noted in IPCC's recent publication on Climate Change and Land (IPCC, 2019a). Accounting for all emissions (thus excluding removals) and excluding emissions from cropland (as these are mostly related to oxidation of peatland), the total yearly emissions in 2018 of Forestry and Other Land Use is 2.9 Gt CO_2e/year. Other sources indicate values in the same order magnitude: a total of 3.15 Gt CO_2e/year (World Resource Insitute, 2014) and 3.3 ± 1.8 GtCO_2/year for 2003-2014 (Friedlingstein et al., 2014) for land-use change and forestry emissions are reported. It can be concluded that the total global emissions resulting from land use change found in the tool lie within ranges from other global estimates. For individual countries there are likely larger differences to be found.

1.3. KEY CROPS AND CHANGES IN LUC EMISSIONS:

The tables below list the results of the 'LUC Impact tool' for several crop-county combinations. In both tables, the results of the current tool are compared to the results from the previous tool (version 2018, including FAO data up to 2016).

Table 1 shows the top 30 of the crop-country combinations that are the largest contributors to the global impact of land use change due to the cultivation of crops. Table 2 shows the top 30 land use change emission factors per hectare of cultivated area.

Table 1. Top 30 crop-country combinations that are the largest contributors to the global impact of land use change due to the cultivation of crops.

Country	Crop	Current area (ha)	Weighted average ton CO2 eq./ha v2021	Weighted average ton CO2 eq./ha v2018	Relative difference (%)
Brazil	Soybeans	3,40E+07	12,62	15,58	-19%
Argentina	Soybeans	1,77E+07	12,00	14,84	-19%
Brazil	Sugar cane	1,01E+07	8,58	9,79	-12%
Brazil	Maize	1,62E+07	5,31	3,21	66%
Democratic Republic of the Congo	Cassava	4,57E+06	16,04	0,00	∞
Indonesia	Oil, palm fruit	1,32E+07	5,34	8,89	-40%
Argentina	Maize	6,34E+06	9,72	10,41	-7%
Nigeria	Yams	6,20E+06	8,20	14,04	-42%
Nigeria	Cassava	6,41E+06	7,19	12,46	-42%
Democratic Republic of the Congo	Maize	2,78E+06	14,29	0,25	5622%
Nigeria	Maize	6,89E+06	5,27	5,32	-1%

Indonesia	Maize	5,22E+06	5,73	2,15	167%
Myanmar	Beans, dry	3,13E+06	8,96	9,98	-10%
Cameroon	Maize	1,27E+06	20,03	19,89	1%
Paraguay	Soybeans	3,42E+06	7,14	24,58	-71%
Democratic Republic of the Congo	Rice, paddy	1,58E+06	15,36	0,00	∞
Nigeria	Rice, paddy	5,48E+06	4,24	6,75	-37%
Canada	Rapeseed	8,89E+06	2,49	1,39	79%
Côte d'Ivoire	Cocoa, beans	4,05E+06	5,25	0,00	∞
Democratic Republic of the Congo	Plantains	1,09E+06	18,61	0,00	∞
United Republic of Tanzania	Maize	3,75E+06	5,30	19,68	-73%
Ethiopia	Maize	2,86E+06	6,90	3,33	107%
Nigeria	Sweet potatoes	1,60E+06	10,62	19,82	-46%
Ethiopia	Cereals, nes	3,04E+06	5,35	4,58	17%
Nigeria	Groundnuts, with shell	3,61E+06	4,49	7,54	-40%
Argentina	Barley	1,11E+06	14,38	16,92	-15%
Kenya	Maize	2,23E+06	7,12	0,05	13449%
Indonesia	Rubber, natural	3,66E+06	4,30	6,14	-30%
Côte d'Ivoire	Cashew nuts, with shell	1,67E+06	9,25	0,00	∞

Table 2. Top 30 land use change emission factors per hectare cultivated area.

Country	Crop	Weighted average ton CO2 eq./ha v2021	Weighted average ton CO2 eq./ha v2018	Relative difference (%)
Democratic Republic of the Congo	Pulses, nes	27,12	2,24	1108%
Peru	Artichokes	25,94	26,40	-2%
Cameroon	Ginger	25,92	27,91	-7%
Cameroon	Chillies and peppers, green	25,78	27,22	-5%
Cameroon	Tomatoes	23,97	25,24	-5%
Cameroon	Nuts, nes	23,66	4,02	489%
Cameroon	Watermelons	23,51	23,94	-2%
Cameroon	Cow peas, dry	23,49	27,73	-15%
Cameroon	Bambara beans	23,46	24,11	-3%
Cameroon	Sweet potatoes	21,60	21,02	3%
Peru	Linseed	21,27	27,58	-23%
Cameroon	Chillies and peppers, dry	20,95	19,11	10%
Kenya	Vegetables, leguminous nes	20,82	0,16	13107%
Kenya	Cauliflowers and broccoli	20,70	0,08	25685%
Cameroon	Cucumbers and gherkins	20,70	22,48	-8%
Kenya	Watermelons	20,64	0,15	13301%
Cameroon	Onions, dry	20,51	21,66	-5%
Suriname	Beans, green	20,42	4,46	358%
Peru	Spices, nes	20,04	23,20	-14%
Cameroon	Maize	20,03	19,89	1%
Cameroon	Sesame seed	19,97	19,13	4%

Kenya	Lettuce and chicory	19,80	0,15	13520%
Cameroon	Rice, paddy	19,61	20,20	-3%
Congo	Tobacco, unmanufactured	19,59	25,69	-24%
Kenya	Cucumbers and gherkins	19,56	0,13	14508%
Democratic Republic of the Congo	Roots and Tubers, nes	19,52	1,79	991%
Peru	Cauliflowers and broccoli	19,44	7,80	149%
Belize	Onions, shallots, green	18,84	29,50	-36%
Democratic Republic of the Congo	Plantains	18,61	0,00	#DIV/0!

More information

Do you have questions, do you want to receive more information, or would you like to request a quotation? Please contact Blonk Consultants.
Email: tools@blonkconsultants.nl
Phone: +31 (0) 182 579970

References

BSI. (2012). *PAS 2050-1: 2012 Assessment of life cycle greenhouse gas emissions from horticultural products*. BSI.

FAO. (2020). *Global Forest Resources Assessment 2020: Main report*. FAO Rome, Italy.

Friedlingstein, P., Andrew, R. M., Rogelj, J., Peters, G. P., Canadell, J. G., Knutti, R., Luderer, G., Raupach, M. R., Schaeffer, M., van Vuuren, D. P., & Le Quéré, C. (2014). Persistent growth of CO2 emissions and implications for reaching climate targets. *Nature Geoscience*, *7*(10), 709–715. https://doi.org/10.1038/ngeo2248

IPCC. (2019a). *Climate Change and Land - An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems*. https://www.ipcc.ch/srccl-report-download-page/

IPCC. (2019b). *Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Introduction (Vol. 4 Chp. 1).* https://doi.org/10.1016/S0166-526X(00)80011-2

World Resource Insitute. (2014). *CAIT Climate data explorer*. cait.wri.org