Direct Land Use Change Assessment Tool

Update description - Version 2018

Title	Direct Land Use Change Assessment Tool
Date	28-11-2018
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1. Introduction

Deforestation is one of the major issues caused by the global agriculture production system, with as much 8% of global CO_2 emissions being attributable to land use change. A well-known example is deforestation for the cultivation of crops such as soybean and oil palm. 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.

Challenge: availability of primary data

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. It is already not trivial to calculate specific impacts of land use change when detailed information is actually available. This becomes even more challenging when no specific information whatsoever is available for the crop of interest. Our 'Direct Land Use Change Assessment Tool' is specifically designed to support LCA-practitioners or other professionals/academics interested in the impacts of land use change.

1.1. Three functionalities

The 'Direct Land Use Change Assessment Tool' is an Excel tool, which provides a predefined way of calculating greenhouse gas emissions from land use change. The tool provides three basic functionalities, based on three different approaches related to data availability of the user.

1. **Country known & land use unknown:** this estimate is based on a number of reference scenarios for previous land use, combined with data from relative crop land expansions based on FAOSTAT.
2. **Country & land use unknown:** a weighted average is determined based on FAO statistics, using the same methodology as in 'country know & land use unknown' for calculating the GHG emissions for each relevant country.
3. **Country & land use known:** these approaches are described in the PAS 2050-1 published by BSI and are made operational in this tool using various IPCC data sources.

The 'Direct Land Use Change Assessment Tool' has grown in past years based on the PAS2050 and specifically the PAS2050-1 framework, the basic methodology of which is now widely referenced in. Examples are the PEF guidelines & Envifood protocol. It is the most comprehensive implementation of a methodology for GHG emissions from direct land use change that is commonly applied.

1.2. Update to version 2018

In this update of the 'Direct Land Use Change Assessment Tool' we incorporated the latest data from FAO up to 2016. Many of the background data have changed, such as areas reported, forest area statistics, and estimations of biomass carbon stock in forests.

In Table 1 (page 4), we give you a preview of the new results for selected countries and crops and some additional insights into the changes compared to the previous versions.

1.2.1. The big picture

The updated statistics explain some of the increases in LUC emissions for individual crops (see below), but they also explain the overall trend for the global average calculated emissions, which increased from a global average of 1.8 in the first version to 2.3 tonne CO_2e/ha in the latest update.

For the total dataset under consideration, this adds up to roughly 3.2 Gt CO_2/year. This result actually lies within ranges from other global estimates as for example published by Friedlingstein et al. (2014)[1], where a range of 3.3 ± 1.8 GtCO_2/year for 2003-2014 is given. Data from the CAIT Climate data explorer (at cait.wri.org)

[1] Friedlingstein, P. et al. (2014). Persistent growth of CO_2 emissions and implications for reaching climate targets. Nature Geoscience, 7(10), 709–715.

give a total of 2.78 Gt CO_2e/year for Land-Use Change and Forestry (data for 2012), which also comes close to our total figure. We should mention that for individual countries there are likely larger differences to be found, but it is interesting to point out that various methodologies at least lead to comparable results. Within this context, emissions from land use change account for roughly 8% of global CO_2 emissions.

1.2.2. Main drivers of change

The direct land use change emissions for a crop-country combination in the "country known, previous land use unknown"-scenario are mainly driven by three 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 conversions from cropland 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 this means that any 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 area harvested for the crop under investigation expand?***
  If the area harvested for a crop under investigation did not increase over a period of 20 years, there is no land use change. 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. For instance, the emissions from groundnuts in Myanmar increased significantly, because they doubled cultivation in the in the past year and did not cultivate groundnuts 20 years ago, the expansion over 20 years has increased enormously. In fact, most changes between the versions of the tool can be explained by the rate of expansion of a crop in a country.

1.2.3. Key new data

Crop data now include statistics from the FAO up to 2016. In the overall data the total expansion of crop area increased with 0.5% to +17% over a 20 year period compared to the previous dataset (2017.2). When the expansion is calculated over the same absolute period, the increase is from +16.5% to +17.5%, indicating that part of the increase is caused by updated statistics while the rest of the increase is caused by the shift in scope by one year. This scope shift can cause originally not expanding crops (resulting in Land Use Change emissions) to change into expanding crops and vice versa.

Also, changes in forest and grassland data can have significant impact on the result. In recent year, FAO data indicated that Malaysia switched from having a decrease in forest and grassland over 20 years to an increase. This means that all crop expansions in Malaysia will not be attributed to loss of forest or grassland and only conversion from annual to perennial crops and vice versa could result in Land Use Change emissions, which have a much lower GHG impact.

1.3. Key crops and changes in LUC emissions

The tables below list, for a number of key crops, the results of the 'Direct Land Use Change Assessment Tool'. Also included is an intermediate update (2015.1) which supplied data for the LUC emissions in our Agri-footprint 2.0 database. This update featured an update of the FAO statistics up to 2012, and as can be seen there was much less change between this first update and the original dataset, indicating that the most significant changes (parallel with the new Global Forest Resource Assessment 2015) were introduced in the course of 2015. In 2017, we made a small adjustment to the methodology to better reflect the PAS-2050-1 protocol. This latest update (v2018) contains all data up to 2016.

Table 1 shows the top 30 of 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 emission factors per hectare.

Table 1 Weighted average results of the Direct Land Use Change Assessment tool (tonne CO_2e/ha)

Country	Crop	Current area (1000 ha)	v2018 (FAO 2016)	v2017 (FAO 2014)	v2016 (FAO 2013)	v2015 (FAO 2012)	v2014 (FAO 2011)	Total impact tonne CO_2
World	**All**	**1.378.676**	**2,30**	**2,33**	**2,24**	**1,96**	**1,84**	**3.173.260**
Brazil	Soybeans	31.870	15,58	14,14	13,21	12,70	10,79	496.568
Argentina	Soybeans	19.364	14,84	15,28	15,43	13,90	13,55	287.413
Brazil	Sugar cane	10.252	9,79	9,68	11,04	11,82	10,81	100.347
Paraguay	Soybeans	3.470	24,58	24,95	24,88	19,41	18,92	85.304
Nigeria	Cassava	6.312	12,46	13,83	9,91	7,64	5,33	78.642
United Republic of Tanzania	Maize	3.990	19,68	18,05	15,28	9,07	7,92	78.522
Indonesia	Oil, palm fruit	8.704	8,89	8,75	11,84	11,73	11,35	77.408
Nigeria	Yams	5.295	14,04	14,84	12,99	8,49	7,36	74.318
Argentina	Maize	4.937	10,41	9,65	9,51	8,37	6,58	51.382
Brazil	Maize	15.266	3,21	3,01	2,22	1,25	1,15	48.985
United Republic of Tanzania	Sunflower seed	1.457	28,46	28,24	26,57	16,47	15,93	41.449
Indonesia	Rice, paddy	14.063	2,89	2,85	0,98	1,70	2,12	40.628
United Republic of Tanzania	Groundnuts, with shell	1.341	27,46	27,28	24,59	15,23	14,42	36.831
Nigeria	Maize	6.554	5,32	1,93	1,03	0,43	0,00	34.900
Myanmar	Beans, dry	3.035	9,98	11,16	11,55	11,95	11,94	30.286
Nigeria	Sweet potatoes	1.489	19,82	22,83	21,94	15,06	15,66	29.507
Nigeria	Okra	1.473	19,27	18,48	14,54	8,44	4,51	28.382
Brazil	Wheat	2.491	10,70	6,84	2,28	0,00	0,00	26.657
United Republic of Tanzania	Sesame seed	936	27,42	26,97	25,29	15,11	13,12	25.657
Cameroon	Maize	1.169	19,89	15,95	18,68	21,48	22,89	23.249
Indonesia	Rubber, natural	3.622	6,14	6,54	8,20	8,38	8,32	22.237
Nigeria	Groundnuts, with shell	2.761	7,54	12,95	12,72	9,82	10,20	20.809
Nigeria	Rice, paddy	3.066	6,75	7,32	5,75	3,68	3,14	20.710
Indonesia	Cocoa, beans	1.713	12,09	12,84	16,42	16,69	16,30	20.698
Niger	Cow peas, dry	5.144	4,02	3,44	3,15	4,00	3,76	20.667
Niger	Millet	7.005	2,89	3,35	3,51	3,54	3,35	20.223
India	Soybeans	11.419	1,69	1,90	1,56	1,55	1,36	19.345
Paraguay	Maize	903	21,28	23,35	23,17	19,04	18,22	19.226
Nigeria	Melonseed	1.055	17,03	15,58	11,31	7,81	8,22	17.958
Angola	Maize	1.562	11,14	5,70	6,36	7,75	9,90	17.408

Table 2 Top 30 impact - Weighted average results of the Direct Land Use Change Assessment tool (tonne CO_2e/ha)

Country	Crop	Current area (1000 ha)	v2018 (FAO 2016)	v2017 (FAO 2014)	v2016 (FAO 2013)	v2015 (FAO 2012)	v2014 (FAO 2011)	Total impact tonne CO_2
Brazil	Soybeans	31.870	15,58	14,14	13,21	12,70	10,79	496.568
Argentina	Soybeans	19.364	14,84	15,28	15,43	13,90	13,55	287.413
Nigeria	Cassava	6.312	12,46	13,83	9,91	7,64	5,33	78.642
Nigeria	Yams	5.295	14,04	14,84	12,99	8,49	7,36	74.318
United Republic of Tanzania	Maize	3.990	19,68	18,05	15,28	9,07	7,92	78.522
Paraguay	Soybeans	3.470	24,58	24,95	24,88	19,41	18,92	85.304
Indonesia	Cocoa, beans	1.713	12,09	12,84	16,42	16,69	16,30	20.698
Angola	Maize	1.562	11,14	5,70	6,36	7,75	9,90	17.408
Nigeria	Sweet potatoes	1.489	19,82	22,83	21,94	15,06	15,66	29.507
Nigeria	Okra	1.473	19,27	18,48	14,54	8,44	4,51	28.382
United Republic of Tanzania	Sunflower seed	1.457	28,46	28,24	26,57	16,47	15,93	41.449
United Republic of Tanzania	Groundnuts, with shell	1.341	27,46	27,28	24,59	15,23	14,42	36.831
Bolivia (Plurinational State of)	Soybeans	1.314	13,16	15,39	15,96	15,70	15,49	17.297
Cameroon	Maize	1.169	19,89	15,95	18,68	21,48	22,89	23.249
United Republic of Tanzania	Beans, dry	1.119	14,84	16,72	15,49	10,34	9,22	16.609
United Republic of Tanzania	Rice, paddy	1.114	12,51	12,42	12,49	6,03	6,12	13.937
Nigeria	Melonseed	1.055	17,03	15,58	11,31	7,81	8,22	17.958
Argentina	Barley	1.002	16,92	18,01	17,57	15,76	13,83	16.955
United Republic of Tanzania	Cassava	985	11,11	6,70	7,10	5,02	5,70	10.947
United Republic of Tanzania	Sesame seed	936	27,42	26,97	25,29	15,11	13,12	25.657
Paraguay	Maize	903	21,28	23,35	23,17	19,04	18,22	19.226
Angola	Beans, dry	801	13,56	13,99	15,66	15,46	15,69	10.860
Cameroon	Sorghum	799	11,53	11,67	11,00	12,07	12,03	9.208
Nigeria	Taro (cocoyam)	749	16,06	15,88	15,18	10,75	10,70	12.033
United Republic of Tanzania	Sweet potatoes	747	19,32	21,26	20,68	11,56	11,63	14.442
Brazil	Sorghum	710	18,17	18,19	16,93	17,04	16,39	12.910
Cameroon	Cocoa, beans	691	10,74	11,06	9,91	10,37	8,45	7.417
Paraguay	Wheat	560	20,78	21,51	21,40	17,94	17,31	11.635
Nigeria	Tomatoes	558	20,99	21,78	20,23	13,79	13,88	11.709
Guinea	Maize	521	17,22	18,10	18,21	17,85	18,09	8.977

More information

Do you have questions, or do you want to receive more information about the Direct Land Use Change Assessment Tool?
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