Contact : Mertens Lara
lara.mertens@uclouvain.be
Phone : 010 47 38 18

The iLUC factor: A solution for indirect land use changes associated with biofuel production?

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lara.mertens@uclouvain.be
Phone : 010 47 38 18

1. Introduction

Indirect land-use change (ILUC) occurs when the production of crops for biofuels in a given land pushes the previous activity to another location. The use of the new location to place the previous activity generates a land-use change attributable to the implantation of the biofuel crop[1]. In other words, if the crops needed to make a particular batch of biofuels crops are grown on uncultivated land, this will cause direct land use change. If crops grown on existing arable land are used to make biofuels instead of food, this will likely cause ILUC because of the necessity to replace the food (Figure 1). Due to changes in the carbon stock of the soil and the biomass, indirect land-use change has consequences in the greenhouse gas (GHG) balance of a biofuel.

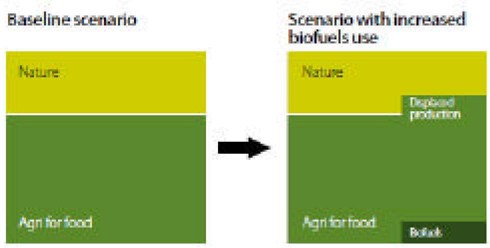

Figure 1 -Schematic representation of indirect land use change mechanism[2]

The Commission is required, by December 2010, to submit a report to the European Parliament and to the Council, reviewing the impact of indirect land use change on greenhouse gas emissions and addressing ways to minimise that impact (article 19.6 of the Renewable Energy Directive (2009/28/CE)) and article 7d.6 of the Fuel Quality Directive (2009/30/CE)). In preparing its report, the Commission has launched a number of studies in order to better understand the phenomenon of indirect land use change associated with biofuels and bioliquids. The Commission recently opened a public consultation on iLUC and the consultation document can be found on the website of the Commission[3].

2. JRC report on indirect land use changes

The JRC Scientific and Technical Report "Indirect Land Use Change from increased biofuels demand" compares the land use change (LUC) (crop area change) results produced by different economic models for marginal increases in biofuel production from different feedstock. The models address the general issue of "land use change" instead of differentiating between direct and indirect land use changes. In other words, the models do not distinguish which feedstock is grown on "new" or "old" land: they simply look at the consequences of crop demand changes on crop land area. The modellers were requested by JRC-IE to run scenarios corresponding as closely as possible to the following specification (e.g. marginal runs against existing baseline of the following scenarios):

[1] Turner B.T., Plevin R.J., Hare M., Farell A., 2007. Creating markets for green biofuels: Mesuring and improving environmental performance. Research report UCB-ITS-TSRC-RR-2007-1. University of California Berkeley. Transportation Sustainability Research Center, April, 2007

[2] Source: Bioenergy – a time accounting time bomb. 2010. Birdlife International.

3 http://ec.europa.eu/energy/renewables/consultations/2010_10_31_iluc_and_biofuels_en.htm

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A. marginal extra ethanol demand in EU
B. marginal extra biodiesel demand in EU
C. marginal extra ethanol demand in US
D. marginal extra palm oil demand in EU (for biodiesel or electricity)

The LUC results (kha/Mtoe) of the different marginal simulations are presented in Figure 2.

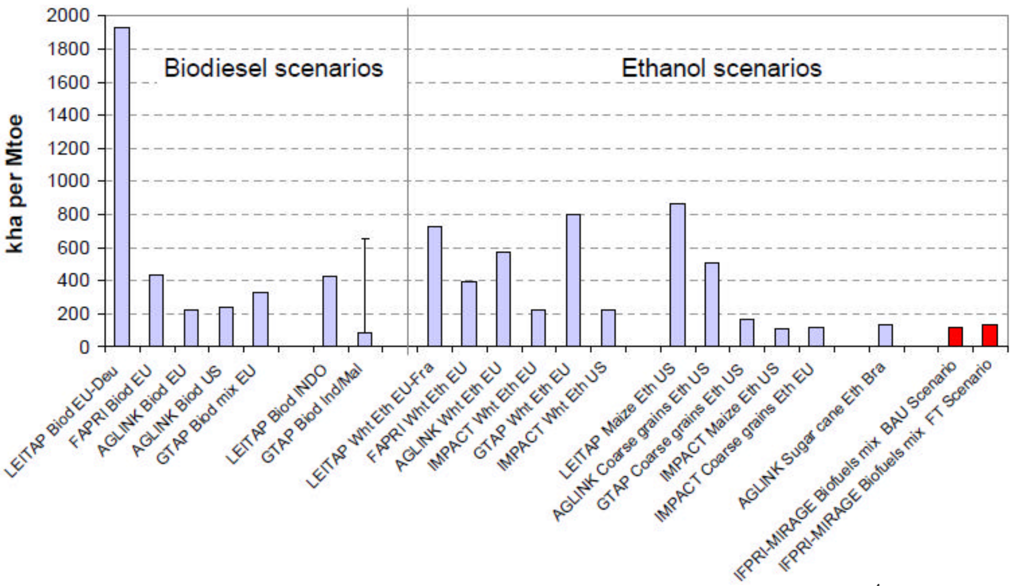

Figure 2 - Marginal changes in area per Mtoe for all models and scenarios[4]

As shown in the figure above, LEITAP generally shows the highest LUC per toe biofuel. For ethanol scenarios this can be explained by underestimation of the by-products effects, but for EU biodiesel, this explanation is insufficient to account for the large difference.

To illustrate the carbon impact of this crop area increase, the ILUC results should be presented in terms of GHG emissions. To do so, JRC made use of a simplified approach, using a fixed emission factor (an average value of 40 tC/ha for soil C emissions was used (IPCC default values report 38 to 95 tC/ha following land cover conversion for EU and agricultural areas in North America). Results of this simplified calculation are presented in Figure 3. Where the models reported palm oil area expansion, an additional 19 tCO_2 per ha per year are added to the emissions to account for peat oxidation. A fixed emission factor does however not account for the large variations of soil properties, vegetation and climate around the world and the limitations of this approach should be kept in mind.

[4] Edwards, R., Mulligan, D., Marelli, L. 2010. Indirect Land Use Change from increased biofuels demand – Comparison of models and results for marginal biofuels production from different feedstocks. JRC Scientific and Technical Report.

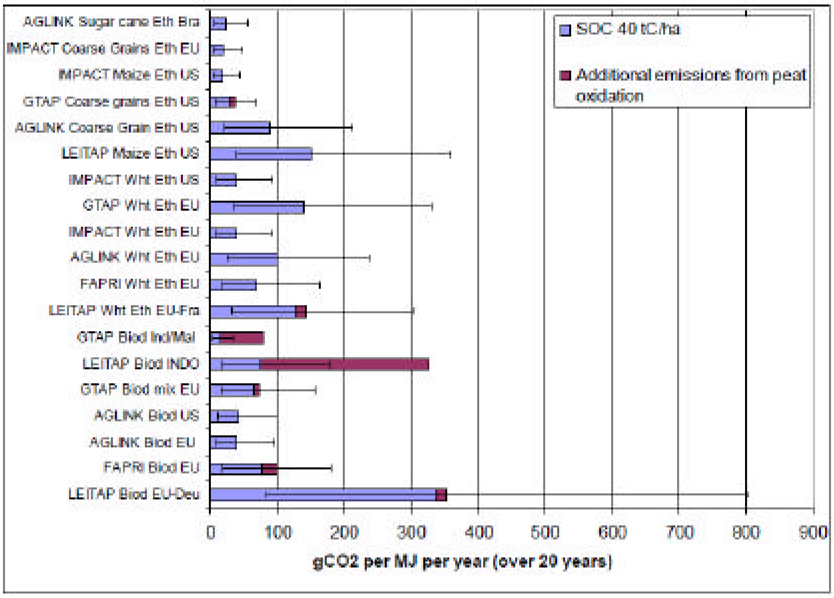

Figure 3 - Rough indication of emissions assuming 40 tonne of C per hectare over 20 years

Two modellers did however report on CO2 emissions associated with their LUC results. FAPRI-CARD could report calculations of CO_2 emissions for two scenarios simulated (more details on the CO_2 marginal emissions resulting from FAPRI-CARD can be found in Annex 1). GTAP modellers made use of emission factors (from Hertel et al., 2009) to calculate LUC emissions over 30 years. These emission factors are region specific (where data are available) and are developed for each type of land conversion: i) Forests to crops; ii) Pasture to crops; iii) Pasture to forests. The emission factors used by GTAP modellers can be found in Annex 2. CO_2 results of the FAPRI-CARD and GTAP models are presented in Figure 4

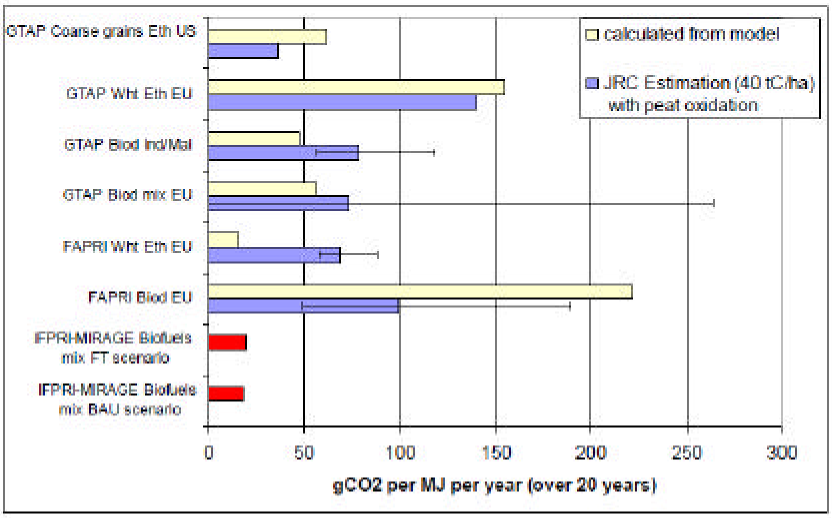

Figure 4 - Comparison between JRC indicative estimates of CO2 emissions and precise value calculated from FARPI -CARD and GTAP data

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3. Discussion

Land Use Change (LUC) is a global issue which largely transcends the biofuels sector. A producer could supply palm oil from arable land to the biofuel sector and in the mean time clear forested land to supply palm oil to the food sector. Indirect land use changes (iLUC) reveals to be a question of sustainable land use management which, to be tackled effectively, should be treated in an integrated way (indirect and direct land use changes from all relevant sectors). The biofuel legislation is not adequate to treat macro-issues such as land use change as it does not make sense to link ILUC effects to individual consignments of biofuels. Only well-enforced national and international legislations are capable of treating this matter effectively. However, the probability of seeing the implementation, on the short and even middle term, of a global, well-enforced international agreement, ensuring worldwide sustainable land use management is slim. The inclusion of an iLUC factor in the greenhouse gas (GHG) emission calculations for biofuels is therefore often brought forward as the most relevant short term approach. The iLUC factor has the advantage of being efficient and simple to implement. However, tackling iLUC exclusively through an iLUC factor limits the impact assessment to GHG emissions. LUC is not just a question of GHG emissions but can also be expressed in terms of biodiversity, use of natural resources (soil and water) and effect on local communities. Moreover, as all compensation measures, a GHG factor will not actually prevent deforestation from happening. Deforestation and biodiversity loss can hardly be compensated by increased GHG savings on some other side of the globe, for example in another step of the supply chain.

The understanding of the issue at the present moment seems insufficient to form a base for legislation. The models present large differences in terms of results and several uncertainties persist, which are discussed in the Literature Review of the Commission on the subject (July 2010). These uncertainties are briefly formulated below. First, despite the fact that JRC has requested all models to provide the same output, marginal tonnes GHG/toe biofuels for every biofuel from every feedstock, the comparability of the results remains limited. Some models are not capable of defining one feedstock: they can only deal with policy drivers. Others can only deal with one crop at a time. There is no exact set of scenarios that all the models can work on at the time being. Moreover, there is no consensus about which land use data-set is best for iLUC modelling and the available datasets give noticeably different results. Several uncertainties also remain regarding crop yields. According to a literature review of the Commission on the impact of land use change on GHG emissions' from biofuels and bioliquides, high assumptions could reduce the amount of land converted by 15% compared with low assumptions. Higher yields can require relatively large quantities of extra fertilizer and extra emissions from those possible additional fertilizers have not been estimated. Some studies assume that converted land will have a lower yield than already cultivated land. According to the literature review of the Commission and depending on the study, the removal of this assumption would reduce the amount of land needing to be converted by approximately 17% to 67%. What is more, some models consider the slowdown of the declining trend of cropped area in the EU due to the increased cultivation of energy crops as a missed opportunity to allow the land to revert to grassland or forest, which translates into a GHG cost of the policy. The substitution of animal feed by co-products is also subject to divergence, in terms of the rate of substitution and the types of animal feed replaced. Besides, none of the models reviewed by the Commission take into account the sustainability criteria (minimum GHG emission savings and restrictions on land) imposed by the RES Directive or possible legislations on land use for nature protection purposes imposed by public authorities. Additionally, there are numerous differences in how the studies calculate changes in carbon stocks. According to the literature review of the Commission, the carbon stocks attributed to particular land types vary by factors of between 2 and 15 from one study to another. Also, the

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impact of the type of biofuel on land use has not been thoroughly explored and studies which have looked into this issue give widely varying results. Only one study looks at whether the same feedstock has a different land use change impact if produced in a different location. And finally, all models except IFPRI-MIRAGE ignore emissions from the oxidation of tropical peat caused by drainage of tropical peat for planting oil palms. The Commission criticizes the lack of transparency in terms of data and methodology, which limits the comparison in modelling choices.

The inclusion of an iLUC factor, which value could still be very controversial, would add an additional barrier to the sector, which can not be overcome in any way by producers. This is rather inconsistent with the EU policy seeking to promote biofuels. The simple fact of introducing a 10% target implies effects on land use, which can be positive or negative Three of the four most recent studies estimating greenhouse gas impacts – including the only one dealing with the EU – have concluded that biofuels are beneficial in greenhouse gas terms even when their land use impact, as well as a full life cycle analysis, is taken into account[5]. The inclusion of an iLUC factor would fail to account for productions which do not generate, or generate positive, iLUC. For example, energy crops for biofuels which are produced on fallow land generate feed by-products which prevent the further growing of protein rich crops like soybean.

The claim that tackling the iLUC issue through a GHG factor is not effective does not mean to question the relevance of the iLUC issue in the biofuel sector in particular. Biofuels do indeed occupy a particular place in the debate on land use. The cultivation of energy crops exerts a pressure on land, as does any other land use; however some land uses could be qualified as vital in opposition to others. This should be taken into account in sustainable land use management and priority should be given to essential land uses such as crop cultivation for food. The biofuel sector should however be put on an equal footing as for example the oil industry when dealing with the social and environmental consequences of land use changes. The tricky thing about biofuels resides in the fact that their existence is based on a sustainability claim. Despite the fact that biofuels represent only a minor part of agricultural practice, their environmental impact is therefore generally treated in an uncompromising way.

In conclusion, sustainable land use management is of vital importance in a world with growing demography and increased pressure on land and resources. However, land use change is a global and complex issue and tackling the matter through inadequate instruments to justify one's policies and actions is not the right way forward. The inclusion of an iLUC factor will not prevent deforestation from happening and would fail to account for productions which do not generate, or even generate positive iLUC at the risk of imposing an unjustified penalty on the sector. The EU biofuel policy should be directly linked to an enhanced importance of sustainable land use management and to increased initiatives for nature protection purposes around the world.

[5] In-house review conducted for DG Energy as part of the European Commission's analytical work on indirect land use change "The impact of land use change on greenhouse gas emissions from biofuels and bioliquides – Literature Review" July 2010.

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Annex 1[6]

Calculations of CO_2 emissions resulting from the LUC calculated by the FAPRI-CARD made use of the Green- house Gases from Agricultural Simulation Model (GreenAgSiM) model developed within FAPRICARD. The calculations of land-use change related emissions are done in two steps. First, the land-use dynamics need to be calculated based on output from the CARD Model. In a second step, carbon emissions based on land-dynamics and bio-physical conditions are computed. The two sources/sinks of carbon in GreenAgSiM are biomass and soil. A default factor of 0.47 tons of carbon per ton of dry matter is used to calculate the biomass in CO2-equivalent. The change in the amount of soil organic carbon (SOC) depends on factors such as climate region, native soil type, management system after conversion, and input use. The FAO Soil Map was used (which subdivides soil into three large categories with emission factors of 20 t/ha, 40 t/ha, and 80 t/ha), considering medium input, full tillage and the top 30 cm of soil carbon. The conversion is assumed to be from forest, shrub-land, grassland, and set-aside to agricultural land i.e. cropland and pasture. Results from GreenAgSiM model calculations are reported in the table below. In calculating the emissions, the different assumptions of the models play a crucial role. For this specific exercise, FAPRI-CARD assumed (as explained in paragraph 4.2) that the all the increase in ethanol consumption comes from wheat grown in EU (rather than just bought there). The model decides that (after allowing for the use of DDGS in animal feed) most of this wheat is diverted from animal feed, partly because it is replaced by DDGS by-product and partly by imported meat, compensating a decline in meat production in EU. Those meat imports come principally from extensive meat producing regions which do not use much crops to feed the livestock, which lives on ranchland. There is probably an extension of pasture onto nature land as a result, but this does not consider this in the results for cropland.

Table 41: CO_2 marginal emissions calculated from FAPRI-CARD LUC results

	EU Wheat Ethanol	EU Rapeseed Biodiesel
Ethanol/biodiesel increase in million liters	254	288
Ethanol/biodiesel increase in Mtoe	0.130	0.230
Difference in Area Harvested (ha)	44191	83966
Difference in Emissions (in million tons of CO2 -equivalents)	1.67	41.70
CO_2 tonnes per ha	38	497
tC/ha	10	135
CO_2 produced per liter of ethanol (in kg)	6.6	145.0
Energy Content (MJ/liter)	21.2	32.7
Emissions in grams of CO_2 per MJ	310.6	4432.7
Emissions in grams of CO_2 per MJ (over 30 years)	10.4	147.8
Emissions in grams of CO_2 per MJ (over 20 years)	**15.5**	**221.6**

[6] Edwards, R., Mulligan, D., Marelli, L. 2010. Indirect Land Use Change from increased biofuels demand – Comparison of models and results for marginal biofuels production from different feedstocks. JRC Scientific and Technical Report.

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Annex 2[7]

In responding to the JRC-IE request of "reporting the assumptions on carbon release or foregone carbon sequestration made in deducing LUC emissions from conversion of different land use types", GTAP modellers included a table (from Hertel et al., 2009) with emission factors (EF) used to calculate LUC emissions over 30 years (see table below).

Table 42: GTAP Emission Factors (in Tons CO_2 / Ha)

Region	Forest to Crop	Pasture to Forest	Aboveground Biomass	Pasture to crop
1 USA	760	219	18	106
2 EU27	297	362	18	156
3 BRAZIL	388	164	18	72
4 CAN	705	434	18	196
5 JAPAN	574	223	18	85
6 CHIHKG	574	223	18	196
7 INDIA	574	223	18	196
8 C_C_Amer	388	164	18	72
9 S_o_Amer	388	164	18	72
10 E_Asia 5	574	223	18	85
11 Mala_Indo	937	337	18	85
12 R_SE_Asia	937	337	18	85
13 R_S_Asia	937	337	18	85
14 Russia	311	392	18	156
15 Oth_CEE_CIS 2	297	362	18	156
16 Oth_Europe	297	362	18	156
17 MEAS_NAfr	152	59	18	82
18 S_S_AFR	305	129	18	43
19 Oceania	388	198	18	98

Region specific EFs (where data are available) are developed for each type of land conversion:

1) Forests to crops
2) Pasture to crops;
3) Pasture to forests.

The small amount of aboveground biomass in annual crops that results in carbon sequestration is also taken into account (third column of the table) The JRC-IE calculated the corresponding marginal CO2 emissions per year for the four GTAP scenarios multiplying the regionally disaggregated LUC data (in ha/Mtoe) by the emission factors in the above table. Carbon release and foregone carbon sequestration were calculated considering:

1. Emissions from forest loss
2. Sequestration from forest gain
3. Sequestration from gain in crop area
4. Emissions from loss of Pasture area

Total CO2 emissions calculated by the JRC-IE for the four scenarios are reported in the table below.

	EU Wheat ethanol	US Coarse Grain Ethanol	EU Biodiesel (mix)	Mala-Indo Biodiesel
Total g CO2/MJ	3092	1245	1134	931
g CO2 / MJ per year (over 20 years)	155	62	57	47

[7] Edwards, R., Mulligan, D., Marelli, L. 2010. Indirect Land Use Change from increased biofuels demand – Comparison of models and results for marginal biofuels production from different feedstocks. JRC Scientific and Technical Report.