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Indirect land use change (iLUC) revisited: An evaluation of current policy proposals*

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Abstract:

The contribution of biofuels to save greenhouse gas emissions has been challenged over the last years. A still unresolved question is how to quantify emissions from indirect land use change (iLUC). In this article we discuss the implications of uncertainties on the current policy proposals in the European Union (EU). We conclude that it is inappropriate to calculate crop-specific iLUC-emissions and to include them into binding regulation. We argue that modelling results, particularly crop-specific ones, should not be used for policy decisions. Our discussion of the current EU policy proposal suggests that a combination of an increase in the minimum emissions savings threshold and limits to biofuel production are a safe way to ensure with a high degree of certainty a climate mitigation impact of biofuels.

Keywords: Biofuel policy, indirect land use change, European Union, policy proposals

JEL classification: Q42, Q24, Q48, Q16

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1. Introduction

The production of biofuels in the transport sector of the European Union (EU) has been promoted for over a decade, but the question on how to quantify and regulate the so-called indirect land use change (iLUC) remains unresolved. This article offers insights into the sources of uncertainty regarding the results on the quantity of greenhouse gas emissions from iLUC (iLUC-emissions) and discusses the implications of these uncertainties for regulating iLUC in the EU. This article adds important insights to the debate on how to address the iLUC compared to existing reviews on land use change (LUC) modelling (e.g. Golub and Hertel (2012), Dumortier et al. (2011)). We explain opportunities and challenges when using scientific results for formulating effective policy measures for iLUC. In particular, we comment on the current proposal of the European Commission (EC) to include iLUC into the EU's Renewable Energy Directive (EU-RED).

In 2009, the EU extended its goal of a 5.75% share of renewable energy in the transport sector by 2010 (EU 2003) to a share of 10% by 2020 (EU 2009). In addition to increasing energy security and promoting the agricultural sector, the expected reduction in greenhouse gas emissions (called emissions in the following) is the main reason for subsidising biofuel production. This view that biofuels provide emission reductions was challenged by a publication by Searchinger et al. (2008). As a response, the EU-RED, recognising the need for a calculation of emissions, requires the accounting of emissions from LUC in the emission balance as part of the certification of biofuels (EU 2009). However, so far only the computing of emissions from the production process, transport and direct LUC (dLUC) is required. By definition, dLUC "occurs when a previous land use is converted to bioenergy crop production" (Plevin et al. 2010, p. 8015). These direct emissions are part of a standard emissions balance, which is used to calculate emissions for biofuels.[1]

Part of LUC is indirect. "ILUC-emissions occur when grassland and forest are converted to cropland somewhere on the globe to meet the demand for commodities displaced by the production of biofuel

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[1] as in the EU-RED (EU 2009), the US Energy Independence and Security Act (EISA) of 2007, and California's Low Carbon Fuel Standard (LCFS)

feedstocks" (Plevin et al. (2010), p.8015).[2] ILUC is caused by increasing prices for agricultural commodities, thus making land expansion profitable. It is therefore a global phenomenon that is transmitted through global markets for agricultural commodities. As a consequence, iLUC induced by national biofuel support policies may occur anywhere in the world and not necessarily in the country that implemented the policy. If this was the only cause of demand changes, iLUC indeed could be completely attributed to the promotion of biofuels.

However, the identification of iLUC is made difficult due to the complex interrelations in agricultural and downstream markets. Biofuel production is closely connected with food production, particularly meat, since e.g. meals for animal feed are jointly produced with vegetable oils which are used for both, biofuel and food production. Therefore, there is no direct causal relationship between increases in biofuel production and iLUC.

Nonetheless, some studies suggest that iLUC-emissions may be larger compared to emissions from dLUC (e.g. Plevin et al. 2010). Therefore the European Commission (EC) aims at including iLUC-emissions into its regulation of biofuels. Thus, there is a need for quantified estimates of alleged iLUC-emissions for policy regulation. However, such estimations require a comprehensive analysis of the complex agricultural production systems. Several different conceptual approaches have been used to quantify iLUC-emissions. These different approaches result in quite different contributions to the identification and quantification of ilUC and to the determination of a causal relationship between iLUC and the expansion of biofuel production.

The article is organised as follows. In section 2, we provide an overview of the current discussion about LUC regulations in the EU. In section 3, we discuss and assess the various methods that have been used to quantify iLUC-emissions. In section 4, we present modelling results that quantify the price and LUC effect of biofuel promotion and discuss possible limitations of the models. Based on the modelling results, in section 5, we assess current policy proposals. In particular, we comment on

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[2] For a definition of iLUC see also Gawel and Ludwig (2011).

their potential success in controlling for iLUC-emissions. Finally, we summarise our findings and conclude the article.

2. Control of GHG Emissions from LUC in the EU

Scientists, policy makers, and stakeholders have discussed whether the current regulation in the EU-RED is sufficient to indirectly account for iLUC or whether new measures need to be introduced. We briefly review current biofuel support policies and the proposals for iLUC regulation

The current regulation of emissions in the EU-RED has two major components:

- The EU-RED prohibits the use of land with high carbon stocks[3] or high biodiversity in the production of feedstocks for biofuels.
- For feedstock production on all other land types, the certification procedure must include an assessment of emissions throughout the value chain.[4] The assessment of emissions must include emissions from transport and production, as well as emissions from dLUC. The resulting emission balance is evaluated and compared with comparable emissions from fossil fuels (diesel or gasoline)[5]. Each biofuel must achieve a minimum emission saving threshold (MEST) of 35%.

Only biofuels that meet these requirements are eligible for inclusion in the national quotas, and hence receive a price premium on the market.[6]

The 35% MEST can be interpreted as a precautionary measure to ensure that biofuels indeed lead to emission savings in light of the uncertainties involved in assessing the emissions of a particular biofuel

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[3] which are all continuously forested and peat land areas

[4] This can be conducted using the default values of the EU-RED, the individual emissions values of a particular value chain, or using normalised (standardised) regional emission values.

[5] According to the fuel quality directive (Directive 98/70/EC) GHG emissions of biofuels shall be compared to the latest available actual average emissions from the fossil part of petrol and diesel consumed in the Community as reported under Directive 98/70/EC. If no such data are available, the value used shall be 83.8 gCO2eq/MJ which is also used in this article.

[6] For a detailed discussion of these EC guidelines, see Lange (2011).

produced in a particular location. The MEST could also be understood as a safety belt for potential iLUC that has so far not been included in the GHG balance. In a similar precautionary approach standardised default values have been set for emissions of biofuels along their whole supply chain. These values represent a conservative estimate of emissions when compared to the values observed in the market. Consequently, the required 35% MEST, combined with the default values, could be understood as a "risk factor" that prevents biofuels from potentially violating the objective of climate change mitigation. Because the "risk factor" for emissions from the production process and dLUC do not explicitly account for iLUC-emissions, the question is whether the 35% MEST is sufficiently high to accommodate potential iLUC-emissions.

The mechanism through which the MEST influences iLUC is straightforward. Whether a certain biofuel passes the requirements of the EU-RED is determined by the emission balance of the entire production process in the event of no dLUC[7]. This means that a biofuel is not allowed to exceed ~54.5 gCO_{2eq}/MJ emissions from fossil sources throughout the production process under the current 35% MEST level. Increasing the MEST implies that the emissions during the production process need to be lower. If only default values are used, this would eliminate those currently available biofuels that only provide GHG savings below the increased MEST.[8] The biofuels remaining in the market would be those with high energy yields per hectare as this is a major factor influencing the emission balance of biofuels (Lange 2011). Thus, the remaining portfolio would consist of biofuels that, on average, produce more energy per hectare than the portfolio under the lower MEST. This would reduce the price effect of the biofuel production on prices of agricultural commodities and thus would lower the iLUC of the biofuel mandate.

Reports about high iLUC emissions (e.g. USC 2001) have found wide media and public attention such that it was questioned whether iLUC-emissions are sufficiently covered by the current 35% MEST. After discussing several options for taking into account iLUC-emissions within the EU biofuel

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[7] If a production causes dLUC, it logically cannot cause iLUC.

[8] This holds in the case that default values are used to calculate the emission balance. A biofuel producer could not use the default values and prove in an individual GHG assessment that his overall emissions are below the default values.

framework (EC 2010 p. 14), in June 2014, the Energy Council of the EU reached a political agreement on a draft directive on iLUC[9] (EC 2014). The EC proposes to

- limit the consumption of conventional biofuels from 10% to 7% (the current share) by 2020;
- increase the amount of advanced biofuels to achieve the 10% target by 2020 by double-counting them;
- report on iLUC and its influence on emissions savings based on estimated iLUC-factors;
- retain the option to introduce adjusted estimated iLUC-factors into the sustainability criteria.

A detailed description of these options is provided in the appendix. This compromise implies that iLUC is neither addressed through an increase in the MEST, nor does it introduce a specific iLUC-factor which could drive some biofuels out of the market. However, through the promotion of so-called advanced biofuels with double-counting, incentives will be set to reduce the share of crop-based biofuels. The reporting requirement of iLUC –factors without counting them in the GHG-balance introduces transparency and presumably political pressure to move away from certain biofuel feedstocks with an unfavourable iLUC-factor. In addition, the EC preserves the option to introduce additional iLUC regulations in the future. Therefore, the debate about appropriate approaches for quantifying iLUC is still on the table. IlUC would need to be introduced into the computation of the GHG-balance of biofuels by being based on sound scientific evidence but also being sufficiently easy to quantify for regulatory purposes. However, before reviewing approaches for calculating iLUC-emissions, the scientific challenges and the approaches chosen for determining iLUC will be discussed. Against this background, we then discuss the proposed solutions for quantifying iLUC.

3. Approaches for determining GHG emissions from iLUC

Since iLUC is a response of land owners and farmers to price increases of agricultural commodities, the causal chain leading to this effect needs to be identified. Delzeit et al. (2016) discuss this issue and identify a series of analytical steps that need to be gone through: first, a site-specific identification of replacements of food and feed production by biofuel feedstocks; second, an economic analysis of the

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[9] This directive amends the fuel quality directive (98/70/EC) and EU-RED (EU 2009).

global market responses to this replacement; and third, a site-specific identification of land cover change from non-agricultural land to cropland which is used for producing food or feed. This means that only that land use change that is done for food and feed counts as iLUC, whereas the land use change toward the production of biofuel feedstocks would count as direct land use change (dLUC) but not iLUC. They conclude that this can only be done at a spatially highly disaggregated level and with the help of economic models that can identify the global and local market responses to the introduction of biofuel policies in the agricultural sector and beyond. Several methods have been proposed with which emissions from iLUC are claimed to be quantifiable and which could be used to adjust the GHG-balance with iLUC emissions. They can be roughly classified into a) ad-hoc/deterministic approaches, b) econometric estimates, and c) numerical simulation models. The ad-hoc approaches use past observations about LUC and attribute those to iLUC. The econometric studies go a step further and try to deduct from historical data through econometric techniques the amount of land expansion caused by biofuel policies which is then extrapolated to future land use change und consequently to iLUC. Finally, numerical simulation models explicitly introduce demand and supply of biomass for food, feed, and fuels, thus taking into account the price effects that lead to LUC, both locally as well as globally.[10]

Delzeit et al. (2016) find that none of the approaches, as they are published today, can actually identify iLUC. All share the fundamental drawback that they are not able to differentiate between iLUC and dLUC, i.e., they can only identify net land use change which is the combined effect of dLUC and iLUC. They also conclude that numerical models are best suited for assessing the overall land use change caused by biofuel policies. The simulation models mimic the price effects on agricultural markets directly. Therefore, they can be used to introduce inherent uncertainties and to analyse the robustness of the results through sensitivity analyses and provide upper and lower bounds for the likely LUC effects.

The proposal of the EC (2014) contains crop-specific iLUC-factors which are presumably based on the results of the study by Laborde (2011). We argue that calculating crop-specific emission factors

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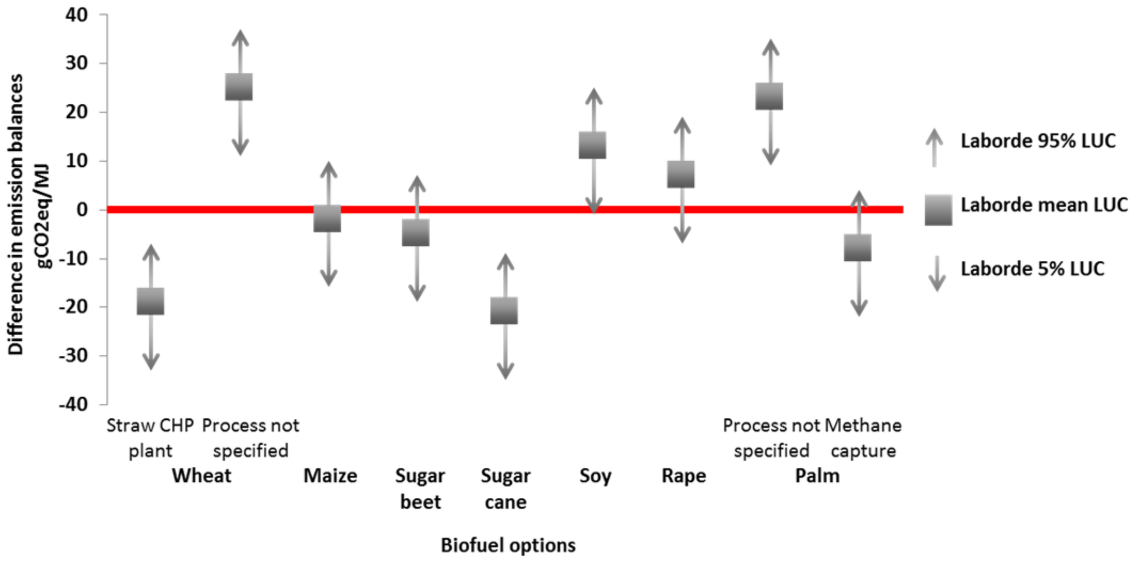
[10] A detailed review of these approaches and their limitations is provided in Delzeit et al. (2016).

suffers from methodological drawbacks, as price effects on demand and substitution of feedstuff are an aggregated effect. Crop-specific LUC-.emissions amount to 12 gCO_2/MJ for cereals and other starch rich crops, 13 gCO_2/MJ for sugars, and 55 gCO_2/MJ for oil crops. All LUC-emissions together in Laborde (2011) have a weighted mean of 38.8 gCO_2/MJ and a confidence interval of 24.4-50.4 gCO_2/MJ for the 5% and 95% intervals. A recent study by Valin et al. (2015) commissioned by the European Commission comes up with 101 gCO_{2eq}/MJ for the EU biofuel mix in 2020, while a sensitivity analysis shows values ranging from 20 to 150 gCO_{2eq}/MJ which is mainly caused by natural vegetation biomass and peatland emissions from biodiesel production (p. 241). In fact, highest LUC emissions are simulated for biodiesel from palm oil (231 gCO_{2eq}/MJ) of which 69% is attributed to peatland oxidation. Note that LUC emissions from palm oil are associated with largest uncertainties: results range between close to zero to around 500 gCO_{2eq}/MJ. If the crop-specific values are taken, none of the biodiesel pathways would have a positive GHG balance. Because of the doubts about the reliability of crop-specific iLUC-factors, we only use the average iLUC-factors in the subsequent discussion.

4. Uncertainties in iLUC emissions of biofuels

The implications of these uncertainties in modelling iLUC can nicely be illustrated with reference to the Monte Carlo analysis of Laborde (2011) (see description in the appendix). This study was commissioned by the EC to assess the emissions caused by iLUC under the EU biofuel target. In fact, it did quantify the net effect of dLUC and iLUC but not iLUC separately. However, given that, at least in the case of the EU biofuel regulation, dLUC is unlikely to take place because of the high GHG values from LUC (Lange 2011), the results of Laborde (2011) can be interpreted as emissions from iLUC. We combine the LUC emissions with the default values for emissions from production processes throughout the supply chain (well-to-wheel emissions = WTW emissions) in order to get to the overall GHG balances of the different biofuels. These allow us to illustrate the impact of the probability distribution of the emission balances on the GHG savings of the different biofuel options.

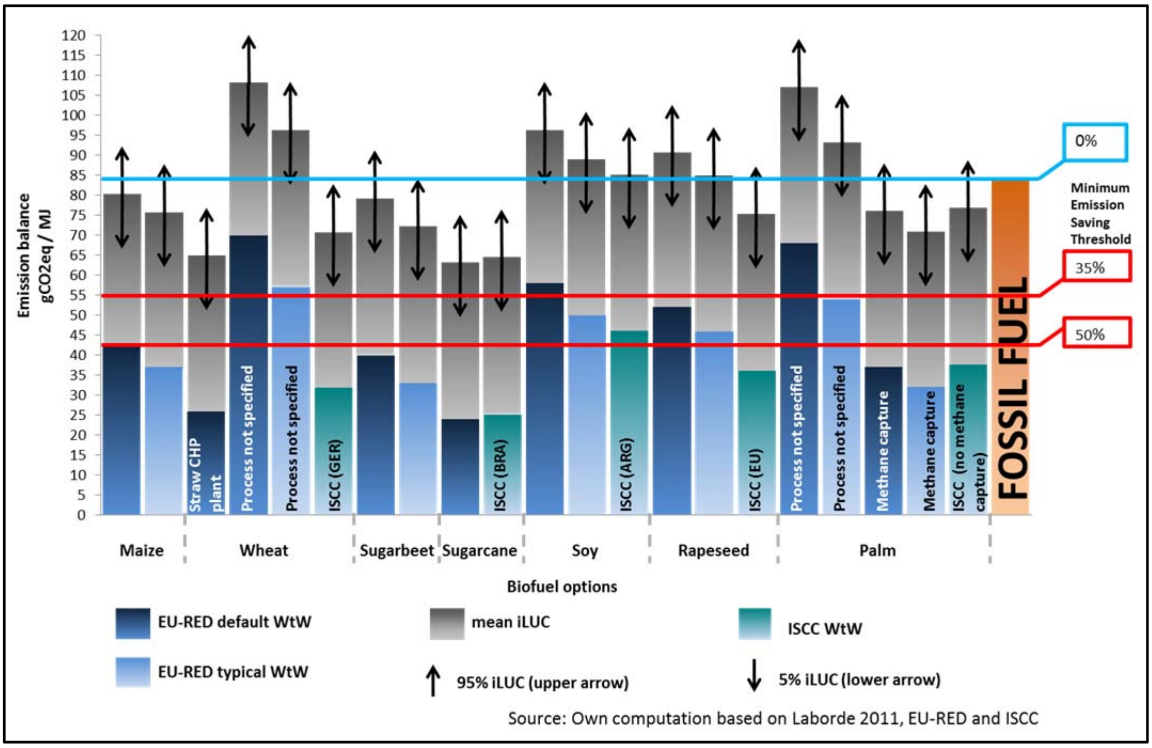
Figure 1: Difference between emission balances of biofuel options and emissions balances of fossil fuel alternative



Source: Own presentation based on Laborde 2011 and EU-RED

Figure 1 illustrates the difference in emission savings of biofuels from different feedstocks. Here, emission savings are defined as the difference in emissions between the biofuel and the fossil fuel alternatives (FFA) which is expressed on the vertical axis. On the horizontal axis, the most important biofuel feedstocks for bioethanol and biodiesel are listed. The squares indicate the mean value of the LUC emissions from Laborde (2011) plus the WTW emissions. All squares below the red line indicate positive emission savings even if iLUC is taken into account. In fact, if only mean values are used, five out of nine options would show positive emission savings. However, if the uncertainties are taken into account the results are not that obvious any more. The upward arrows in Figure 1 point to the 95 percentile limit, the downward arrows to the 5 percentile limit of the Monte Carlo simulation. Accordingly, the arrows represent the probability distribution of the model results within the 95% and 5% confidence intervals caused by the uncertainty range of key model parameters. If the full uncertainty range is taken into account, i.e. if there is a 95% probability that the biofuel would indeed provide emission savings, then only bioethanol derived from sugarcane or from wheat processed by efficient straw-fired combined heat and power (CHP) plants would pass the test. In contrast, biodiesel derived from palm processing without methane capture and ethanol derived from wheat processed in standard plants will most likely not contribute to climate change mitigation. For all other biofuel options, there is at least a possibility that their LUC emissions will be too large to maintain positive emission savings.

However, it needs to be emphasised that the numbers in Figure 1 represent the most conservative estimate of the emission savings. This is the case because the default values from the EU-RED are used. In reality, most processes have been improved over the last few years and now cause much lower emissions than the default values. Figure 2 combines information on the different process emissions with the LUC emissions from Laborde (2011). In contrast to Figure 1 which shows differences in emissions, Figure 2 shows the emissions of different biofuels in gCO2eq/MJ. The dark blue bars represent the default values for the WTW emissions from the EU-RED. As the default values are intentionally set at a high level in order to account for all, i.e. also the less efficient, production processes, we also include the typical values for the WTW emissions from the EU-RED with the lighter blue bars. Furthermore, where available, we show values for WTW emissions based on individual GHG calculations during the certification process by the biomass certification system ISCC (International Sustainability and Carbon Certification) which has been recognised by the EC for performing individual emission accounting to verify compliance with the sustainability criteria of the EU-RED. The grey bar represents the mean LUC emissions calculated by Laborde (2011) and the arrows point towards the 5% and 95% percentiles.



Source: Own computation based on Laborde 2011, EU-RED and ISCC

Figure 2 Well-to-Wheel GHG emissions including iLUC for different biofuel pathways

According to the latest developments in conversion technologies there are several biofuel pathways that will certainly have lower GHG emissions than fossil fuels (zero emission savings indicated by the blue line). Modern conversion plants for bioethanol based on wheat and sugar beet, and certainly sugarcane, have lower GHG emissions when compared to fossil gasoline. In the case of biodiesel, advanced conversion of palm with methane capture surely has lower emissions as well. However, even advanced conversion technologies for soy and rapeseed show a low but positive probability for higher GHG emissions than fossil fuels.

Given these uncertainties regarding the climate mitigation potential of different biofuel options that are related to a variation in actual GHG-emission values at the plant level but also to uncertain parameter values with which iLUC-emissions are modelled and calculated, it is clear that regulatory agencies would need to address iLUC. In the next section we discuss the proposal put forward by the European Commission in the light of these uncertainties.

5. Evaluating the EC's proposal to capture iLUC

Based on the classification of decision making under uncertainty as discussed by Di Lucia et al. (2012), the new proposal by the EC (EC 2014) includes a policy mix of preventive (support of non-land using biofuel option) and precautionary (limit production levels) policies. This was a reaction to the wide-spread critique that biofuels may not always lead to emission savings and that even the current MEST of 35% is seen as not being sufficiently high to control for the emissions from iLUC which are not included in the emission accounting currently.[11]

The decision on the suitable level of the MEST essentially depends on the degree of risk aversion of the society, simply because it boils down to the question with which probability society would accept a biofuel support policy that does not lead to emission savings. Figure 2 illustrates the impact of different MEST, where the blue and red horizontal lines indicate zero, 35% and 50% emissions savings. Thus, in figure 2, for complying with the current 35% MEST, the WtW emissions generated by a biofuel option (blue bars) have to remain below the horizontal line of 35% emission savings. For evaluating whether the biofuel option lead to emission savings all emissions (WtW and iLUC) need to remain below the zero emission saving line.

Suppose emissions of biofuels including iLUC as computed on behalf of the EC shall be lower than the fossil alternative and thus generate positive emission savings with a 95 percent confidence level. Then, according to the data illustrated in figure 2, only biodiesel from palm oil with methane capture and the conversion plant and bioethanol from sugarcane would compass positive emission savings if the typical values are taken. Biodiesel from sugar beet would barely compass such goal. If the ISCC values from advanced plants are taken, bioethanol from wheat would also create sufficient emission savings. If, on the other hand, society would be satisfied with the average values, both for the WtW and the calculated iLUC emissions, most biofuel options would generate positive emission savings,

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[11] We do not consider approaches dealing with good governance of local land use or other sustainability policies because, one, they are discussed in Miyake et al. (2012), Purkus et al. (2012) and Gawel and Ludwig (2011, p.852), and two, these studies conclude that "certification is not in a position to effectively compensate for shortcomings of public action".

with the exception of palm without methane capture and processes that emit according to the default values.

If we compare the current MEST of 35 percent (which is the relevant criterion for market access and which is only applied to the WtW emissions) to the computed emissions including iLUC there is not a high correlation between those biofuel options that pass the 35% MEST and those that show on average positive emission savings when iLUC emissions are considered. In fact, all biofuel options would pass the 35% MEST if typical instead of default values are taken for WtW emissions even though some options cause no positive emissions savings to a high degree of confidence The 50% MEST, on the other hand, would indeed make sure that only biofuels that generate positive emission savings whould pass the threshold given that society is willing to accept the average values of calculated iLUC emissions.

The results imply that if the MEST remained at the 35% level, based on figure 2, several biofuel options would meet the requirements pertaining to the 35% threshold despite causing more emissions than the FFA due to iLUC (e.g. some options of palm or rapeseed biodiesel). For details on this figure, see the Annex). Gawel and Ludwig (2012) refer to this as a type I error.

In contrast, increasing the MEST to, e.g. 50% may rule out some biofuel options even though they may not cause more emissions than the FFA. Gawel and Ludwig (2012) call the resulting risk of welfare losses due to no or to too little biofuel production a type II error. Both errors are caused by the large ranges in the confidence intervals of emissions from LUC as computed by Laborde (2011).

Of course, these results depend heavily on the modelling results of LUC-emissions induced by the expansion of biofuel feedstock production. As these results are generated by only one model and depend on a number of assumptions that must still be verified by empirical observations and by additional modelling exercises, there still exists considerable uncertainty regarding the robustness of the conclusions that can be drawn.

The proposal further suggests lowering the pressure on land by limiting the contribution of conventional biofuels to 7% by 2020. This implies that while no new installations can be constructed, already existing plants can produce such biofuels at a 35% MEST until 2017. As the EC states, this is a clear indication that capacities already in place can run for the lifetime for which they were initially constructed for, but new investments are deemed not profitable and not politically desired.

The current EU proposal also includes the double counting of second-generation biofuels, which are expected to have less land use impact. This means that the actual amount of biofuels in the market could be substantially lower than the counted amount of biofuels. It is questionable whether incentives set by the proposal are target-oriented (i.e., meeting the 10% target in 2020) as several biofuel options that would be double-counted have not achieved marketability and are not competitive. As biofuels are currently the major option for reducing emissions in the transport sector, double counting also lowers the potential reduction in emissions in the sector under the 10% target by 2020. Moreover, the MEST should already set incentives for second-generation biofuels if they indeed exhibit a lower emission balance than traditional biofuels.

Finally, the EC proposal contains the provision of reporting iLUC-emissions based on estimated iLUC-factors. These calculated iLUC-factors reported as crop-specific factors, suffer from considerable drawbacks. a) Current approaches that calculate crop-specific iLUC emission factors suffer from ambiguity and arbitrariness and presume linearity of all emissions from iLUC. b) Economic models are not able to differentiate between iLUC and dLUC. c) A general LUC emission factor that includes dLUC and iLUC eliminates the individual incentive for producers to reduce dLUC. Factors included in the proposal represent marginal LUC-emissions of different crops rather than the iLUC-emissions of a certain crop when markets clear simultaneously. The EC recognises and takes these problems into account by only requiring reporting. The option to introduce iLUC-factors into sustainability criteria is left open in the event that adjusted estimated iLUC-factors are available.

6. Conclusions and policy implications

In this article, we discuss the current EU policy proposal to reduce iLUC-emissions caused by the EU biofuel target. LUC can be quantified using economic simulation models, while a distinction in emissions from iLUC and dLUC is not possible. The currently available models still contain a high level of uncertainty with respect to key model parameters which determine the price, LUC and resulting emissions of biofuel policies. Consequently, the transfer of the results of the current models into iLUC-factors as part of the sustainability criteria is not possible.

In addition, we argue that it is inappropriate to calculate crop-specific emissions from iLUC. This is because calculating LUC-emissions for different crops suffers from methodological drawbacks, as price effects on demand and substitution of feedstuff are an aggregated effect. Accordingly, LUC-emissions cannot be attributed to single crops.

The uncertainty in quantifying iLUC-emissions also guides the evaluation of the policy proposals. Our discussion of the current EU policy proposal suggests that a combination of an increase in the MEST and a limitation of biofuel production is a safe way to ensure that the production of biofuels does not cause higher emissions compared to the fossil alternatives. However, welfare losses might result by ruling out biofuel options or by reducing the consumption of biofuels that could reduce emissions. Thus, the ”correct” level of the MEST is a question of readiness to assume the risk of ruling out certain biofuel options even though they would cause lower emissions than the FFA and the risk of including some biofuel options even though they would cause more emissions than the FFA.

The EU proposal currently focuses on reducing biofuel production from the first-generation, in general, by double counting second-generation biofuels and by limiting first-generation biofuels. We agree that a reduction in the overall amount of conventional biofuels reduces LUC and related emissions. However, double counting second-generation biofuels may not be target-oriented and may result in fewer reductions of the actual (not counted) emissions savings in the transport sector.

An important mechanism not captured by the EC policy options discussed in this article is the possibility to reduce the price effect by producing feedstock for biofuels more productively than the former production for the food and feed sector. This means, in practice, that iLUC is reduced or even eliminated if production of biofuel feedstock has a higher productivity than the former food or feed production process. First experiences from the certification scheme ISCC show that an increase in productivity is possible when the establishment of rules on good agricultural practices based on the requirements for achieving an EU-RED certificate serves as extension services[12].

Increases in productivity to reduce the price effect of biofuel policies should be a key element of the EU-RED iLUC regulations. A possible way of implementing this into the current iLUC proposal is to apply an iLUC-factor as a risk premium on all production on already existing cropland and to reduce or eliminate this factor when producers prove a certain degree of productivity increase in their production area.

Finally, the lessons learned regarding the interactions between productivity increases and land use impacts do not only apply to the biofuel sector but to all developments that increase the demand for agricultural products. This includes the increase in the global population, the increase in the demand for meat and milk products and the increase in the use of biomass in the industry. Increasing production on the currently used areas reduces the impact of these developments on prices for agricultural goods and, therefore, reduces the incentive to convert new areas for agricultural production. This, in turn, reduces LUC-emissions. Therefore, increasing productivity on already used areas should be a key component of all agricultural policies to reduce emissions from LUC.

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[12] Personal information of ISCC

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Appendix

The following key model parameters are addressed in the Monte Carlo simulation of Laborde (2011):

- A shift in the share of land expansions into primary forest, which modifies the emissions released by unit of exploited land expansion;
- A shift in intermediate demand price elasticity of agricultural inputs, indicating how easily the processing sector releases inputs after a biofuel demand shock;
- The ratio between the yield on new cropland and the average yield, which determines the productivity of the newly converted land compared to the already used land;
- The elasticity of substitution between land and other factors (factor intensification);
- The elasticity of substitution between key inputs (feedstuff and fertiliser) and land (input intensification);
- The elasticity of transformation of land and extension elasticity.

In the following, we explain and evaluate the 4 policy options presented in the EC´s “Report from the Commission on ILUC related to biofuels and bioliquids”.

Option A: Take no action for the time being but continue to monitor

To evaluate Option A and B it is necessary to compare various levels of the MEST. For this purpose we rely on the results of Figure 2.

Option A implies that the MEST will remain at the 35% level until 2017 and will then be increased to 50%. Based on figure 2, allowing the MEST to remain at the 35% level would not rule out or eliminate all biofuel options that cause more emissions than the FFA when possible emissions from ILUC are considered. Gawel and Ludwig (2012) call this a type I error. Only biofuels derived from sugar beet, sugarcane, and maize would cause lower emissions than the FFA, based on the sums of the biofuel emissions from the average iLUC and the WTW. According to this emission balance, biofuel derived from rapeseed would cause more emissions than the fossil fuel alternative; however, the 35% MEST would not rule out this option. In addition, if, to compute the sum of the biofuel emission balance, the typical values for WTW emissions from the EU-RED rather than the default values were used, the biofuels derived from palm processed without methane capture and from rapeseed, soy and wheat would meet the requirements for the MEST of 35% despite causing more emissions than the FFA due to LUC.

Option B: Increase the MEST for biofuels

Option B proposes that the MEST be increased to 60% for plants constructed after 2013 and to increase the MEST for plants constructed before 2014 to 50% in 2018.

Figure 2 illustrates that with the MEST at the 50%, the portfolio of eligible biofuel feedstocks is strongly reduced. Only bioethanol derived from sugar beet and sugarcane and from wheat processed by efficient straw-fired CHP plants would meet the requirements of an MEST of 50%. Biofuel from palm processed with methane capture would be the only eligible biodiesel option. According to the Laborde data, all of these options have a very low risk of causing excessive iLUC-emissions as their emission balance is below the blue zero emissions savings line.

However, an MEST of 50% may rule out some biofuel options even though they may not cause more emissions than the FFA. Gawel and Ludwig (2012) call the resulting risk of welfare losses due to no or too little biofuel production a type II error. Furthermore, they conclude that this requires further moderation in the use of biofuels as the approaches to calculate iLUC are either nonexistent or not sufficiently accurate. The error is caused by large confidence interval ranges with respect to emissions from LUC computed by Laborde (2011). The large ranges result from a high variance in the assumed distribution of the analyzed key model parameters.

Suppose the 5 percentile limit of the confidence interval of emissions from LUC is closest to the real iLUC emission. Then, only biofuel derived from wheat processed by inefficient plants and palm processed without methane capture would actually cause more emissions than the FFA. However, the 50% MEST would also rule out biofuels derived from soy and rapeseed.

These results illustrate the role of risk when specific levels of MEST are chosen. The 50% level essentially ensures that there is a high likelihood that biofuels that pass this threshold actually cause fewer emissions than the FFA, though a type II error may occur. The 35% level, to the contrary, may lead to a type I error. Therefore, the choice between the two options comes down to a choice between two errors, that of ruling out some biofuel options even though they would cause fewer emissions than the FFA and that of including some biofuel options even though they would cause more emissions than the FFA.

Despite the uncertainty, the advantage of option B is that it can be implemented easily and quickly within the current EU-RED because it builds on the sustainability regulation already in place, especially on the certification schemes approved by the EC. Schemes such as the ISCC provide a means to account for WTW emissions at the individual level, which could potentially reduce the amount of WTW emissions and thus bring the overall emissions balance in line with the 50% MEST.

Option C: Introduce additional sustainability requirements on certain categories of biofuels

Option C consists of introducing more sustainability criteria than currently implemented to the existing certification process and is divided into two options, C1 and C2. Under C1, EU member states and countries exporting to the EU must comply with requirements to reduce deforestation and must introduce measures to increase the availability of feedstocks in a sustainable manner. Under C2, EU member states and countries exporting to the EU must comply with requirements to produce biofuels through practices with minimal risk of causing GHG emissions from iLUC.

The problem with implementing more sustainability criteria is that certification schemes (usually at the firm/farm level) cannot take into account issues of larger scale. In other words, they cannot control for food security or indirect effects on deforestation (Delzeit et al. 2009). This is consistent with the definition of iLUC as a market effect from an aggregate demand shock for agricultural feedstock caused by biofuel policies. Because the effect is aggregated, a direct link from individual producers cannot be established (Turner et al. 2007).

Even more restrictive sustainability criteria might increase the share of iLUC in the LUC impact of biofuel policies. This is because sustainability criteria can only be applied to a particular biofuel production process that is subject to a certification process. The sustainability criteria currently applied have already resulted in the production of biofuel feedstocks predominantly on land already used to produce crops (Lange 2011). Additional sustainability criteria might increase the leakage from the green biofuels production chain to unregulated systems (Turner et al. 2007). Furthermore, Gawel and Ludwig (2011, p.849) conclude that this instrument "completely lacks practicability and cannot guarantee the absence of iLUC".

There is only one sustainability criterion that could influence the iLUC- emissions of the EU biofuel target, that is, only one that would allow biofuel feedstock production only on degraded land. However, there is no consensus about the location or the definition of degraded land. Hence, such a sustainability criterion cannot be implemented at this time. Furthermore, even if a workable definition of degraded land could be established, it is doubtful whether biofuel feedstock production on such land would be profitable.

Option D: Attribute a quantity of greenhouse gas emissions to biofuels that reflect the estimated indirect land use change impact

Under Option D, estimated iLUC-emission values are incorporated in the existing GHG methodology for biofuels, with the exception of non-land using biofuel options and production that causes dLUC. The mechanism used by this proposal is similar to the increase of the MEST. However, several problems must be resolved:

- Current models are not able to differentiate between iLUC and dLUC, i.e., they can only identify the combined effect of dLUC and iLUC.
- Current approaches that calculate crop-specific LUC emission factors suffer from ambiguity and arbitrariness. Modelling approaches can only identify the LUC effect for all crops together, while econometric and ad-hoc approaches are not considered to be appropriate approaches to calculate these factors (see section 4).
- A general LUC emission factor including dLUC and iLUC destroys the individual incentive for producers to reduce dLUC. Hence, without direct control of the producer´s land use for biofuel feedstock production, the direct incentive for a good agricultural practice would vanish.