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The GHG balance of biofuels taking into account land use change ☆

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ABSTRACT

The contribution of biofuels to the saving of greenhouse gas (GHG) emissions has recently been questioned because of emissions resulting from land use change (LUC) for bioenergy feedstock production. We investigate how the inclusion of the carbon effect of LUC into the carbon accounting framework, as scheduled by the European Commission, impacts on land use choices for an expanding biofuel feedstock production. We first illustrate the change in the carbon balances of various biofuels, using methodology and data from the IPCC Guidelines for National Greenhouse Gas Inventories. It becomes apparent that the conversion of natural land, apart from grassy savannahs, impedes meeting the EU's 35% minimum emissions reduction target for biofuels. We show that the current accounting method mainly promotes biofuel feedstock production on former cropland, thus increasing the competition between food and fuel production on the currently available cropland area. We further discuss whether it is profitable to use degraded land for commercial bioenergy production as requested by the European Commission to avoid undesirable LUC and conclude that the current regulation provides little incentive to use such land. The exclusive consideration of LUC for bioenergy production minimizes direct LUC at the expense of increasing indirect LUC.

1. Introduction

The expansion of biomass production for energy uses is seen as one of the strategies to replace fossil energy sources with non-fossil renewable sources. The European Union for example seeks to achieve a minimum target of 10% renewables in the transport sector by 2020. The contribution of bioenergy to the saving of greenhouse gas (GHG) emissions has recently been criticized because – according to previous practice – the inclusion of the carbon balance of land use change (LUC) has not been included in the GHG balances of bioenergy production. This approach has ignored the fact that, in the process of production, not only does the flow of GHGs in the production process need to be accounted for, but also the change in the stock of carbon contained in the land converted for feedstock production. This is of particular importance if land that has not been used before or has been subject to other uses such as forestry or as pasture comes into use for bioenergy production.

This practice often leads to an overestimation of the carbon mitigation potential of bioenergy considering that today, deforestation and forest degradation for agricultural expansion, conversion to pasture land, infrastructure development, destructive logging and fires cause nearly 20% of global GHG emissions (UN-REDD, 2009). This figure is greater than that of the entire global transportation sector and second only to that of the energy sector. In particular, Brazil and Indonesia show a correlation of large emissions from LUC – accounting for 61% of world CO_2 emissions from LUC (Le Quéré et al., 2009) – and of having the largest increase in the production of feedstocks for biofuels, which is second only to the USA. It is widely agreed that in order to keep climate change impacts within limits with which societies will be able to cope, greenhouse gas emissions need to decrease substantially. This cannot be achieved without reducing emissions from the land use sector (UN-REDD, 2009).

With the Renewable Energy Directive 2003 (RES-D, 2009), the European Comission (EC) put forward sustainability regulations in order to avoid undesirable LUC for the expansion of the bioenergy feedstock production area. The implications of this regulation framework for the dynamics of agricultural expansion, and therefore for the emissions caused by LUC, have so far not been analyzed. Several studies have been conducted, aiming to quantify the overall LUC impact and related emissions of various biofuel expansion scenarios, such as Searchinger et al. (2008), Fargione et al. (2008), Melillo et al. (2009) and Valin et al. (2009), e.g., but they do not account for the sustainability regulations set up in Europe or other world regions. Therefore they somehow model an "uncontrolled" expansion of the biofuel

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feedstock production which is precisely what the sustainability regulations aim to avoid. Other studies such as Hennenberg et al. (2009) or Fritsche and Wiegmann (2008) directly address the sustainability criteria in the RES-D, but mainly focus on public consulting for a better implementation of the RES-D into national law and into practice. Due to the fact that the EC's "Guidelines for the Calculation of Land Carbon Stocks" (referred to as EC Guidelines), a communication related to the sustainability criteria implemented by the RES-D, were only published recently, to our knowledge no other study exists that considers these additional regulations.

In this study we analyze the sustainability regulations set by the EC to account for LUC in the bioenergy production in detail. Our investigation focusses on how the regulation will effect land use decisions for the production of different biofuel feedstocks in different regions of the world. This is done with the intention of evaluating whether the sustainability criteria can effectively prevent emissions from LUC and the destruction of natural habits used for bioenergy feedstock production.

The paper is structured as follows. In Section 2 we first discuss the current political framework, in particular, we analyze the Renewable Energy Directive of the EC. In Section 3 we present the LUC emission calculation method on the basis of the IPCC Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines, 2006) and EC Guideline and draw first conclusions on how this method impacts on LUC choices for an expanding biofuel feedstock production. In a next step in Sections 4.1 and 4.2, we calculate concrete examples for LUC emissions and derive the consequences for the European biofuel policy and the various biofuel options. To evaluate the examples in terms of efficiency we compare the examples by their abatement cost in Section 4.3. Furthermore, in Section 4.4, we discuss the particular case of the conversion of degraded land for biofuel feedstock production in order to appraise the effect of the RES-D regulations upon the competition between food and fuel. Section 5 concludes and gives further recommendations for action.

2. European bioenergy policy and LUC regulations

2.1. Towards the Renewable Energy Directive

Since the beginning of the century, the European Union extended its efforts to increase the use of bioenergy within the Community, mainly with the goal of lowering its dependency on imported oil and reducing GHG emissions in order to tackle global warming. Biofuels receive particular attention within the European bioenergy policy due to the fact that, overall, one third of the European emissions are produced by traffic. Furthermore, in the transportation sector fossil fuels mainly need to be imported from outside the EU, whereas alternative energy sources such as wind or solar energy in the electricity sector were not commercially feasible for use in the transport sector. With the "Directive on the Promotion of the Use of Biofuels or Other Renewable Fuels in Transport" (Directive 2003/39 EC), the EC sets targets of a minimum proportion of 2% biofuels in 2005 and 5.75% in 2010, relative to the total final energy use in the transport sector (European Union (Directive 2003/30/EC, 2003).

In the meantime a discussion arose about the sustainability of global biofuel production. Particularly reports about high deforestation rates in the Amazon and in Southeast Asia, two regions with a large expansion of bioenergy production, aggravated concerns about the risks of biodiversity loss and food and water shortages arising from increasing biofuel production (Goldemberg and Guardabassi, 2009; Rathmann et al., 2010). In the same way the overall GHG reduction potential of biofuels was questioned when LUC emissions for biofuel production were taken into account (Fargione et al., 2008; Searchinger et al., 2008).

In January 2008 the EC presented a review of the 2003 biofuel directive, which was endorsed in December 2008 with the "Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources" 2008/0016 (COD) (referred to as RES-D in the following). It includes a range of sustainability requirements to prevent the promotion of environmentally harmful biofuels. Together with the so called "climate and energy package" it sets a minimum GHG reduction target of 20% (relative to 1990) and a share of 20% of renewable energy in the Community's total energy consumption by 2020.

2.2. Sustainability requirements in the RES-D

The RES-D contain sustainability requirements that mainly tackle the problem of increased bioenergy production potentially causing by the RES-D so called "undesirable" LUC. According to the RES-D "undesirable" LUC can be categorized as LUC for bioenergy crop production from:

- high-bio-diverse land and
- land with a high carbon stock.

The latter is necessary to guarantee that the European biofuel policy actually contributes to the European climate change mitigation strategy. However, since the carbon stock of different land types depends on various factors, the RES-D tries to avoid emissions from LUC for the bioenergy feedstock production through two channels:

- via a general exclusion of some land types from the suitable land type options for bioenergy production and
- via a minimum emissions reduction target.

Concerning the first channel, it is widely agreed that some land types are always carbon rich, such as wetlands, peatlands and continuously forested areas with a canopy cover higher than 30% and therefore, in the same way as high-bio-diverse land, are generally excluded from the suitable land type options for the bioenergy feedstock production (RES-D Art. 17(4)). This also applies to forests with a canopy cover of 10–30%, unless evidence is provided that their carbon stock is low enough to justify their conversion in accordance with the rules laid down in the RES-D (RES-D Art. 17(4)). These rules form part of the second channel:

For the feedstock production on every field, the emissions savings of the final biofuel or other bioliquid need to be at least 35%, considering the emissions caused in the whole value chain including LUC emissions (RES-D Art. 17(2)).[1] This implies that biofuel crops produced on land with a high carbon content before the conversion are less likely to achieve this target.

According to the RES-D, the method and data used for the calculation of emissions from LUC should be based on the IPCC Guidelines and should be easy to use in practice (RES-D Annex V C(10)). With the EC Guidelines the European Comission recently published a draft on guidelines for the calculation of land carbon stocks for the purpose of Annex V of the RES-D. We will discuss this method further in Section 3.

In general, the EC intents to promote the cultivation of crops on degraded land for bioenergy crop production. In other words, the conversion of degraded land into cropland is explicitly defined as a "desirable" LUC. The RES-D attributes a bonus of 29 g CO_2eq/MJ in the computation of the carbon balance, if evidence is provided that the land is significantly salinated or

[1] This threshold shall rise to 50% in 2017 and to 60% in 2018 for installations whose production will start from 2017 onwards (RES-D Art. 17(2)).