BIOFUELS: EFFECTS ON GLOBAL AGRICULTURAL PRICES AND CLIMATE CHANGE

HARALD GRETHE,
ANDRE DEPPERMANN,
SANDRA MARQUARDT

Institute of Agricultural Policy and Markets, Universität Hohenheim

HEINRICH
BÖLL
STIFTUNG

Oxfam
Deutschland

Im Auftrag und Herausgegeben von Oxfam Deutschland und der Heinrich-Böll-Stiftung

Die deutsche Zusammenfassung wurde mit finanzieller Unterstützung von BirdLife Europe, T&E, EEB und Packard erstellt. Die darin vertretenen Standpunkte geben die Ansicht der Autoren wieder und stellen in keiner Weise die offizielle Meinung der Unterstützer dar.

Dezember 2013

Biokraftstoffe: Auswirkungen auf globale Agrarpreise und Klimawandel

Deutsche Zusammenfassung der Studie „Biofuels: Effects on Global Agricultural Prices and Climate Change" von Harald Grethe, Andre Deppermann und Sandra Marquardt, Universität Hohenheim

Die starke politische Förderung von Biokraftstoffen der ersten Generation, d.h. Biodiesel aus pflanzlichen Ölen (Sonnenblumen-, Raps-, Soja- und Palmöl) und Bioethanol aus Zuckerpflanzen und Getreide, wird von zahlreichen wissenschaftlichen Gremien (z. B. Wissenschaftlicher Beirat Agrarpolitik beim BMELV 2007, WBGU 2008, Leopoldina 2012) vor allem aus zwei Gründen abgelehnt: 1) Dem signifikanten Beitrag zu steigenden Nahrungsmittelpreisen und 2) dem fragwürdigen Beitrag zum Klimaschutz aufgrund der indirekten Effekte auf die globale Landnutzung.

Die EU und die USA sind auf globaler Ebene die bedeutendsten Player, wenn es um die politische Förderung von Biokraftstoffen der ersten Generation geht. Diese Studie quantifiziert die Effekte der EU-Förderung von Biokraftstoffen auf die globalen Agrarpreise mithilfe von Simulationsrechnungen und analysiert ihre Klimaeffekte basierend auf einer Literaturauswertung. Im Folgenden werden die wichtigsten Ergebnisse zusammengefasst.

• Auswirkungen auf die globalen Agrarpreise und den EU-Außenhandel

- Die Abschaffung der politischen Förderung von Biokraftstoffen in der EU im Jahr 2020 würde voraussichtlich zu einem Rückgang der Nachfrage nach Biokraftstoffen aus Nahrungsmitteln von acht Prozent (unter den gegenwärtigen gesetzlichen Vorgaben) auf ein Prozent des gesamten Energieverbrauchs im Verkehrssektor führen. Dies würde eine ähnliche Änderung der Produktion von Biokraftstoffen verursachen. Es gäbe deutliche Auswirkungen auf die Agrarpreise und den Außenhandel der EU:
  - Die Weltmarktpreise für pflanzliche Öle lägen um 16 Prozent und für Ölsaaten um circa 10 Prozent niedriger.
  - Die Effekte fielen bei Zucker und Getreide geringer aus, weil die Bioethanolproduktion in der EU deutlich unter der Biodieselproduktion liegt, und die Nachfrage für diese Produkte für die Biokraftstoffproduktion in der EU einen deutlich geringeren Anteil am globalen Marktvolumen hat, als dies bei Ölsaaten der Fall ist. Der Weltmarktpreis für Zucker fiele um 3,4 Prozent, die Weltmarktpreise für Getreide im Durschnitt um 2,1 Prozent und der Weltmarktpreis für Weizen um ungefähr 4 Prozent.
  - Der globale Preisindex für alle Ackerprodukte (Zuckerpflanzen, Getreide, Ölsaaten, Kartoffeln) läge um 2,6 Prozent niedriger, wenn die EU-Förderung von Biokraftstoffen abgeschafft würde. Dies sind Effekte in einer beachtlichen Größenordnung, da es sich ja nur um isolierte Effekte eines einzigen Politikbereichs der EU handelt: Andere Bioenergie-Politiken der EU oder die Bioenergie-Politik anderer Länder sind nicht berücksichtigt.
  - Die Nettoimporte der EU von Biokraftstoffen und ihren Rohstoffen lägen um 17,9 MTOE (Millionen Tonnen Öläquivalent) niedriger als bei einer Beibehaltung der gegenwärtigen Förderung. Das entspräche dem 1,8 fachen des Outputs der gesamten deutschen Ackerfläche in Höhe von 11,8 Millionen Hektar. Im Vergleich: Die Biokraftstoff-Nachfrage läge um 21 MTOE niedriger. Daraus folgt: Wenn die EU an ihren Biokraftstoff-Zielen festhält, würden etwa 85 Prozent der politisch getriebenen EU-Nachfrage nach Biokraftstoffen in 2020 direkt oder indirekt über Importe abgedeckt.
  - Wenn die EU die politische Förderung von Biokraftstoffen beenden würde, sänken die Nettoimporte von Biokraftstoffen, Ölsaaten und pflanzlichen Ölen. Bei Getreide würde die EU vom Netto-Importeur zum Netto-Exporteur und bei Zucker käme es zu einem leichten Anstieg der Nettoexporte.
  - Es wird oft argumentiert, dass die Reduzierung der EU-Biokraftstoffproduktion höhere Eiweiß-Importe für Futtermittel mit sich bringen würde. Das ist wahr, wird aber durch gegenläufige Effekte mehr als kompensiert: Bei einer Abschaffung der politischen Förderung von Biokraftstoffen würden die Netto-Importe von Kleber und Ölkuchen für Futtermittel zwar um ungefähr drei Millionen Tonnen ansteigen, aber die Nettoimporte von Getreide würden um 24 Millionen Tonnen und die von Ölsaaten um sechs Millionen Tonnen sinken.

- Dieser Zusammenhang kann bereits heute beobachtet werden. Die deutschen und EU-Nettoimporte von Biokraftstoffen und ihren Rohstoffen entwickeln sich seit dem Jahr 2000 etwa entsprechend dem Anstieg der Biokraftstoff-Nachfrage: In Deutschland stiegen sie im Zeitraum 2000-2011 um 3,3 MTOE und in der EU um 9,5 MTOE.

• Die globalen Agrarpreise und die Ernährungssicherheit

- Eine geringere Nachfrage nach Biokraftstoffen in der EU führt zu niedrigeren Weltmarktpreisen und zu geringeren Ausgaben für Importe in Nahrungsmittel importierenden Ländern. Wenn die Preisänderungen in Regionen mit gefährdeter Ernährungssicherheit übertragen werden, was in vielen Ländern in erheblichem Maße der Fall ist, würde dies in den meisten Fällen die Ernährungssicherheit der Haushalte, die mehr Nahrungsmittel kaufen als verkaufen, verbessern.

• Biokraftstoffe und Klimawandel

- Die politische Förderung von Biokraftstoffen wird vor allem mit Klimaschutzzielen begründet. Allerdings basiert die angeblich positive Klimabilanz von Biokraftstoffen vor allem darauf, dass die aus der Verbrennung von Biokraftstoffen resultierenden Emissionen in „life cylce assessments" (LCA) nicht berücksichtigt werden. Sie gelten aufgrund der bei der Produktion von Biokraftstoff-Rohstoffen stattfindenden Absorption von Kohlenstoff als CO2-neutral. Dieses Bild ist allerdings verzerrt: Die indirekten Effekte, d.h. die Veränderung der Treibhausgasemissionen durch die Intensivierung der Landwirtschaft und die globalen Landnutzungsänderungen müssen ebenso berücksichtigt werden.

- Der genaue Umfang der indirekten Intensivierungs- und Landnutzungseffekte, die auf Biokraftstoff-Politiken zurückzuführen sind, kann nicht isoliert beobachtet werden. Er kann nur durch Simulationen mit biophysikalischen und ökonomischen Modellen abgeschätzt werden.
- Solche Modellanalysen sind komplex und mit Unsicherheiten behaftet. Das rechtfertigt jedoch nicht, die durch die Biokraftstoffnachfrage verursachten Landnutzungsänderungen und Intensivierungseffekte zu ignorieren. Stattdessen sollte die wissenschaftliche Praxis der Bewertung von Landnutzungs- und Intensivierungseffekten kontinuierlich verbessert werden.
- Die bestehenden Abschätzungen der indirekten Landnutzungseffekte der EU-Biokraftstoffnachfrage sind heterogen. Trotz dieser Unsicherheiten bewegen sie sich in einer Größenordnung, die die relativen Emissionsniveaus von verschiedenen Biokraftstoffen und ihren Rohstoffen ändern kann und ihre Förderung generell infrage stellt. Legt man den Durchschnitt aller in dieser Studie ausgewerteten Untersuchungen und Studien zugrunde, erfüllt keines der Biodiesel-Produktionsverfahren der ersten Generation die EU-Nachhaltigkeitsschwellenwerte, nämlich eine 35-prozentige Emissionsreduzierung bei bestehenden Anlagen vor und eine 50-prozentige Emissionsreduzierung bei Anlagen nach dem 1. Januar 2017. Biodiesel hat einen sehr hohen Anteil am gesamten Biokraftstoffverbrauch im EU-Verkehrssektor: 74 Prozent in 2010.
- Bei Bio-Ethanol aus Zucker und Getreide kann ein leichter Rückgang der Treibhausgasemissionen erreicht werden. Allerdings zu viel zu hohen Kosten pro Einheit vermiedenem Treibhausgas-Ausstoß: Die politische Förderung von Bioethanol ist nicht effizient. Es bestehen andere Möglichkeiten sowohl im Bereich der erneuerbaren Energien wie auch bei der Energieeinsparung, weitaus größere Treibhausgaseinsparungen zu den gleichen Kosten zu erreichen.

• Schlussfolgerungen

- Die politische Förderung von Biokraftstoffen in der EU verringert die globale Verfügbarkeit von Biomasse für andere Zwecke. Dabei fehlt ihr eine überzeugende Begründung: Sie ist keine effiziente, so überhaupt wirksame Klimaschutzpolitik.
- Die Abschaffung der politischen Förderung von Biokraftstoffen aus Nahrungsmitteln würde einen wichtigen Beitrag zur Entspannung der globalen Biomassebilanz darstellen. Andere wichtige Maßnahmen sind die Erhöhung der landwirtschaftlichen Produktivität, die Reduzierung von Nahrungsmittelabfällen und nachhaltigere Ernährungsstile mit einem geringeren Konsum von tierischen Produkten.
- Die Korrektur der fehlgeleiteten EU-Biokraftstoffpolitik ist längst überfällig. Die politische Förderung von flüssigen Biokraftstoffen der ersten Generation sollte in den nächsten Jahren auf eine transparente Art und Weise vollständig abgebaut werden.
- Der gegenwärtige Vorschlag für eine neue Biokraftstoff-Richtlinie der EU-Kommission ist ein Schritt in die richtige Richtung. Er greift allerdings zu kurz und ist der Gefahr ausgesetzt, von den Mitgliedstaaten unter dem Druck von landwirtschaftlichen Interessensgruppen und der Biokraftstoffindustrie verwässert zu werden.

CONTENTS

LIST OF ACRONYMS

AEZ	Agro-Ecological Zones
BTU	British Thermal Unit
CAPRI	Common Agricultural Policy Regionalised Impact Modelling System
CES	Constant Elasticity of Substitution
CH_4	Methane
CHP	Combined Heat and Power Plant
CO_2	Carbon Dioxide
DDGS	Dried Distillers Grains with Soluble
EP	European Parliament
EPA RFS II	US Environmental Protection Agency Renewable Fuel Standard II
ESIM	European Simulation Model
EU	European Union
FAOSTAT	Statistical Division of the Food and Agriculture Organisation
FAPRI-CARD	Food and Agricultural Policy Research Institute and Center for Agriculture and Rural Development Model
GE	General Equilibrium Model
GHG	Greenhouse Gas
GTAP-BIO	Global Trade Analysis Project Model (biofuel version)
IEA	International Energy Agency
IFPRI	International Food Policy Research Institute
IMF	International Monetary Fund
IMPACT	International Model for Policy Analysis of Agricultural Commodities and Trade
IPCC AFOLU	Intergovernmental Panel on Climate Change Agriculture, Forestry and Other Land Use Guideline
JRC-IE	Joint Research Center Institute for Energy
LCA	Life Cycle Assessment
LUC	Land Use Change
MIRAGE-BioF	Modelling International Relationships in Applied General Equilibrium for Biofuel Analysis
MJ	Megajoule
MTOE	Million Tons of Oil Equivalent
NGO	Non-Governmental Organization
NREAP	National Renewable Energy Action Plans
OECD	Organisation for Economic Cooperation and Development
PE	Partial Equilibrium Model
RED	Renewable Energy Directive (of the EU)
US	United States

ABSTRACT

Starting with the so-called food price crisis in 2007/2008, global agricultural prices have increased substantially. This constitutes a concern from a food security perspective, as most of the world's poor are net food buyers. Due to its contribution to high prices as well as a questionable contribution of biofuels to climate change mitigation, the high political support in the EU for so-called first generation biofuels, i. e. biodiesel from plant oils and bioethanol from sugar crops or cereals, has been criticised heavily by various scientific expert committees. The general consensus is that such support should be ended.

This study finds that EU biofuel policy results in 16% higher prices for plant oils, 10% higher prices for oilseeds and about 2.6% higher global crop prices on average. This is substantial, as it is the isolated effect of just one policy of the EU, not yet including other bioenergy policies or other countries, such as the USA. Furthermore, this study reviews the literature and concludes that supporting first generation biofuels is not an efficient, if at all effective climate policy. This is because of the significant effects of using biomass for biofuels: intensified global agriculture as well as conversions of non-agricultural land to agricultural use. The 2012 proposal for a new biofuel directive by the European Commission represents a move in the right direction, albeit much too hesitant. However, it is in danger of being watered down by Member States under the pressure of interest groups. While the quantification of the effects of biofuel support is surrounded by numerous uncertainties, these uncertainties do not justify ignoring land use change and the intensification impacts of biofuels. Instead of denying the existence of such effects due to their complexity, efforts should rather focus on continuously improving the validity of assessments of land use and the intensification implications of biofuels.

KEY RESULTS

1) Impact of EU Biofuel Support on Global Agricultural Prices and Trade
   - The abolishment of all political support for biofuels from crops in the EU by 2020 is likely to result in demand for biofuels from crops falling from 8% to 1% of total transport energy consumption, i. e. by 7 percentage points. Biofuel supply is likely to fall accordingly to slightly less than 1% of total transport energy consumption.
   - Were the EU to source 1% instead of 8% (as envisaged under current legislation) of its energy needs in transportation from first generation biofuels in the year 2020:
   - Global prices for plant oils would be 16% lower and the prices of inputs for plant oil production, i. e. oilseeds such as rapeseed and sunflower seed, would also decline significantly by almost 10%.
   - Due to lower EU production of bioethanol compared to biodiesel, coupled with a lower EU share in global cereal and sugar than in global oilseed markets, the effects on global prices for bioethanol feedstock are lower: The global sugar price would fall by 3.4%, global cereal prices would fall by 2.1% on average and global wheat prices would fall by about 4%.
   - The average crop price index in all countries other than the EU would fall by 2.6% if EU biofuel policies were to be abolished. This is substantial, as it is the isolated effect of just one policy within the EU, i. e. not yet including other bioenergy policies or those of other countries, such as the USA.
   - EU net imports of biofuels and biofuel feedstock would fall by 17.9 MTOE (million tons of oil equivalent), which is equivalent to 1.8 times the output of the total German crop area of 11.8 million ha. By comparison, biofuel demand would decline by 21.1 MTOE. In conclusion, if EU policy would stick to its current biofuels targets, about 85% of politically driven EU demand for biofuels in 2020 would directly or indirectly stem from imports.
   - For biofuels as well as for oilseeds and plant oils, net imports decline in case of abolishment of EU biofuel support. For cereals, the EU turns from a net importer to a net exporter and for sugar, EU net exports slightly increase.
   - The often used argument that the reduction of EU biofuel production would trigger higher protein imports for animal feed is true but rather insignificant compared to the reduced net imports of biofuels and biofuel feedstock: in case of the abolishment of biofuel support, net imports of gluten feed and oil cakes are simulated to increase by about 3 million tons, but cereal net imports would fall by 24 million tons and oilseed net imports would decline by 6 million tons.
   - A similar situation can already be observed today: Both EU and German net imports of biofuels and biofuels feedstock have developed in line with increasing biofuel demand since the year 2000. For example, German net imports of biofuels and crops used as biofuel feedstock increased by 3.3 MTOE between the years 2000 and 2011 and EU net imports of these products increased by 9.5 MTOE over the respective period.

2) Impacts of Global Agricultural Price Level on Food Security
   - Less demand for biofuels in the EU would lead to lower world market prices and lower import bills of net food importing countries. If prices are transmitted to regions with a high prevalence of undernourishment, this is likely to improve food security of net food buying households.
   - Improving the global availability of food, however, is only one means of decreasing hunger. The main condition for food security is the reduction of poverty.

3) Biofuels and Climate Change
   - Political support for biofuels in the EU is proclaimed to be motivated by climate change mitigation objectives. However, not including emissions from biofuel combustion, as biofuels are considered to be "carbon-neutral" in conventional in life cycle assessments (LCAs) due to the preceding absorption of carbon from the atmosphere caused by growing biofuel feedstock, means that the picture that is painted is incomplete. Instead, indirect effects such as GHG emissions resulting from an intensification of agriculture and global land use change need to be taken into account.
   - The exact extent of the effects of indirect intensification and land use change attributable to biofuel policies cannot be observed in isolation. It can only be estimated based on biophysical and economic modelling.
   - Such modelling is associated with complexities and uncertainties. This, however, does not justify ignoring land use change and the intensification impacts of biofuels. Instead of denying the existence of such effects, efforts should rather focus on continuously improving the validity of assessments of land use change and the intensification effects of biofuels.

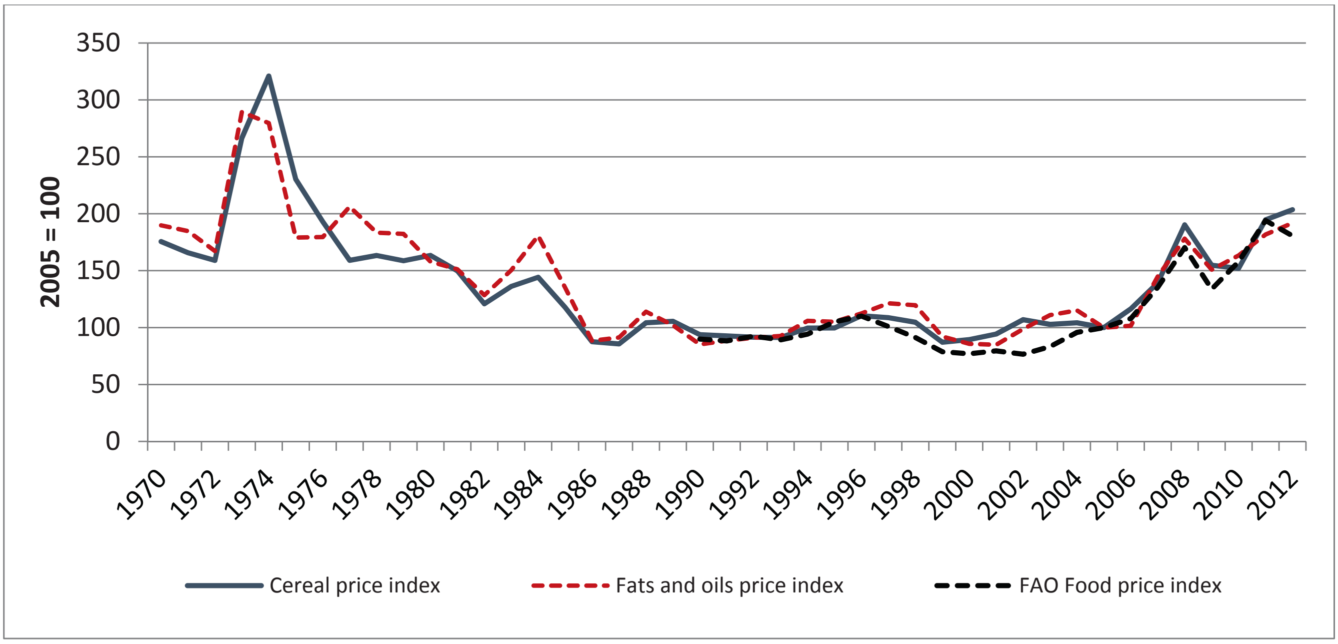
- Existing estimates of indirect effects display a substantial heterogeneity in GHG emissions. Yet, even given these uncertainties, indirect effects constitute a factor that alters the relative emission levels of different biofuel feedstocks. Based on the average of all simulation studies reviewed for this paper, none of the biodiesel feedstocks, corresponding to approximately 74% of biofuel consumption in EU road transport in 2010, would meet the sustainability thresholds of the EU directive (emission savings in existing installations 35% before and 50% after 01/2017). For bioethanol production from sugar and wheat, slight reductions in GHG emissions may be achieved. However, these reductions would be costly: political support for bioethanol from crops is not efficient. Other means of reducing GHG emissions allow for much greater reductions at the same economic cost.

4) Conclusions
   - EU biofuel support has a negative impact on the global availability of biomass and lacks any convincing motivation: it is not an efficient, if at all effective, climate change mitigation policy.
   - The abolishment of political support for biofuels produced from crops would be one important element in relaxing the global biomass balance. Other measures include the enhancement of agricultural productivity, the reduction of waste and more sustainable diets with low levels of animal protein.
   - The need to correct the European Union's misguided policy on biofuels is long overdue: political support for liquid biofuels gained from agricultural biomass should be phased out transparently over the next few years.
   - The current proposal for a new biofuel directive by the European Commission is a move in the right direction, though it is much too hesitant. However, it is in danger of being watered down by Member States under the pressure of interest groups.

1 INTRODUCTION

Following a global trend of declining real agricultural prices since the beginning of industrialisation and lasting until the end of the last century, the situation has substantially changed over the last decade. Starting with the so-called food price crisis in 2007/2008, global agricultural prices have increased substantially (Figure 1). This is due to various factors such as limited land and water resources as well as declining yield growth rates, growing human demand caused by population as well as income growth, growing demand for feed due to the share of animal products in diets increasing with rising incomes and new demand components such as the increasing demand for biomass for the production of energy and materials, often summarised under the term "bioeconomy".

Figure 1: Cereal Price Index, Fats and Oils Price Index and FAO Food Price Index 1970-2012 (2005 = 100, real prices)



Sources: World Bank (2013), FAOSTAT (2013), own calculations.

High agricultural prices are a concern from a food security perspective, as the largest share of the global poor and food insecure are net food consumers, i. e. their access to food deteriorates with high food prices. This situation needs to be addressed in various ways: by increasing incomes and providing better access to productive resources to the food insecure in order to enhance their purchasing power, as well as increasing agricultural productivity and ensuring a more sustainable use of biomass in order to mitigate the global price increase. A more sustainable use of biomass would entail reducing food waste, lowering meat consumption in industrialised countries and giving careful consideration to the benefits and costs of turning agricultural biomass into bioenergy and materials with a special focus on the competition with food use.

Especially the high political support for so-called first generation biofuels, i. e. biodiesel from plant oils (such as sunflower, rapeseed, soy, and palm oil) and bioethanol from sugar crops or cereals, has been criticised heavily by various scientific expert committees (Wissenschaftlicher Beirat Agrarpolitik beim BMELV 2007, WBGU 2008, Leopoldina 2012) for two reasons: i) the significant contribution of this political support to increasing global agricultural prices, ii) the questionable contribution of first generation biofuels to mitigating climate change due to the indirect effects on global land use.

The poor or even negative contribution of first generation biofuels to climate change mitigation has been the subject of heated debate: Compared to fossil fuels, biofuels reduce GHG emissions if one takes into account only the direct emissions of biofuel production based on a life cycle assessment, and if one does not consider tailpipe carbon emissions generated by biofuels because the combustion of biomass is assumed to be carbon-neutral due to the preceding absorption of carbon from the atmosphere during plant growth. However, the use of biomass in the production of biofuels additionally has indirect effects caused via the price effect:

1) Higher prices may cause land use change elsewhere, i. e. not at the location where biofuel inputs are produced. By way of example, converting rapeseed in the EU to rapeseed oil and to biodiesel could drive up the global price for vegetable oils and result in forests in South East Asia being converted into palm oil plantations. Such effects are called indirect land use change (iLUC).
2) In addition, global agricultural land use would intensify due to higher global prices.
   The intensification as well as the expansion of agricultural area is associated with an increase in GHG emissions and other potentially negative environmental effects, such as nutrient emissions to water bodies or reductions in biodiversity. This may substantially diminish the GHG reduction effect of biofuels and even result in a positive net contribution of biofuels towards GHG emissions compared to fossil fuels.

In political terms, the USA and the EU, as proponents of first generation biofuels, are the most important international players. This study has quantified the effect of EU political support for biofuels on the global price level of agricultural products and found it to be significant: EU policy in this field alone results in about 2.6% higher global crop prices. This is significant for two reasons: firstly, it is just one isolated policy by one group of countries, i. e. not yet including other bioenergy policies (e. g. for biogas), comparable policies of other countries (e. g. the USA), or other aspects of non-sustainable consumption (e. g. high food waste rates and diets containing high shares of animal products). Secondly, and in contrast to the proclaimed political motivation for supporting biofuels, their contribution to mitigating climate change is, if at all positive, very limited and far too expensive compared to alternative policies for greenhouse gas reductions. Thus, EU biofuel support has negative effects on the global availability of biomass and lacks any convincing motivation.

This study firstly addresses the effects of EU biofuel policy on global agricultural prices and secondly summarises the literature, clearly showing that supporting biofuels is not an efficient, if at all effective climate policy. Chapter 2 provides an insight into how EU biofuel policy, biofuel production and the current political debate have developed. Chapter 3 analyses the size of world market price effects caused by EU biofuel policies, based on simulations using the European Simulation Model (ESIM), which is a mathematical model of the world agricultural sector, and puts them in the context of the academic literature. Subsequently, Chapter 4 discusses the extent to which higher global agricultural prices impact global food security. The concept of iLUC, as well as the order of size of total LUC effects, are discussed and analysed in Chapter 5 based on a literature review. Finally, Chapter 6 concludes that a correction of the European Union's misguided policy on biofuels is long overdue: political support for liquid biofuels produced from crops should be phased out transparently in the medium term. The current proposal for a new biofuel directive by the European Commission is a move in the right direction, albeit much too hesitant and in danger of being watered down by Member States under the pressure of interest groups.

2 EU BIOFUEL POLICY AND BIOFUEL PRODUCTION

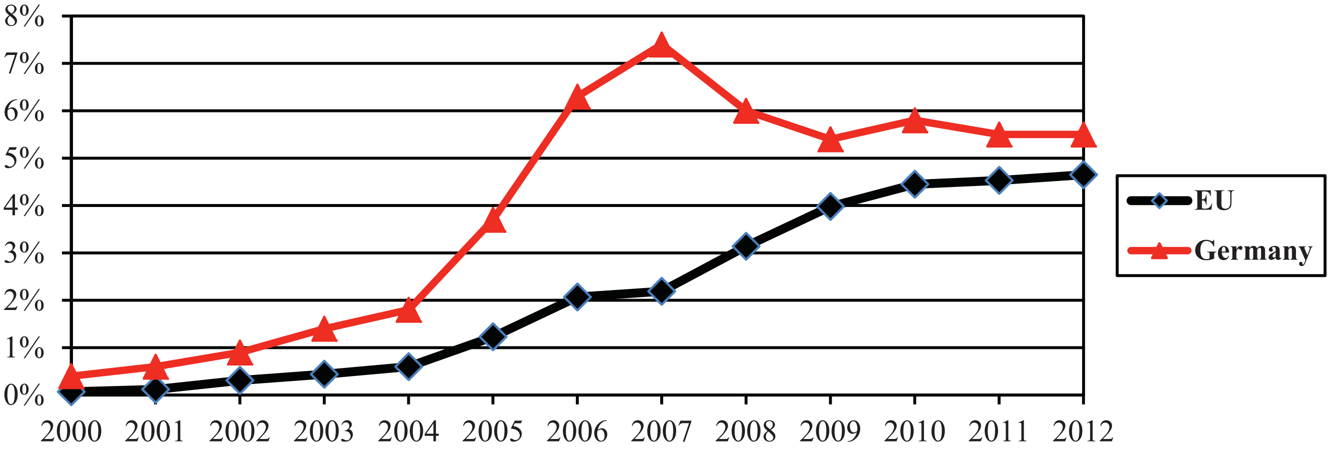
As concerns grow over climate change and the imminent depletion of non-renewable resources, different actors in society have placed increasing emphasis on the search for new, sustainable and renewable energy sources. As a result of this endeavor, the beginning of the 21st century saw EU policymakers focus increasingly on advancing liquid biofuels as an energy source for transportation. Besides, this was politically justified by the contribution they would make on energy supply security, technological development and job creation (e. g. European Commission 2012a, 98). In addition to the genuine motivation behind these objectives, biofuels also received broad-based support from the agricultural lobby as well as agricultural policymakers. This can be explained by the declining trend in global agricultural prices throughout the last century, along with the much-cited political responses and problems: particularly domestic price support policies resulting in excess supply, and subsequent supply management policies such as quota systems and obligatory set-aside, export subsidisation, large public stocks and the supported destruction of agricultural products. An additional outlet for agricultural products was, thus, highly welcome in order to stabilise prices and mitigate the need for supply limiting policies as well as the subsidisation of exports. In addition, liquid biofuels were supported by a fast-evolving biofuel industry.

Bolstered by EU as well as member state legislation (see Box 1), the share of biofuels in total transportation energy evolved steadily and reached 4.27 % (Figure 2) by 2010, resulting, in combination with renewable electricity (0.43%) in a 4.7% total share of renewables in transportation. However, for 2010, this share varied substantially between Member States, i. e. from 0% in Denmark and Estonia to 7.5% in Slovakia and with Germany being at 5.3% (ECOFYS 2012).

Box 1: EU Biofuel Policies (Mandatory Targets for all Member States)

	Current regulation (Renewable Energy Directive from June 2009)	**EU-Commission proposals of October 2012 (European Commission 2012b)**
Share of renewable in total transport energy by 2020	10%	10%
Of which, first generation biofuels	No limit	5% at maximum
Counting of second generation biofuels	Double counting for biofuels from lignocellulosic material and others	Double counting for biofuels from lignocellulosic material and others Fourfold counting for biofuels from algae, straw and other by-products
Sustainability criteria		
Minimum GHG savings relative to fossil fuels	Existing installations: 35% before and 50% after 01/2017 Installations in operation after 01/2017: 60% from 2018 on	Existing installations: 35% before and 50% after 12/2017 Installations built after 06/2014: 60%
Accounting for indirect land use change	None	Reporting, but not counting against emission reduction targets

Figure 2: EU and German Biofuel Demand (2000-2012, in % of total transport energy)



Sources: European Commission (2007a, 2007b), ECOFYS (2012), USDA (2011), BMU (2013).

Yet, while legislators in the EU, with broad-based lobby support, were focusing on increasing the use and production of biofuels, the economic and societal environment had fundamentally changed: due to a combination of agricultural policy reform and rising global agricultural prices, biomass has become scarce on EU markets as well. In addition, academia, NGOs, international organizations and the general media have increasingly questioned the true capacity of biofuels to be sustainable, climate- and people-friendly. As early as 2007, the OECD put forward a report summarising the carbon emission reduction costs calculated in other studies and showed that they were extremely high: 340 US$/t and more for biodiesel and 590 US$/t and more for bioethanol (Doornbosch and Steenblik 2007, 38) compared to less than 50 €/t for several other forms of bioenergy (Wissenschaftlicher Beirat beim BMELV 2007, WBGU 2008), such as biogas from manure or the direct combustion of lignocellulosic biomass. Shortly thereafter, first academic publications even questioned whether biofuels were contributing to GHG emission reductions at all (Searchinger et al. 2008) and reports from various organisations and advisory boards (Wissenschaftlicher Beirat beim BMELV 2007, WBGU 2008, Leopoldina 2012) consistently and uniformly recommended putting an end to the political support for demand and production of liquid biofuels from crops in the EU.

In spite of the evidence put forward against politically supporting first generation biofuels by a broad coalition of development as well as environmental NGOs, international organizations and academia, the direction followed by the EU biofuel policy seemed surprisingly unaffected until recently. In October 2012, the European Commission published a proposal for a Directive to amend the Renewable Energy Directive and the Fuel Quality Directive (European Commission 2012b), limiting biofuels from food crops to 5% of total transport fuels (Box 1). In addition, the proposal effectively reduces the current mandatory 10% target by 2020 through a system of double or fourfold counting of biofuels from feedstock that has a lower effect on land use such as waste or lignocellulosic materials. For example, the 10% renewable energy target could be met by producing 2.5% of total transport energy from organic waste, which counts fourfold. Furthermore, the proposed Directive introduces estimated iLUC emission values, which should be considered in reporting carbon emission savings to the European Commission, but which do not yet count against the emission reduction targets. Including iLUC values, however, even if solely for reporting purposes, would make transparent how little biofuels contribute to GHG emission reduction and how expensive support policies are relative to the small amount of GHG reductions. Thus, any plans for reporting are heavily opposed by biofuel supporters. Finally, the Commission proposes to anticipate the 60% minimum greenhouse gas emission saving requirement (relative to fossil fuels) for biofuels from new installations from January 2018 to July 2014. For existing installations, the saving requirement of 35% would be valid until 2017 and increase to 50% in 2018. Massive opposition against this proposal, which has the potential to become a landmark of biofuel policy change in the EU, has been formulated by the agricultural as well as the biofuel lobby, especially in Member States with currently high biofuel shares such as France and Germany. The French minister of agriculture recently favored a 7% limit for first generation biofuels (agri.eu 2013) whereas the German government initially supported the 5% limit for biofuels from crops suggested by the Commission proposal (Deutscher Bundestag 2013). The EU parliament adopted a legislative resolution on September 11, which is introduced to the European Council for further decision-making and suggests that the maximum limit for first generation biofuels should be 6% instead of 5% (European Parliament 2013, Amendment 152). Recent news on the discussion in the EU Council of environment ministers (EuropeanVoice, 2013) suggest, that the Commission's proposal may be watered down further substantially with the maximum for first generation biofuels being set at 7%.

The effectiveness of measures introduced in the legislative resolution adopted by the EU parliament in order to mitigate iLUC effects is to be determined by a report that the European Commission is to submit in 2017. This report should also give updated (i.e. based on available scientific evidence) suggestions on a possible incorporation of iLUC values into formal reporting requirements regarding biofuels' GHG emission reductions, which would then be applied from 2020 onwards (European Parliament 2013, Amendment 60).

3 THE IMPACT OF BIOFELS ON GLOBAL AGRICULTURAL PRICES

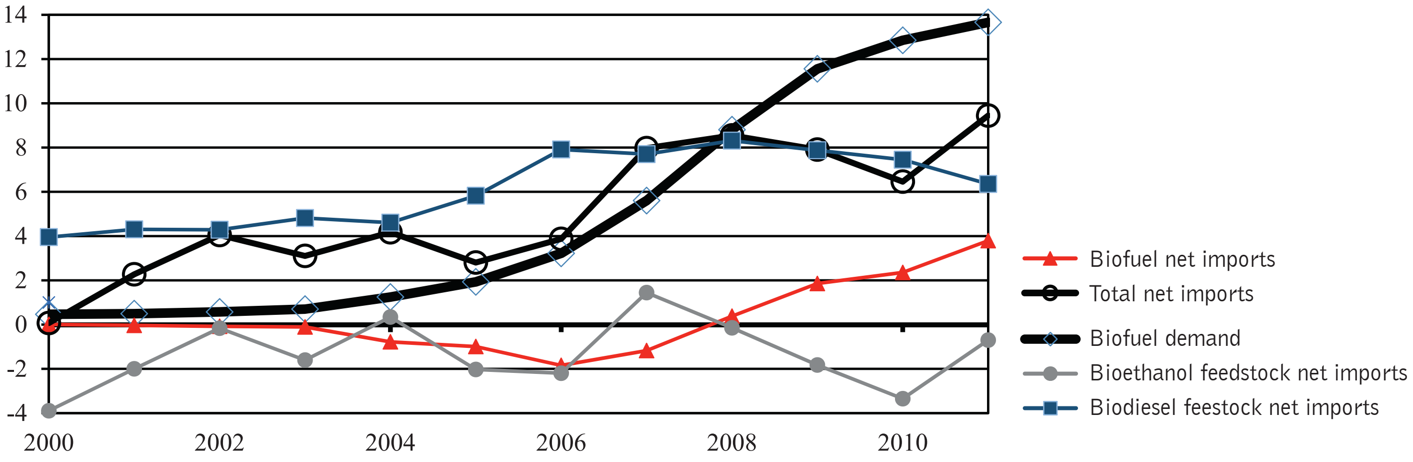
3.1 Introduction

Increasing demand for biomass for biofuel production results in higher domestic prices, higher EU imports and lower EU exports of biofuels, biofuel feedstock (agricultural products used for the production of biofuels such as cereals or oilseeds/vegetable oils) and potentially also other agricultural products. Such changes can already be observed in the EU (Figure 3) as well as the German (Figure 4) trade balance in the period 2000 to 2011. These figures depict:

- Total biofuel demand (biodiesel and bioethanol).
- Total biofuel net imports (imports minus exports; a negative number indicating a net export and a positive number indicating a net import situation).
- Net imports of biodiesel feedstock (oilseeds and vegetable oils).
- Net imports of bioethanol feedstock (cereals and sugar).
- Total net imports of biofuels and biofuel feedstock.

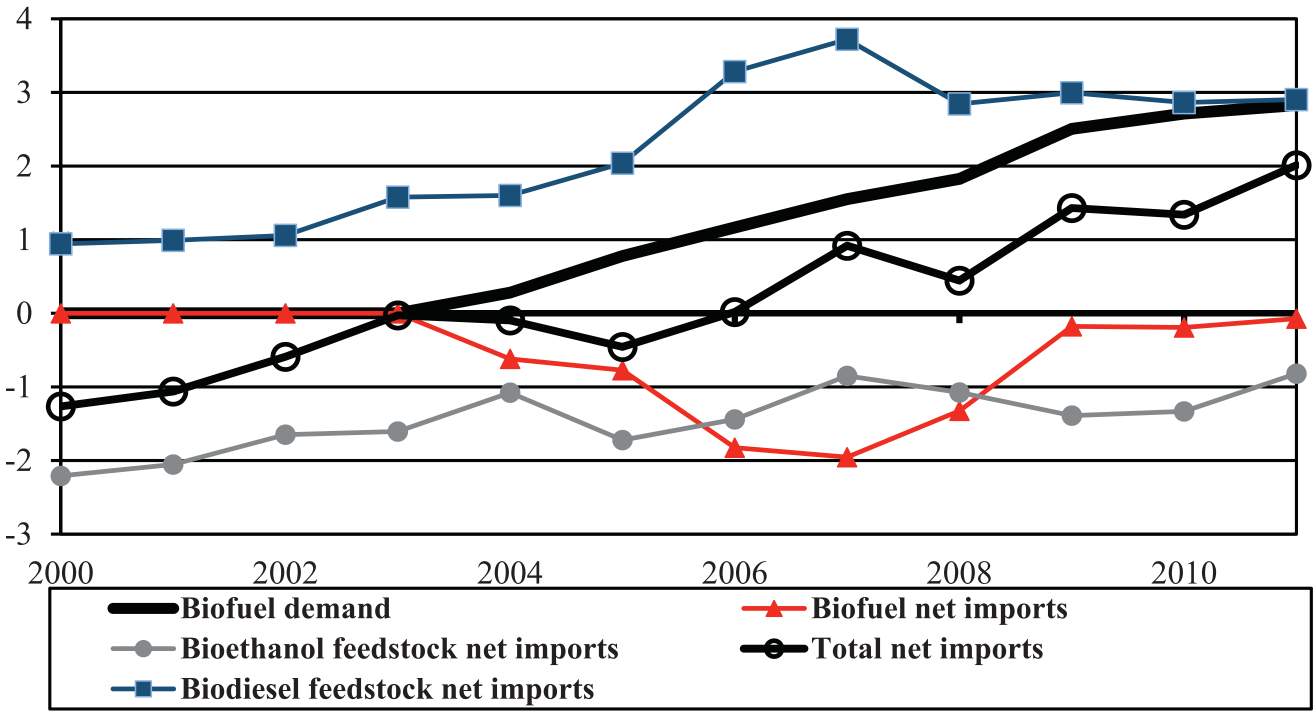
In order to be able to aggregate different products, such as rapeseed, palm oil and biodiesel, they are expressed in terms of their energy content, which is in Million Ton Oil Equivalent (MTOE). For example, one ton of rapeseed is equivalent to 0.29 ton oil equivalent. Total biofuel demand in the EU in 2011, which was at 14 MTOE, would thus equal about 48 million tons of rapeseed. Assuming an average EU rapeseed yield of about 2.9 ton/ha, this would be similar to a total area requirement of 17 million ha, or about 1.5 times the crop area of Germany. This simple calculation in itself shows that biofuels require significant agricultural area: Meeting the 10% renewables in transportation energy target, for example, solely with biodiesel from rapeseed, would require more than 100 million tons of rapeseed or about 20% of the total crop area of the EU. Covering all of our transport fuel demand from first generation biofuels would require a crop area twice as large as that of the EU.
Figures 3 and 4 show that EU and German net imports of biofuels and biofuel feedstock developed in line with increasing demand for biofuels: The increase of total biofuel demand in the EU between 2000 and 2011 by 13 MTOE is accompanied by an increase in total net imports of biofuels and biofuel feedstock of 9.5 MTOE. Expressed in rapeseed area at average EU yields, this increase in EU imports is roughly equivalent to the total crop area of Germany. These 9.5 MTOE are spread across various products: biofuel net imports increased by almost 4 MTOE, biodiesel feedstock net imports by 2.4 MTOE (oilseeds and vegetable oils) and bioethanol feedstock net imports by about 3 MTOE (cereals and sugar). For Germany, the increase in net imports of biofuels as well as biofuel feedstock between 2000 and 2011 accounted for about 3.2 MTOE and thus even exceeded the increase in biofuel demand of 2.8 MTOE. Increasing net imports contributed to increasing international prices (Figure 1), which were transmitted to other countries' domestic markets depending on their market integration.

Figure 3: EU Biofuel Demand and Net Imports of Biofuels and Biofuel Feedstock (2000-2011) (in MTOE)



Sources: EUROSTAT (2013), ECOFYS (2012), own calculations.

Figure 4: German Biofuel Demand and Net Imports of Biofuels and Biofuel Feedstock (2000-2011) (in MTOE)



Sources: EUROSTAT (2013), BMU (2013), own calculations.

However, the pure coincidence of increasing biofuel demand, increasing biomass imports and increasing international prices, though hinting at a potential interrelation, is not a proof of causality: Many supply and demand factors, as well as trade policies, contribute to changes in global prices and the contribution of biofuel demand to such changes cannot easily be isolated. Simulation models of the global agricultural sector are a widely applied method to analyse the impact of isolated shocks such as the increasing demand for biofuels. Therefore, Section 3.2 presents a simulation model analysis of the effect of EU biofuel policies on global agricultural prices prepared for this study, Section 3.3 puts these results into perspective and Section 3.4 presents the conclusions.

3.2 Simulation Model Analysis

3.2.1 Model Description and Scenarios

ESIM is a global, mathematical simulation model of agricultural production, consumption of agricultural products, and some simple processing activities. It is currently being developed and used at the University of Hohenheim and the European Commission. ESIM depicts the use of oilseeds for biodiesel production and cereals and sugar crops for bioethanol production in mathematical equations. It also accounts for the production, consumption and trade of biofuels as well as the production and feed use of by-products such as gluten feed in the case of corn and wheat and oilcakes in the case of biodiesel. ESIM has been used for academic papers as well as for policy support papers on bioenergy scenarios before (e.g. Banse and Grethe 2008; Deppermann et al. 2012, Fonseca et al. 2010). For a detailed description of ESIM see Grethe (2012).

To understand how a change in EU biofuel policy would impact world food prices we ran two scenarios. Firstly, a reference scenario "Ref" up to the year 2020, in which the EU is assumed to reach its renewable energy target of 10% in the transport sector. This scenario is based on population and income as well as technical progress projections, the assumption that certain policy changes which are very likely or already decided will be implemented (e.g. the abolishment of sugar and milk quotas) and on world market price projections as made by the OECD/FAO (2012). Consistently, the assumptions on the development of EU biofuel demand, supply and trade also follow OECD/FAO (2012):

- So-called first generation biofuels from oilseeds, cereals and sugar beet will account for 8% of total transportation energy of the EU in 2020. This includes the assumption, that the remaining 2% will be covered by renewable electro mobility (0.43% in 2010) and biofuels from waste and non-food lignocellulosic material (0.06% in 2010).
- About 87% of biodiesel and 91% of bioethanol use in the EU will be produced domestically in the EU in 2020 (this does not mean that biofuel feedstock such as vegetable oils and cereals is necessarily produced domestically), with the remainder being imported.
- The biodiesel/bioethanol ratio, measured in energy content, will be 66.5/33.5. This compares to a current (2010) ratio of 78/22 (ECOFYS 2012). We have thus replicated the substantial increase in the bioethanol share assumed in the OECD projections. IFPRI projections for 2020, in contrast, assume a more conservative decline in the biodiesel/bioethanol ratio to72/28 (Laborde and Valin 2012).

As the only change compared to the reference scenario, the second scenario "NoSup" assumes the abolishment of all political support for biofuels produced from crops in the EU. In consequence, we assume that demand for biofuels from crops will drop from 8% to 1% of total transport energy, i. e. by 7 percentage points and that biofuel supply will fall accordingly to slightly less than 1% of total transport energy. This includes a long-term adjustment and assumes, in accordance with market expert expectations, that biofuels from crops will not be economically viable except in some niche markets (1%) due to their production cost being substantially above the cost price of fossil fuels. In the short run, the adjustment process may be slower as investments in refineries have already been made and installations may be kept running as long as the variable costs are covered.

Under the "NoSup" scenario, the human demand for biofuels in countries other than the EU is assumed to remain constant compared to the reference scenario, i.e. lower biofuel demand in the EU will not, via falling international prices for biofuels, contribute to more biofuel demand in other countries. This is because many countries have defined quantitative targets for their biofuel demand, which results in non-price-responsive demand. Some countries, however, in which biofuel use is primarily market driven, such as Brazil, may extend their biofuel consumption whereas others, for which EU political action on biofuels may be a role model, may likewise reduce their supporting policies.

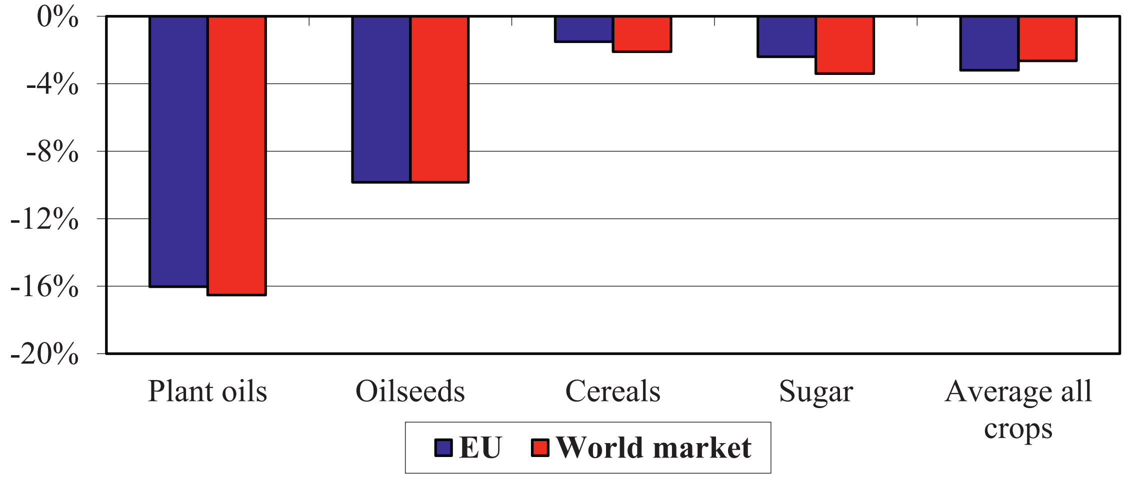
3.2.2 Results

The following sections compare the results of the "NoSup" to the reference scenario at the end point of the simulations, the year 2020. Developments between the model basis (2006/2008) and the year 2020 under the reference scenario are not discussed, as they are due to many causes, whereas we want to assess the impact of an isolated change in biofuel policies. Section 3.2.2.1 looks at the effect on global agricultural prices. Following this, the effects on EU supply, demand and trade for biofuels and biofuel feedstock are examined in Section 3.2.2.2.

3.2.2.1 Prices

Figure 5 shows price changes in % which would materialize if political support were to end (NoSup) compared to the reference scenario (Ref). These price changes, thus, directly reflect the EU sourcing 1% instead of 8% of its energy needs in transportation from first generation biofuels.

Figure 5: Price Changes under NoSup Relative to the Reference in 2020 (in %)



Source: Own calculations.

At around 16%, the most distinct decline in prices is for plant oils, as these are direct inputs for biodiesel production which is the dominant biofuel in the EU. Accordingly, prices for the inputs for plant oil production, i. e. oilseeds such as rapeseed and sunflower seed, also heavily decline by almost 10%. Due to a lower EU production of bioethanol compared to biodiesel and the EU having a much lower share in global cereal and sugar markets than in global oilseed markets, the effects on global prices for bioethanol feedstock are much lower. The global sugar price declines by 3.4% and global cereal prices (without rice) decline by 2.1%. The price of wheat, which is the main cereal input in bioethanol in the EU, drops by slightly more than 4%. The average crop price index (not including pasture and fodder, but including all cereals, oilseeds, potatoes and sugar crops) in all countries other than the EU declines by about 2.6% if EU biofuel policies were abolished.[1] Changes in the EU price are similar due to the fact, that the EU market is well integrated with the world market.

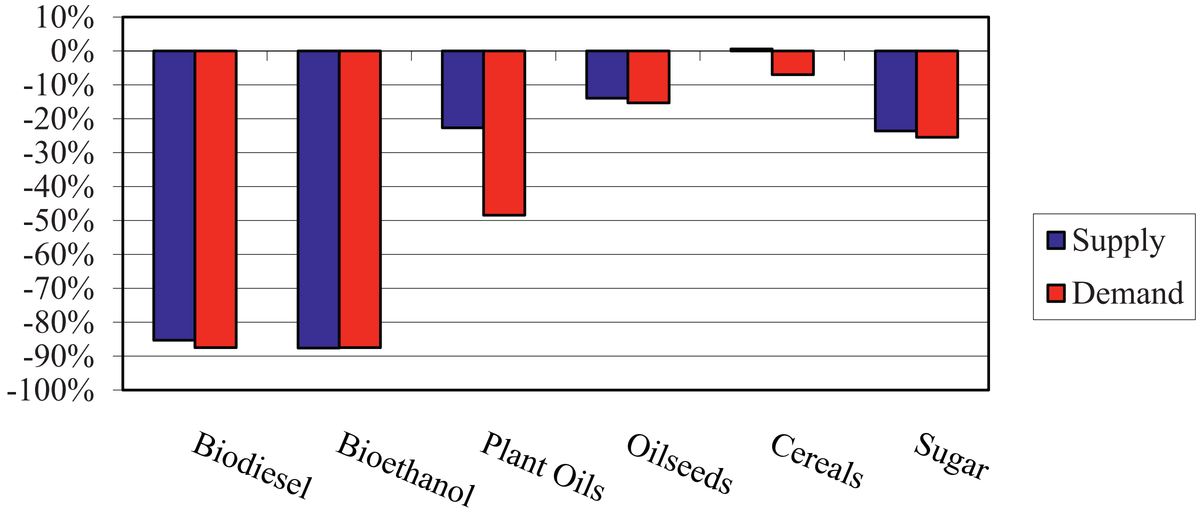
3.2.2.2 EU Agricultural Market Balances: Supply, Demand and Trade

Given that all other factors are equal, lower biofuel demand in the EU results in a lower total demand for biomass, falling biomass prices, and, in response to this, falling biomass production. The effects on EU supply and demand are depicted in Figure 6 as percentage changes under the "NoSup" scenario compared to the reference scenario. As determined by assumption (see Section 3.2.1 above), biodiesel and bioethanol use as well as production in the EU almost disappear completely. For all other products, demand declines substantially more than supply. As a result, abolishing EU biofuel support would result in fewer imports and more exports of biofuels and biofuel feedstock, as shown in Figure 7.

---

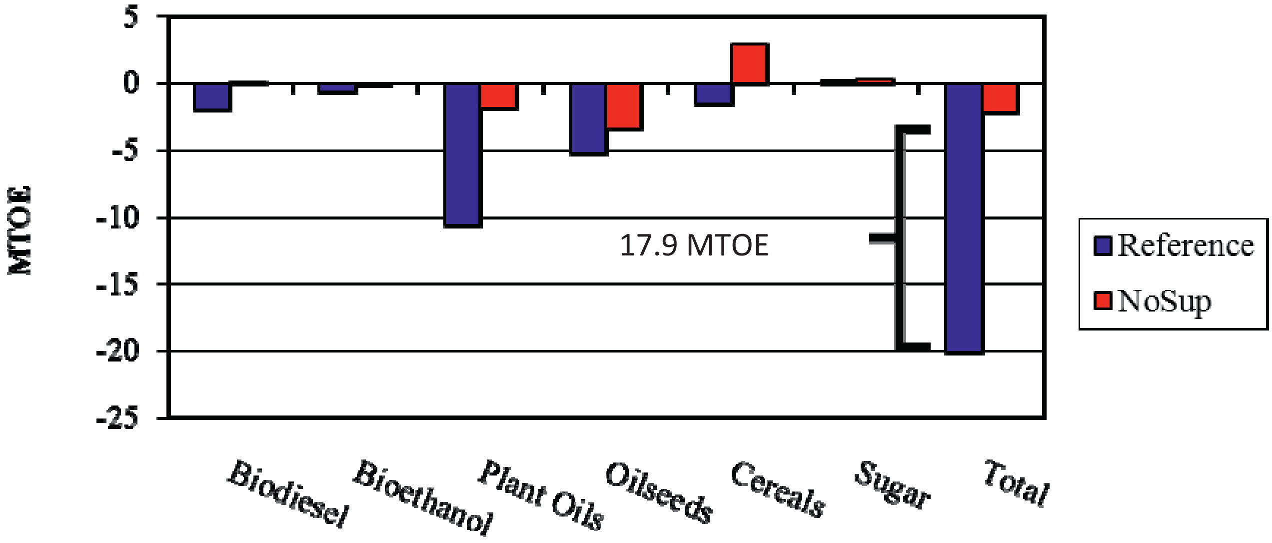
[1] In case that EU demand for biodiesel and bioethanol from crops would decline from 8% to 4.5% of biofuels in total transport energy, i. e. corresponding to half of the reduction simulated in this study, price effects would be approximately half as strong. Such a scenario would come close to the limitation of first generation biofuels to 5% as recently proposed by the European Commission.

Figure 6: Change in EU Supply and Demand under NoSup Relative to Ref in 2020 (in %)



Source: Own calculations.

Figure 7: EU Net Trade under NoSup and Reference in 2020 (in MTOE)



Source: Own calculations.

As can be seen in Figures 3 and 4, net trade (the sum of exports and imports) is aggregated in Million Tons Oil Equivalent (MTOE), in order to make different products comparable. Figure 7 shows EU net trade in MTOE, both in the reference and in the "NoSup" scenario. A negative number indicates, that EU imports exceed EU exports (the EU is a net importer) and a positive figure indicates that EU exports exceed EU imports (the EU is a net exporter). For biofuels, as well as for oilseeds and plant oils, net imports would decline if EU biofuel support were to be abolished. For cereals, the EU shifts from being a net importer to a net exporter, while for sugar, EU net exports slightly increase. The overall decline in EU net imports of biofuels and biofuel feedstock is 17.9 MTOE, which is equivalent to 1.8 times the output of the total German crop area of 11.8 million ha. This compares to a decline in biofuel demand of 21.1 MTOE. In conclusion, about 85% of politically driven EU demand for biofuels in 2020 in the reference scenario would directly or indirectly stem from imports, whether in the form of biofuels or biofuel feedstock.[2] This is fully plausible: if we substantially increase one demand component (biofuels), without significantly reducing another (feed, food) in a group of countries not having substantial area reserves and being open to trade (EU), the additional demand will mainly be satisfied by increasing imports/decreasing exports! For example, domestically produced rapeseed oil being used for biodiesel may be substituted by imported palm oil. The often-heard argument that reducing EU biofuel production would trigger higher protein imports for animal feed is true, but rather insignificant compared to the reduced net imports of biofuels and biofuel feedstock: if biofuel support were to be abolished, net imports of gluten feed and oil cakes are simulated to increase by about 3 million tons, but cereal net imports would fall by 24 million tons and oilseed net imports would decline by 6 million tons.

---

[2] The additional demand for biomass caused by biofuel demand in the EU mainly relying on non-EU feedstock is also found in other studies. For example, simulations based on the CAPRI model (Edwards et al. 2010, 80) find 70% of EU increased biomass demand caused by ethanol demand and 90% of EU increased demand for biomass due to biodiesel demand relying on imported fuels or imports of products used as biofuel feedstock.

3.3 Putting Results into Perspective

3.3.1 Land Use

The fall in agricultural prices results in declining land use for agriculture and less intensive production. This land might be left fallow, be afforested or used for nature reservation purposes. In the EU, the decline is simulated at about 0.6% or 0.9 million ha, roughly the agricultural area (crops and pasture) of Saxony. For non-EU countries, the simulation model used for this study only depicts agricultural production, but not agricultural land use. However, some side calculations can provide a rough estimate of what may be the effect on non-EU agricultural land use:

- Side calculation 1:
  - EU net imports of biomass, measured in MTOE, decline by 17.9 MTOE.
  - This energy content would be roughly equivalent to 30 million ha based on world average yields of rapeseed or wheat.
  - Part of this reduced EU import demand would result in a global extensification of agriculture and lower yields, part would result in higher demand for biomass elsewhere for animal feed as well as for human consumption due to lower prices and part of it would result in less agricultural area use. Assuming a 50/50 ratio of adjustments in supply and use and a 50/50 ratio of adjustments of yield and area in non-EU countries, the resulting area reduction would be 7.5 million ha, which is about 64% of the crop area of Germany.
- Side calculation 2:
  - ESIM simulations show a decline in crop production in non-EU countries of about 1.34% if biofuel support were to be abolished.
  - Assuming that this decline would be distributed at a ratio of 50/50 among declining yields and declining area, the decline in area would be 0.67%.
  - With a global non-EU arable area of 1289 million ha (FAOSTAT 2013), the non-EU area reduction would thus be 8.6 million ha.[3]

3.3.2 Comparison to Price Effects Simulated in other Studies

Fonseca et al. (2010) present the impact of the share of first generation biofuels in total transport fuels being only 3.4% instead of 7% in case of an EU policy abolishment based on simulations with the AGLINK-COSIMO model. This would result in vegetable oil prices dropping by about 16% and, counterintuitively, almost constant oilseed prices. The effect on cereal prices is reported to be very small (less than 2%). Edwards et al. (2010) report world market price effects of isolated small changes in biofuel demand in the EU. According to the simulations they ran with the AGLINK-COSIMO model, the shock simulated in this study (-14 MTOE of biodiesel and -7 MTOE of bioethanol) would result in a decline in the price of vegetable oils of 18% and of 2.6% for oilseeds. Assuming that all the ethanol were produced from wheat, the world market price for wheat would fall by 5.9% and the world market price for corn would fall by 0.5%. This would be equivalent to a price decline of 1.7% for total cereals, including rice. If all bioethanol were to be produced from wheat, the total global fall in crop area would be about 7.2 million ha.

Laborde and Valin (2012) simulate an EU demand shock of an additional 15.2 MTOE of first generation biofuels from crops (which is equivalent to about 72% of the shock applied in this study) and find an additional 2.4 million ha of land being used for pasture and cropland as well as an increase in average global prices of about 2% for cereals, 10% for sugar, 33% for plant oils and 25% for oilseeds. Laborde (2011) finds an increase in global cropland of 2 million ha under a similar scenario.

In conclusion, other studies also find the effects of EU biofuel policies on global cereal prices to be close to 2%. The effects on global vegetable oil prices simulated in this study of about 16% are in line with simulations with AGLINK-COSIMO, as reported in Edwards et al. (2010). Laborde and Valin (2012) as well as Fonseca et al. (2010) (if considering a shock of equal size), however, report price effects for vegetable oils which are about twice as high.

3.3.1 Recent Global Price Developments

Global cereal, as well as plant oil prices have doubled over the last decade (see Figure 1). Many factors have contributed to this development (HLPE 2013). They include increasing food and feed demand and the limited potential for further increases in agricultural area and yields as well as the increasing demand for bioenergy. More short-term factors, such as low stock to use ratios for major agricultural commodities and export restricting policies of many countries, contributed to price peaks in 2007/2008.

The simulations performed in this study show that, even today, EU biofuel policy significantly contributes to the high international price level for agricultural commodities and has the potential to do so even more in the future. Simulated price changes of 16% for plant oils, 10% for oilseeds and 2.1% for cereals may seem small at first sight. However, one has to take into account that these are long-term, persistent effects and that simulations only address liquid biofuel policies in the EU and not in other regions, such as the US. Furthermore, other forms of bioenergy such as biogas are not included. Therefore, the overall effects of bioenergy policies in industrialised countries may be several times higher than those reported here.

---

[3] This cannot be more than a very rough estimate as on the one hand, the crop aggregate in ESIM does not include all crops grown on the FAO aggregate arable area, and on the other hand, it includes some of the grassland, which is not contained in the FAO aggregate arable area. In conclusion, there are biases in both directions.

3.4 Conclusions

The abolishment of EU policies for liquid biofuels would result in an almost complete cutback in biofuel production from crops. This would have strong effects on global agricultural prices: prices for plant oils would fall by 16%, for oilseeds by 10%, for cereals on average by 2.1% and by about 4% for wheat. The average global price level for all crops would fall by 2.6%. These results are roughly in line with those from other simulation model based studies.

The resulting reduction in agricultural production would take place mainly in countries other than the EU: agricultural land use in the EU would be reduced by 1 million ha and by an estimated 8 million ha in the rest of the world. The EU trade balance would substantially change: EU net imports would decline by 17.7 MTOE, which equates to about 85% of the reduction in demand for biofuels and roughly 1.8 times Germany's crop area. When putting these results into perspective, one has to take into account that these are the effects of EU liquid biofuel policies alone. Adding the effects of biofuel policies in other regions such as the US and other bioenergy policies such as those for biogas in Germany, the effects on world market prices would be substantially higher.

In conclusion, the abolishment of political support for biofuels produced from crops would be one important element in relaxing the global biomass balance. Other measures include the enhancement of agricultural productivity (Wissenschaftlicher Beirat Agrarpolitik beim BMELV 2012), the reduction of waste (Grethe et al. 2011) and a focus on sustainable diets with a low level of animal protein (Cordts et al. 2013).

4 IMPACTS OF THE GLOBAL AGRICULTURAL PRICE LEVEL ON FOOD SECURITY

The impacts of biofuel demand on food security are complex and comprise several channels: effects resulting from higher biomass prices, effects resulting from direct competition for production resources such as land and water (for example through investments in large-scale biofuel production in developing countries), and effects resulting from the availability of energy to rural households in remote regions (HLPE 2013). The simulations carried out for this study and presented above focus on the effect of EU biofuel demand on global agricultural prices. Accordingly, this chapter discusses the effects of the global price level on food security and does not include other transmission channels from biofuel demand to food security.

The global agricultural price level indicates the global availability of biomass: When biomass is scarce, the global price level is high and when in abundant supply, the global price level is low. Figure 1 shows how global cereal as well as fat and oil price levels developed in real terms from 1970 to 2012. Two things can be observed: firstly, prices tend to be volatile in the short run, which is mainly due to changes in the weather, but also other variables such as macroeconomic shocks (e. g. the oil price crisis in the early seventies). Secondly, the global price level for cereals showed a declining trend until the early nineties, remained quite constant until 2005 and has been on the increase afterwards. Overall, the price level since 2007 has been about 50 - 100% higher than in the two preceding decades. The absolute number of undernourished has varied between 800 and 1000 million since the seventies without a clear trend.

Thus, global hunger persisted even in the period of low global food prices in the 1980s and 1990s. This reflects global food availability being just one factor among many in order to ensure food security. Undernourishment is not predominantly an issue of global food availability, but of access to food and in the overwhelming majority of cases, it is the economic access to food which stands in the way of food security: Poverty is the main reason for food insecurity.

Still, lower demand for biofuels in the EU leads to lower world market prices and reduces the import bill of net food importing countries. If lower prices are transmitted to regions with a high prevalence of undernourishment, the food status of net food buying households improves. Early FAO reports on the effects of the food price crisis in 2007/08 assumed that the number of undernourished had increased by 75 million due to soaring food prices (FAO 2008). More recent estimates, however, assume this number to be substantially lower and also stress the inadequateness of current FAO methodology to estimate the effects of short- to medium-term price shocks on undernourishment (FAO 2012, 10). Nevertheless, the principal argument remains: most of the poor and food insecure are net food consumers who benefit from low world market prices: their access to food improves. The effect is not only on the quantity of calorie consumption, but low prices also allow for more diverse diets resulting in less micronutrient deficiencies and often result in a more equitable intra-household distribution of food.[4] Still, the statement that lower world market prices caused by lesser EU biofuel demand would lead to a global decline in undernourishment is often confronted with several criticisms:

1. "The effect on world market prices is low". The average drop in cereal prices simulated in this study is 2.1%, and 16% for vegetable oils; other studies show similar orders of magnitude. This is substantial, as it is the isolated effect of just one policy of the EU, not yet including other bioenergy policies or policies of other countries, such as the USA. The isolated effect of this policy change on global undernourishment is indeed likely to be relatively low, but it is one element in relaxing the global biomass balance. Together with other countries such as the USA turning away from using crops for liquid fuels, and turning away from other policies using crops for bioenergy, e. g. biogas (Britz and Delzeit 2013), the effects would be substantially stronger.
2. "Global price changes may not be transmitted to domestic markets in developing countries". The relationship between international prices and prices at household level in food insecure regions is indeed a complex one (see Winters (2002) for a framework to analyse the linkages between international prices and poverty and Winters et al. (2004) for a summary of the empirical evidence). The degree of price transmission depends, among others, on the quality of infrastructure, applied policies and competition along the market chain. Especially in remote regions with poor infrastructure price transmission may not be perfect. But even if price transmission is imperfect: There is strong scientific evidence that in the long run at least substantial parts of global price changes are transmitted to developing country markets. Furthermore, even in the unlikely case of no price transmission at all (for example due to isolating market policies): especially the poorest among the developing countries (Least Developed Countries) are strong net importers of basic staple foods and therefore benefit from low global prices.[5]

---

[4] See FAO (2011) for a summary of the effect of global price levels on food security.

[5] Low price transmission may also reinforce negative effects of biofuel demand on food security if biofuel feedstock is grown within food insecure regions and is driving up prices there.

3. "Many of the poor are farmers and they would be negatively affected by low prices". Indeed, while net food purchasing households are affected in a positive manner by lower prices, net food selling households are negatively affected. But on a global scale the fast majority of poor households are net food buyers. Even the rural poor which includes landless households as well as subsistence farmers, are predominantly net-food buyers. This being said, there are exemptions among countries and regions (Ivanic and Martin 2006; Aksoy and Isik-Dikmelik 2008; FAO 2011 and the literature cited there).

   In conclusion, the global price effects resulting from biofuels are of significance for global food security: high food prices hurt the poor. But improving the global availability of food represents but one prerequisite for decreasing hunger. The main obstacle to achieving food security are the reduction of poverty and the improvement of access of the poor to production resources. A mix is needed comprising investments in rural infrastructure, agricultural research and public services and efforts to improve governance systems and institutions, which provide a favorable environment for agricultural production and allow markets to work within food insecure regions. Finally, efforts focusing on poverty reduction are most important, e. g. through the provision of access of the poor to education, land, water, employment, and other income sources as well as to public services such as social protection systems and medical care.

5 BIOFUELS AND CLIMATE CHANGE

5.1 Introduction

As shown above, the politically generated demand for biofuels results in a global intensification of agriculture and an increase in agricultural area. This may have various adverse environmental effects such as increased nitrogen emissions or a loss in biodiversity. In light of the political motivation for supporting biofuels, i. e. to mitigate greenhouse gas (GHG) emissions, it is especially the climate effects associated with an increased demand for biofuels which are important and controversially discussed. Two aspects cause special concern: first, a high share of first generation biofuels – i. e. biofuels from food- and feed-relevant crops – and second, an increasing biofuel demand from countries (e. g. Brazil, China, US) and regions (e. g. EU) that due to their size have a significant impact on world market developments. The concern associated with these two aspects is their potential to increase the amount of land area being converted to cropland - i. e. LUC – to meet growing biofuel demand. Such an agricultural area expansion is associated with negative climate impacts – e. g. conversion of high-value carbon areas such as forests. Since the climate-friendliness of biofuels is the key argument for political support, legislators are under increasing pressure to consider the full climate impact of biofuel production, especially GHG emissions associated with direct and indirect land use change (dLUC and iLUC), respectively.

To assess GHG emission implications of using biofuels versus the use of conventional fossil fuels (diesel and gasoline), life cycle assessments (LCAs)[6] are conducted to determine net GHG emissions of biofuel expressed in grams of CO_2 equivalent per megajoule (MJ) of fuel. Under an attributional LCA approach covering all products, emissions from all sectors would add up to total economy-wide emissions. If no consideration were given to iLUC emissions or emissions from the intensification of existing land use, this type of assessment would assign biofuels substantially lower GHG emission values compared to fossil fuels, i. e. portray biofuels as being more climate-friendly and thus complying with the EU Renewable Energy Directive's (RED) thresholds for emission savings compared to fossil fuels[7]. This results from the circumstance that emissions from biofuel combustion are not accounted for, as they are considered to be "carbon neutral" due to the preceding absorption of carbon from the atmosphere during plant growth of the biofuel feedstock. This approach would be correct if biofuels would be produced purely from "additional biomass", i. e. biomass that otherwise would not be grown, and without any change in the soil carbon stock. Since this is rarely the case, the purely attributional LCA approach applied in the RED is incomplete and should be supplemented by taking indirect effects into account such as the intensification of agriculture on existing agricultural land as well as iLUC.

The measurement of LUC effects in general, and iLUC effects in particular includes various uncertainties which makes their inclusion into EU legislation, as described in Section 2 above, a challenge. These uncertainties are analysed in this section which starts by defining direct and indirect LUC, followed by a literature review of different approaches and challenges that are associated with measuring iLUC. This encompasses key findings from different studies on this subject including an evaluation of employed models and their results. Studies reviewed are Searchinger et al. (2008), Al-Riffai et al. (2010), Edwards et al. (2010) and Laborde (2011).

---

[6] An LCA "links the various steps of producing the biofuel feedstock, its transport and conversion into the final liquid product with auxiliary inputs such as fertilizer, diesel fuel, process heat and electricity, and also factors in possible co- and by-products (e. g. animal feed)" (Fritsche and Wiegmann 2011, 55).

[7] For example, wheat-based bioethanol is currently (based on RED) associated with net GHG-emissions amounting to 39.39 gCO2eq/MJ and conventional gasoline with emissions of 83.8 gCO2eq/MJ. Therefore the use of bioethanol would be associated with 53% fewer emissions than gasoline. If consideration of iLUC results in a higher net emission value of bioethanol, these emission savings will be lower and may no longer be able to meet the reduction thresholds as defined in Article 17, i. e. biofuels need to currently satisfy a 35-percent reduction threshold of emissions and, as of 2017, this threshold will shift to a 50-percent reduction of emissions (European Commission 2009, 36).

5.2 Land Use Change Impacts of Biofuels – a Definition

Land use change in general refers to the alteration of the main use of a piece of land – this might be planting corn instead of wheat, turning pasture into cropland or turning forest into pasture. While such changes can have numerous economic, environmental and social consequences, the concept of land use change – when applied to biofuels - is concerned with implications for GHG emissions and carbon stock alterations that can be associated with such a change. If biofuel feedstocks are planted in areas which were previously occupied by e. g. forest or grassland, then this land conversion will have direct implications on GHG emissions by releasing carbon that has been stored in the vegetation and soils of these forests and grasslands (Searchinger 2010, 1). This is referred to as direct land use change (dLUC) effect.

More complex is the definition of indirect land use change (iLUC) effects. As defined in Searchinger (2010), iLUC "(...) occurs when dedicating existing agricultural land to biofuels triggers market forces that lead to land conversion elsewhere to replace food (and feed) (...)" (1). Thus, if e. g. EU farmers increasingly plant rapeseed for biofuel production instead of for food consumption, this land use change would lead to world market prices increasing for rapeseed oil and also for other plant oils which are close substitutes. This in turn makes it attractive for producers in e. g. Indonesia to expand their production of palm oil. While this may seem a straightforward chain of events, one needs to consider that Indonesian producers (to stay with the example) can respond to these market conditions in different ways. These potential reactions in turn are associated with different levels of GHG emissions.

The following three reactions may occur and in reality a mix of these three would likely be observed (adapted from Searchinger (2010, 2)):

1. Non-replacement (consumption deficit, no iLUC) – Indonesian palm oil production is unable (due to e. g. technical constraints, lacking infrastructure) to contribute to a replacement of lost vegetable oil supply on domestic and world food markets. This results in
   - reduced human consumption due to higher prices,
   - fewer GHG emissions due to lower carbon metabolism.
2. Crop replacement (intensification of agricultural production, sometimes referred to as "intensification iLUC" (e. g. Bertzky et al. 2011)): Indonesian production is intensified, i. e. higher yields per unit of land are realised on existing agricultural land. This results in
   - more carbon sequestration per unit of land due to a higher plant growth of oil palms,
   - higher GHG emissions due to e. g. intensified fertiliser application.
3. Land replacement (land area expansion; iLUC in the narrow sense, sometimes referred to as "conversion iLUC" (e. g. Bertzky et al. 2011)): Indonesian farmers are able to replace lost vegetable oil supply by expanding land area under cultivation, e. g. by converting forest, pasture, grassland or fallow land into cropland. This results in
   - GHG emissions from land clearing, a potential loss of soil carbon, foregone future carbon sequestration,
   - carbon sequestration from newly planted oil palms.

The first case represents a situation in which GHG emissions are reduced, but in the light of a relatively inelastic demand for basic food products it is unlikely to constitute the dominant share of total adaptations. Furthermore, this effect is not desirable for large parts of the global population with a low income. The net GHG emission effects of the subsequent two cases further depend on a variety of situation-specific factors, e. g. emissions associated with employed technology for intensification and characteristics of cleared vegetation and soil.

The interdependences of the many indirect effects caused by biofuel demand and the uncertainties involved in their measurement make the quantification of iLUC effects and the assignment of appropriate emission coefficients difficult.

5.3 The Challenge of Measuring iLUC

The challenge of capturing iLUC and intensification effects lies in the fact that they cannot be observed in an isolated way as they occur together with many other changes in complex biophysical and socioeconomic systems. This implies that they can only be estimated based on biophysical and economic modelling, which allows for isolating land use change and intensification effects caused by one single demand component such as the EU's biofuel feedstock demand. In other words: Although land use change can be observed and measured e. g. by using satellite imagery, the difficulty lies in determining which fraction of total land use change can and should reasonably be attributed to the use of biofuels in the EU.

This circumstance has resulted in numerous different modelling approaches with different values associated to iLUC. It is because of these differences and the related uncertainties, and also due to intensive lobbying activities, that policy-making has, to date, struggled to include iLUC implications into legislation.

The difficulty of quantifying iLUC becomes apparent when looking into the different parameters and data sources that are needed to capture this effect and to translate it into an emission value expressed in gCO_2eq/MJ of fuel. Table 1 illustrates this point by describing the individual steps in the assessment of indirect land use change emissions (adapted from Fritsche and Wiegmann (2011, 14, 54) and Broch et al. (2013, 3).

Table 1: Steps Involved in an iLUC Assessment

Step	**Data required for the assessment**	**Key parameters that influence data values associated with individual steps**
Additional biofuel and biofuel feedstock demand (triggers market responses)	Changes in production, trade, consumption of food and feed Unit: tons/year per country	• Choice of agro-economic model • Fuel type (biodiesel or bioethanol) • Biofuel technology pathway (first, second or third generation biofuels)
Additional area demand (e. g. for food and feed displacement)	Unit: ha/year per country	• Yield assumptions • Intensification/land expansion possibilities • Crop substitution possibilities • Usability of biofuel crop by-products (e. g. to replace crops used for feed)
Land use change emissions on newly cultivated land	Based on I. Carbon values of displaced vegetation type (e. g. grassland, forest, pasture) II. Soil carbon stock (changes) III. Forgone carbon sequestration IV. Carbon values of new vegetation Calculation: I + II + III - IV Unit: kg GHG/(ha and year)	• Land type classification • Land use (previous, current) • Regional allocation (implications for yield potential, carbon stocks) • Database of carbon values, CO_2-equivalents • Choice of time horizon for annualisation of emissions
Emissions per unit biofuel	Unit: g CO_2eq/ MJ	• Yield (tons per ha) • Crop energy yield (MJ per ton) • Potential carbon sequestration of biofuel crop

As indicated by the listed key parameters, the result of such an iLUC assessment greatly depends on different model specifications and assumptions (e. g. which model is used, at what rate individual crops can be substituted in these models etc.); assumptions on biophysical characteristics such as yield development and land types; and issues of data availability and complexity. These components are often assessed by different scientific disciplines and thus studies face the challenge of coupling the different model components in a meaningful way (Fritsche and Wiegmann 2011).

As a result of these complexities and uncertainties, even though the studies in this literature review generally refer to the same definition of iLUC they arrive at different results when it comes to quantifying this phenomenon based on simulation models because of the plentiful choices of model parameters, underlying assumptions and the use of different data sources.

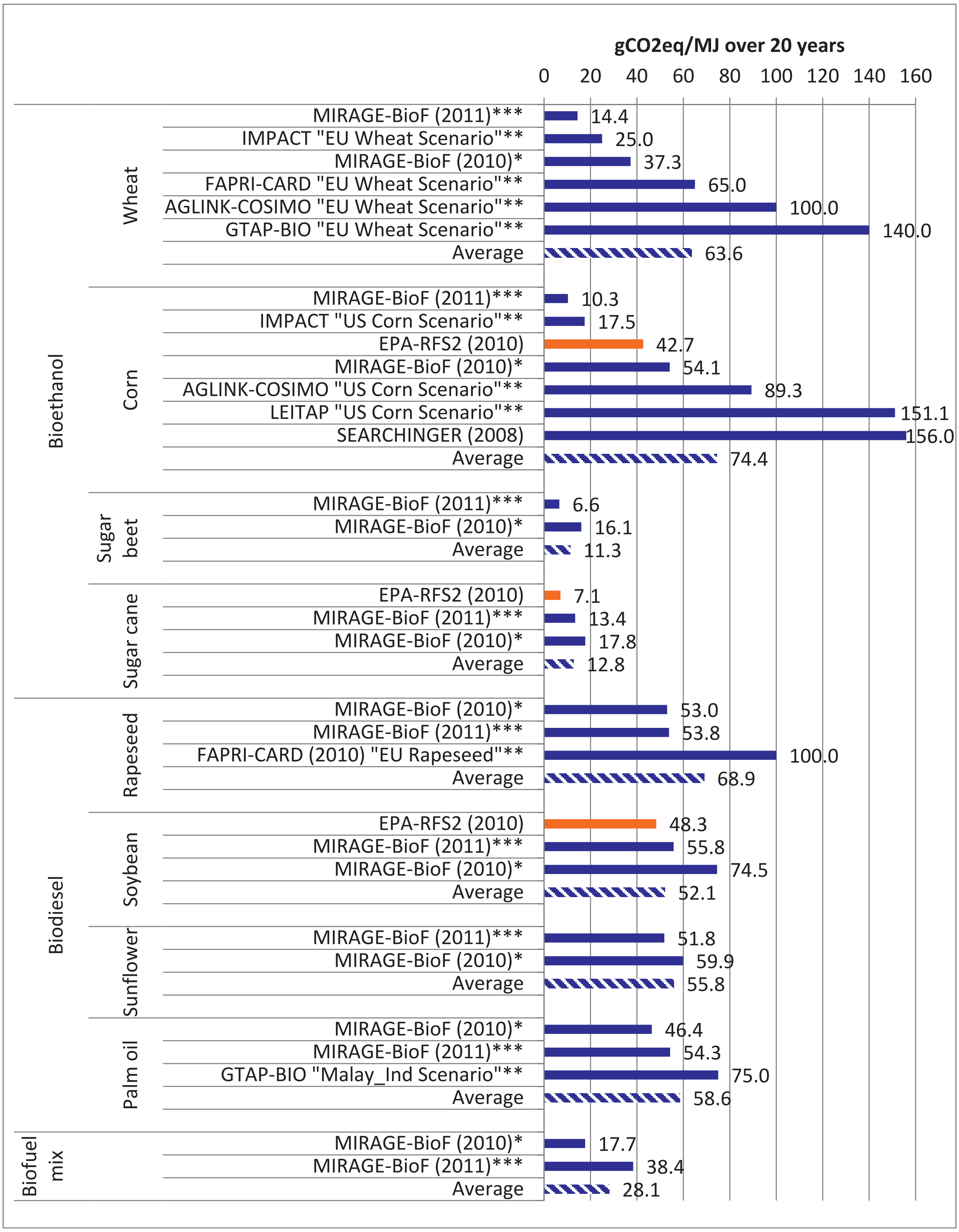
Furthermore, it must be noted that current studies focus on capturing net LUC. They assess the overall change in cropland and cropland use and thus derive a value for cropland expansion relative to a baseline scenario, but they cannot differentiate between the uses of crops planted on single units of these lands. This is associated with issues of data availability and the limited ability of models to trace individual units of agricultural production (Laborde 2011, 21). Laborde and Valin (2012) argue in this respect that when one uses "(...) a global model where all markets are cleared simultaneously (this) does not allow computing the 'indirect land use' effect of a policy versus a 'direct' effect. If this discrimination can make sense in a causal analysis or in a policy debate, it is purely artificial in a general equilibrium perspective (...)" (2). For this reason, the subsequent results-section will refer solely to LUC and not iLUC.

5.4 Empirical Results from LUC-Quantification

As previously stated, the studies in this literature review are only able to assess net LUC. Thus, even though some authors use the terms iLUC and LUC interchangeably, this results-section will refer to LUC to clarify that the model-based values are unable to satisfy the iLUC definition given in section 5.2. Furthermore, none of the reviewed studies consider the additional GHG emissions resulting from the intensification of agriculture, such as the increased emissions of nitrous-oxide due to higher fertiliser use. This leads to a bias of underestimating the indirect effects of biofuel demand on GHG emissions.

Figure 8 gives an overview of the results obtained for LUC-emission coefficients differentiated according to biofuel type and biofuel feedstock calculated by the four different studies. The aim of deriving such coefficients with values expressed in grams of CO_2eq per MJ of biofuel is that they can then supplement traditional LCAs, i. e. be included in the general assessment methodology of biofuels' GHG emission performance. The LUC emission values represent annual emissions over a 20-year timeframe with the choice of timeframe being based on current values in legislation (EU uses 20, US 30 years). For comparison, Figure 8 also includes relevant emission coefficients as included in US legislation (EPA-RFS2). Finally, for each of the biofuel feedstock categories an average over all studies has been calculated.

Figure 8: Overview of LUC-Emission Coefficients



*Al-Riffai et al. (2010), **Edwards et al. (2010), ***Laborde (2011)

Note: For Searchinger et al. (2008), original values are reported for a 30-year time horizon and have been adapted by the authors to a 20-year time horizon. For EPA (2010), original values are reported for a 30-year time horizon and in kg CO_2eq/mmBTU and have been adapted by the authors to a 20-year time horizon and gCO_2eq/MJ.

Sources: Al-Riffai et al. (2010), Laborde (2011), Edwards et al. (2010), EPA (2010), Searchinger et al. (2008), own calculations.

Generally speaking, LUC data is more widely available for bioethanol than for biodiesel feedstock. This can be attributed to the US (and Brazil) showing great interest in bioethanol market advancement after the 1970s oil crises (HLPE 2013). The early-on LUC-debate in the US also prompted US legislators to take this matter into consideration when formulating guidelines aiming to assess the overall GHG emission balance of biofuels. Based on scientific findings they thus included representative LUC-emission coefficients into legislation (e.g. EPA-RFS2 ruling of 2010 – see EPA (2010)).

Figure 8 shows that LUC-emission coefficients vary substantially among studies. For example, for bioethanol from wheat, the variation lies between 14.4 grams and 140 grams of CO_2eq per MJ of bioethanol, with the average being around 64 grams. For biodiesel from rapeseed this variation is lower and ranges from 53 to 100 grams of CO_2eq per MJ. The high variation between the results of the models highlights the influence of certain key parameters: yield assumptions, geographical allocation of area expansion, biodiesel/bioethanol ratio, and peatland emissions. However, the results are also influenced by other factors (e. g. role of by-products, possibility for intensification, land types included in model), and deviations in values are generally the result of a sum of these factors. Therefore, one should be cautious when trying to interpret the differences in results.

The potential influence of such differences in data, model specification, parameters and other assumptions can be seen from the following examples:

1. **Yield assumptions**
   Concerning the differences in LUC emission values within one feedstock category, it can be observed that studies based on the models IMPACT and MIRAGE-BioF frequently report the lowest emission factors. Studies based on these models generally assume higher yield growth rates for crops compared to the other studies analysed, and thus less area expansion is required if biofuel demand increases (Edwards et al. 2010, 8). Given that they do not include emissions that might be associated with higher yield-increases (e. g. intensification relying on higher rates of fertiliser application), the impact of the modeled demand increase is translated into relatively low CO_2 emission coefficients. For the IMPACT model, this effect is further enhanced due to the assumption of yields being equally high[8] on existing and on newly cultivated croplands (Edwards et al. 2010, 75), which results in a lower need for area expansion.

2. **Geographical allocation of area expansion**
   AGLINK-COSIMO and GTAP-BIO results provide an example of the influence of geographical factors. Scenarios modeled in AGLINK-COSIMO generally project a significant degree of agricultural area expansion to be located in the category "other Asia", which includes e. g. Indonesia and Malaysia (Edwards et al. 2010, 58). Areas in this regional aggregate are considered to be high-value carbon areas and thus area expansion therein is associated with comparatively high changes in carbon stocks, which contributes to the high LUC emission coefficients associated with the AGLINK-COSIMO results. GTAP-BIO, in contrast, predicts that a large part of the agricultural area expansion will occur in low-yielding regions (e. g. Subsaharan Africa) (Edwards et al. 2010, 35) which requires a larger amount of land and therefore also leads to relatively high LUC factors.

3. **Differing biodiesel/bioethanol ratios**
   Al-Riffai et al (2010) and Laborde (2011) both rely on the MIRAGE-BioF model. Yet, the 2010 simulation results in an overall LUC-emission coefficient of 17.7 gCO_2eq/MJ biofuel, whereas the 2011 study reports a value of 38.4 gCO_2eq/MJ. The considerable difference in values is to a large extent explainable by the different biodiesel-to-bioethanol ratio that is needed to satisfy overall additional EU biofuel demand in 2020 (Laborde 2011, 107). While the 2010 study defines this ratio to be 55/45 %, the study from 2011 uses a larger biodiesel share, i. e. a ratio of 72/28 %, which is much closer to the current situation and therefore more realistic. As depicted in the figure above, on average both studies assign higher LUC-emission coefficients to biodiesel compared to bioethanol crops. This implies that a higher biodiesel share to meet additional EU demand also leads to higher overall LUC emissions.

4. **Peatland emissions**
   This source of uncertainty becomes increasingly relevant the higher the share of biodiesel in a modeled scenario. Palm oil can serve either directly as a biofuel crop or replace displaced vegetable oils from food, feed and industrial demand[9]. In Indonesia and Malaysia, oil palm plantations are the greatest drivers of agricultural area expansion. Since agricultural area expansion in these countries takes place primarily on peatland, models need to factor in emissions from this land cover type. However, there is limited data available on the actual share of agricultural area expansion taking place on peatland; and different estimates exist concerning carbon values stored in peatlands and released when this land type is converted[10] (Edwards et al. 2010). Al-Riffai et al. (2010) assume agricultural area expansion into peatland to correspond to 27 % and 10 % of total agricultural area expansion for Indonesia and Malaysia, respectively with associated emissions of approximately 22 tCO_2eq/ha per year (38, 64). Laborde (2011), on the other hand, estimates 33 % of agricultural area expansion into peatland for these two countries with an emission value of 55 tCO_2eq/ha per year (94). These differences in values can have significant implications for the overall LUC results, especially given that e. g. Laborde (2011, 63) reports peatland emissions to be accounting for roughly 35 % of overall LUC emissions of biodiesel feedstocks.

---

[8] Other models generally assume lower yields on newly cultivated land.

[9] The attractiveness of palm fruit, i. e. palm oil, lies in the fact that this feedstock produces a variety of usable by-products and that it has a relatively high oil yield (Al-Riffai et al. 2010).

[10] An extensive review of the peatland-factor can be found in Edwards et al. (2010, 141-144).

5.5 Evaluation of iLUC Concept and Empirical Studies

While the results in 5.4 only refer to net LUC and were thus discussed as yielding 'LUC emission values', these results are considered as proxies for iLUC emission values. Therefore, the difficulties associated with deriving LUC emission values can serve as a basis for the evaluation of the feasibility of the iLUC concept. As suggested by the results above, iLUC modelling efforts yield a range of values across feedstocks but also for one specific feedstock type. This can be attributed to technical aspects of the relevant models (e. g. chosen elasticities, accounting for by-products, levels of sector-disaggregation), the underlying database and different scenario specifications. To generate iLUC-emission coefficients that can be sensibly combined with a life cycle assessment of biofuels, different models/model specifications should be run using similar scenario-specifications to yield comparable iLUC results.

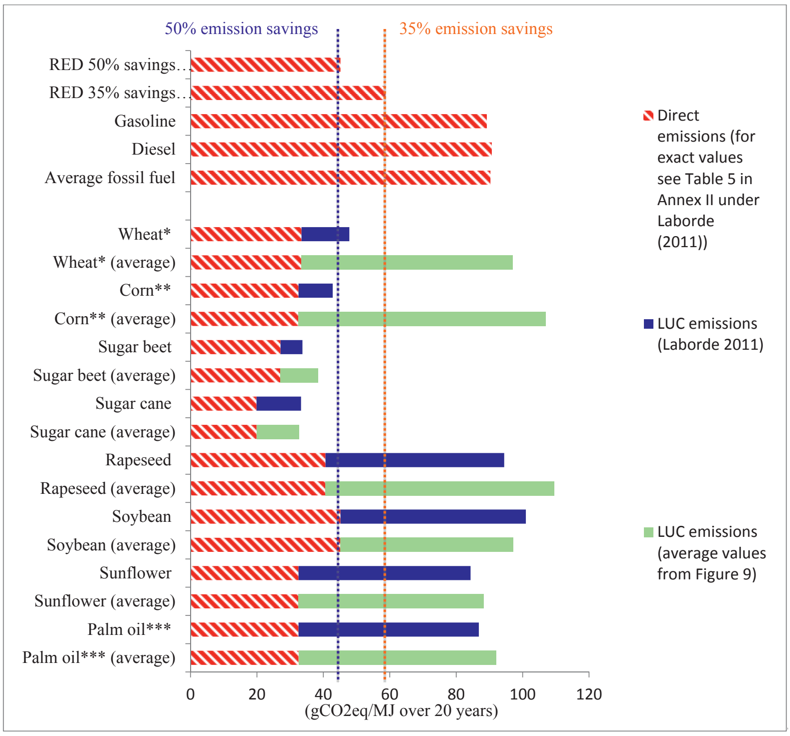
Furthermore, the credibility of modelling results could be improved by applying greater scrutiny when it comes to the incorporated input data. As discussed above in section 5.4, assumptions regarding peatland emissions can have considerable impacts on obtained results. Many of the models in this review have relied on values from Edwards et al. (2010) for this factor, without further discussing the possibility of using other sources or rather relying on a range of factors. This argument also holds true for another source of input data, which can potentially affect results: Most of the modelling efforts rely on carbon values for carbon stored in vegetation and soil from IPCC (2006). However, information in this respect is subject to change given the ever-evolving state of scientific knowledge and technological means of measuring such aspects. This provides modellers with both an opportunity and a challenge to use a larger range of data sources, which would result in a range of iLUC emission values instead of a single point estimate.

Moreover, the nature of iLUC-effects requires that special focus be placed on developments in transition and developing countries and specifically on the different land use/land cover types within these countries and regions. Yet, many of the employed models were originally designed to simulate the trade and price impacts of certain policies (Prins et al. 2010). Thus, they often only provide information on land use changes and associated emissions at a high level of aggregation and/or with a regional bias towards developed countries/regions. All these aspects make the results of modelling iLUC efforts vulnerable to criticism, thereby questioning their validity. However, one should not question the reality of iLUC-effects merely on the grounds of their abstract character. Modelling and monitoring efforts should rather focus on developing best practices in iLUC quantification, improving existing databases, ensuring a more consistent use of terminology, transparent documentation of methodology, extensive sensitivity-analyses, and striving to trace the underlying causes of differences in results between models and simulations.

5.6 iLUC and Policy Implications

Taking indirect land use change into consideration when determining the overall emissions of biofuels and comparing these values with emissions from conventional fossil fuels can lead to an alteration of the assessment of biofuels as a contributor to climate change mitigation. In Figure 9, direct emissions for the individual biofuel feedstock (dependent on processing pathways as identified in the EU's RED) have been extended to incorporate LUC-emission values from Laborde (2011) and the average values as documented in Figure 8. For comparison purposes, the figure also includes the emissions of the respective conventional fossil fuel technologies[11] and the emission levels corresponding to the currently applicable 35 % as well as the 50 % emission reduction targets that biofuels must fulfill by 2017 according to RED (European Commission 2009, 36).

Figure 9: Net Emissions of Biofuel Pathways



Note: Technological pathways (as defined in RED and included in Laborde (2011)):
*Wheat ethanol (natural gas as process fuel in combined heat and power (CHP) plant),
**Corn ethanol (natural gas as process fuel in CHP plant),
***Palm oil biodiesel (process with methane capture at mill).
Sources: European Commission (2009), European Commission (2012a),
Laborde (2011), own calculations.

---

[11] As defined in European Commission (2012a).

These findings highlight that, even given the uncertainties surrounding the exact values of LUC emissions, they constitute a factor that alters the relative emission levels of different biofuel feedstocks. Based on Laborde's (2011) results[12] as well as on the average coefficients from various studies, none of the biodiesel feedstocks – corresponding to approximately 74% of biofuel consumption in EU road transport in 2010 (European Commission 2013) – would meet the sustainability thresholds of the EU directive. These results therefore question the justifiability of biofuel policies in the context of climate change mitigation objectives. Even for bioethanol, where sustainability targets can be achieved based on LUC coefficients from the more optimistic studies, the high carbon reduction costs need to be taken into account.

Aside from land use change as a result of biofuel promotion having potentially harmful implications for global climate, these developments are also associated with wider social and biophysical implications. Land use changes, where e. g. primary forests or grasslands are converted to arable areas for biofuel (dLUC) or food/feed (iLUC) production, potentially affect traditional rural living environments as well as alter local biodiversity and can pose further strains on the global endeavor towards sustainable development. The situation can be further aggravated in cases where biofuels also trigger more intensive farming practices associated with a) the establishment of large-scale plantations – i. e. impairing small-holder agriculture, b) potentially higher levels of e. g. fertiliser run-off into the water cycle and thus affecting overall water quality (HLPE 2013) and c) higher emissions of GHG nitrous-oxide due to higher fertiliser use.

In order to curb negative effects of feedstock production for biofuels, European legislation includes sustainability clauses that, for example, limit direct land expansion for biofuel production counting against the 10% renewable target within certain biospheres. However, the assessment of the true fulfilment of these criteria and thus also the climate-friendliness of biofuels is difficult due to the plenitude of international certification schemes that were established for this purpose (HLPE 2013). Additionally, by not addressing the root of the iLUC problem, i. e. its nature as a market-mediated effect, adopting certification schemes does not influence global demand structures for agricultural crops. Therefore, there is a danger that while biofuel feedstock production is shifted to areas that meet sustainability criteria, agricultural production for other uses moves to less sustainable areas and the overall pressure on globally available land area is maintained, the iLUC threat is sustained (Witcover et al. 2013, 69).

While LUC-calculations in general and iLUC-calculations in particular, are surrounded by numerous uncertainties, these uncertainties do not justify ignoring the land use change impacts of biofuels. Biofuels in the EU, unlike other agriculture-based products and production methods, are principally supported from the perspective of climate change mitigation and should therefore be assessed in view of this specific objective. In this context, assuming the combustion of biofuels as carbon neutral in LCA due to the previous absorption of carbon by the biofuel crop cannot be justified if indirect effects of using biomass are not taken into account. Thus, calls for using iLUC or LUC assessment for all products (as advocated by Delzeit et al. (2011) and Finkbeiner (2013)), neglect the principal underlying policy-driver for EU support of the biofuel industry, i. e. the GHG emission reducing effect of biofuels. Therefore, instead of denying the existence of iLUC effects due to their complexity, efforts should rather focus on continuously improving the quantifiability and comparability of the land use implications of biofuels. The mitigation of climate change is a holistic concept, and any action taken in this respect should therefore also be subject to a holistic impact assessment.

---

[12] These values are used as basis for suggested iLUC emission factors as included in the 2012 reform proposal (European Commission 2012b) and discussed in the Impact Assessment (European Commission 2012a).

6 CONCLUSION

The abolishment of EU support policies for liquid biofuels in 2020 would result in an almost complete cutback of EU biofuel production from crops. Instead of 8% (as envisaged under current legislation), the EU is likely to only source about 1% of its transportation energy needs from first generation biofuels. This would have a major impact on global agricultural prices: prices for plant oils would fall by 16%, by 10% for oilseeds, on average by 2.1% for cereals, and by approximately 4% for wheat. The average global price level for all crops would fall by 2.6%, compared to the scenario under current EU-biofuel legislation. These results are roughly in line with those from other simulation model based studies. And they are significant: this is the isolated effect of just one policy of the EU, not yet including other bioenergy policies or those of other countries, such as the USA.

The resulting reduction in agricultural production, assuming political support for first generation biofuels in the EU were to be abolished, would take place primarily in countries other than the EU: Agricultural area in the EU would be reduced by 1 million ha, and by an estimated 8 million ha in the rest of the world. The EU trade balance would substantially change: EU net imports would decline by 17.9 MTOE, which is equivalent to about 85% of the reduction in demand for biofuels and roughly 1.8 times the total German crop area.

Less demand for biofuels in the EU would thus lead to lower world market prices and lower import bills of net food importing countries. If prices were to be transmitted to regions with a high prevalence of undernourishment, food security of net food buying households would improve. Improving the global availability of food, however, is only one prerequisite for decreasing hunger. The main challenge to achieving food security is to reduce poverty.

Political support for biofuels in the EU is proclaimed to be motivated by climate change mitigation objectives. However, the emissions from biofuel combustion are not being accounted for in a LCA, as they are considered "carbon neutral" due to the preceding absorption of carbon from the atmosphere caused by growing biofuel feedstock. This gives an incomplete picture. Instead, indirect effects such as GHG emissions resulting from an intensification of agriculture and global land use change need to be taken into account. The exact extent of the effects of indirect intensification and land use change attributable to biofuel policies cannot be observed in isolation. It can only be estimated based on biophysical and economic modelling.

Such modelling is associated with complexities and uncertainties. This, however, does not justify ignoring land use change and the intensification impacts of biofuels. Instead of denying the existence of such effects, efforts should rather focus on continuously improving the validity of land use and intensification effect assessments of biofuels. Such improvements can be reached by developing best practices in iLUC quantification, improving existing databases, ensuring a more consistent use of terminology, transparent documentation of methodology, extensive sensitivity-analyses, and striving to trace the underlying causes of differences in results between models and simulations.

Existing estimates of indirect effects display a substantial heterogeneity in GHG emissions. Yet, even given these uncertainties, indirect effects constitute a factor that alters the relative emission levels of different biofuel feedstocks. Based on the calculated average from the simulation studies reviewed for this paper, none of the biodiesel feedstocks, corresponding to approximately 74 % of biofuel consumption in EU road transport in 2010, would meet the sustainability thresholds of the EU directive if indirect effects were to be taken into account. For bioethanol production from sugar and wheat, slight reductions in GHG emissions may be achieved. However, these reductions would be too costly: political support for bioethanol from crops is not efficient. Other means of reducing GHG emissions allow for much greater reductions at the same economic costs (Wissenschaftlicher Beirat Agrarpolitik beim BMELV 2007).

Aside from land use change as a result of biofuel promotion having potentially harmful implications for the global climate, these developments are also associated with wider social and biophysical implications. Land use changes, where e. g. primary forests or grasslands are converted to arable areas for biofuel or food/feed production, potentially affect traditional rural living environments as well as alter local biodiversity and can pose further strains on the global endeavor towards sustainable development. The situation can be further aggravated in cases where biofuels also trigger more intensive farming practices associated with a) the establishment of large-scale plantations and the impairment of small-holder agriculture, b) potentially higher levels of e. g. fertiliser run-off into the water cycle and thus affecting overall water quality and c) higher emissions of the GHG nitrous-oxide due to higher fertiliser use.

In conclusion, EU biofuel support has a negative impact on the global availability of biomass and lacks a convincing motivation: it is not an efficient, if at all effective climate change mitigation policy. The need to correct the European Union's misguided policy on biofuels is long overdue: political support for liquid biofuels gained from cops should be phased out transparently over the next few years. The current proposal for a new biofuel directive by the European Commission is a move in the right direction, though much too hesitant. However, it is in danger of being watered down by Member States under the pressure of interest groups.

7 REFERENCES

agri.eu (2013): France wants higher biofuel use than EU lawmakers. http://agri.eu/france-wants-higher-biofuel-use-than-eu-lawmakers-news5276.html.

Aksoy, M. A., Isik-Dikmelik, A. (2008): Are low food prices pro-poor? Net food buyers and sellers in low-income countries. Policy Research Working Paper Series No. 4642, The World Bank.

Al-Riffai, P., Dimaranan, B., Laborde, D. (2010): Global Trade and Environmental Impact Study of the EU Biofuels Mandate. Vol. 125. IFPRI Washington, DC. http://environmentportal.in/files/biofuelsreportec.pdf.

Banse, M., Grethe, H. (2008): Effects of the New Biofuel Directive on EU Land Use and Agricultural Markets. Contributed paper at the EAAE Seminar "Modelling Agricultural and Rural Development Policies". Seville/Spain. 31 January – 1 February 2008.

Bertzky, M., Kapos, V., Scharlemann, J.P.W. (2011): Indirect land use change from biofuels production: implications for biodiversity. JNCC Report No. 456.

BMU (2013): Zeitreihen zur Entwicklung der erneuerbaren Energien in Deutschland. http://www.erneuerbare-energien.de/die-themen/datenservice/zeitreihen-entwicklung-ab-1990/

Britz, W., Delzeit, R. (2013): The impact of German biogas production on European and global agricultural markets, land use and the environment. Energy Policy 62: 1268-1275.

Broch, A., Hoekman, S. K., Unnasch, S. (2013): A Review of Variability in Indirect Land Use Change Assessment and Modeling in Biofuel Policy. Environmental Science & Policy 29 (May): 147-157.

Cordts, A., Duman, N., Grethe, H., Nitzko, S., Spiller, A. (2013): Auswirkungen eines verminderten Konsums von tierischen Produkten in Industrieländern auf globale Marktbilanzen und Preise für Nahrungsmittel. In: Rentenbank (ed.), "Sicherung der Welternährung bei knappen Ressourcen". Schriftenreihe der Rentenbank. Frankfurt/Main. Band 29: 103-136.

Deppermann, A., Bruchof, D., Blesl, M., Boysen, O., Grethe, H. (2012): Energy from Biomass: Linkages between the Energy and the Agricultural Sector in the EU until 2050. Contributed paper at the International Association of Agricultural Economists Conference. Foz do Iguaçu/Brazil. 18 – 24 August 2012.

Delzeit, R., Klepper, G., Lange, K. M. (2011): Review of IFPRI study:'Assessing the Land Use Change Consequences of European Biofuel Policies and Its Uncertainties.' Study on Behalf of the European Biodiesel Board by Kiel Institute for the World Economy, Kiel, Germany. http://www.ebb-eu.org/EBBpressreleases/Review_iLUC_IfW_final.pdf.

Deutscher Bundestag (2013): Antwort der Bundesregierung auf die Kleine Anfrage der Abgeordneten Bärbel Höhn, Cornelia Behm, Hans-Josef Fell, weiterer Abgeordneter und der Fraktion BÜNDNIS 90/DIE GRÜNEN – Drucksache 17/12257. 13.2.2013.

Doornbosch, R., Steenblik, R. (2007): Biofuels: Is the Cure Worse than the Disease? OECD Document SG/SD/RT(2007)3. OECD, Paris.

ECOFYS (2012): Renewable Energy Progress and Biofuels Sustainability. Report for the European Commission, Submission September 2012, Tender Number: ENER/C1/463-2011-Lot2.

Edwards, R., Mulligan, D., Marelli, L. (2010): Indirect Land Use Change from Increased Biofuels Demand. JRC Scientific and Technical Reports. JRC 59771. http://www.eac-quality.net/fileadmin/eac_quality/user_documents/3_pdf/Indirect_land_use_change_from_increased_biofuels_demand_-_Comparison_of_models.pdf.

EPA (Environmental Protection Agency) (2010): Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program; Final Rule Part II. http://www.gpo.gov/fdsys/pkg/FR-2010-03-26/pdf/2010-3851.pdf.

European Commission (2007a): The Impact of a Minimum 10% Obligation for Biofuel Use in the EU-27 in 2020 on Agricultural Markets. Impact assessment of the Renewable Energy Roadmap – March 2007. DG Agri, AGRI G-2/WM D(2007), 30.04.2007, Brussels.

European Commission (2007b): Report on the Progress Made in the Use of Biofuels and Other Renewable Fuels in the Member States of the European Union. Communication from the Commission to the Council and the European Parliament. COM(2006) 845 final, 10 January, Brussels.

European Commission (2009): Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the Promotion of the Use of Energy from Renewable Sources and Amending and Subsequently Repealing Directives 2001/77/EC and 2003/30/EC. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF.

European Commission (2012a): Commission Staff Working Document IMPACT ASSESSMENT Accompanying the Document Proposal for a Directive of the European Parliament and of the Council Amending Directive 98/70/EC Relating to the Quality of Petrol and Diesel Fuels and Amending Directive 2009/28/EC on the Promotion of the Use of Energy from Renewable Sources. Brussels: European Commission. http://ec.europa.eu/energy/renewables/biofuels/doc/biofuels/swd_2012_0343_ia_en.pdf.

European Commission (2012b): Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL Amending Directive 98/70/EC Relating to the Quality of Petrol and Diesel Fuels and Amending Directive 2009/28/EC on the Promotion of the Use of Energy from Renewable Sources. COM(2012) 595. http://ec.europa.eu/energy/renewables/biofuels/doc/biofuels/com_2012_0595_en.pdf.

European Commission (2013): Commission Staff Working Document Accompanying the Document Report from the Commission to the European Parliament and the Council Renewable Energy Progress Report. http://ec.europa.eu/energy/renewables/reports/doc/swd_2013_0102_res_en.pdf.

European Parliament (2013): European Parliament legislative resolution of 11 September 2013 on the proposal for a directive of the European Parliament and of the Council amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the use of energy from renewable sources (COM(2012)0595 – C7-0337/2012 – 2012/0288(COD)). http://www.europarl.europa.eu/sides/getDoc.do?type=TA&reference=P7-TA-2013-0357&language=EN&ring=A7-2013-0279.

EuropeanVoice (2013): Biofuel reform in trouble. http://www.europeanvoice.com/article/imported/biofuel-reform-in-trouble/78789.aspx

EUROSTAT (2013): Database. http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/

FAO (2008): The State of Food Insecurity in the World 2008. Rome.

FAO (2011): The State of Food Insecurity in the World 2011.

FAO (2012): The State of Food Insecurity in the World 2012.

FAOSTAT (2013): FAO Statistical Databases & Data-sets. Available at: http://faostat.fao.org/default.aspx

Finkbeiner, M. (2013): Indirekte Landnutzungsänderungen in Ökobilanzen – wissenschaftliche Belastbarkeit und Übereinstimmung mit internationalen Standards. Paper commissioned by Verband der deutschen Biokraftstoffindustrie and Verband der ölsaatenverarbeitend Industrie in Deutschland.

Fonseca, M. B., Burrell, A., Gay, H., Henseler, M., Kavallari, A., M'Barek, R., Domínguez, I.P., Tonini, A. (2010): Impacts of the EU Biofuel Target on Agricultural Markets and Land Use: a Comparative Modelling Assessment. European Commission, Joint Research Centre, Institute for Prospective Technological Studies. http://www.eurosfaire.prd.fr/7pc/doc/1281625394_jrc58484_biofuel.pdf.

Fritsche, U R., Wiegmann, K. (2011): Indirect Land Use Change and Biofuels. Directorate General for Internal Policies, Policy Department A: Economic and Scientific Policy. http://www.europarl.europa.eu/committees/en/studiesdownload.html?languageDocument=EN&file=35128.

Grethe, H. (ed.) (2012): European Simulation Model (ESIM): Documentation (Model Code, Parameterization, Database). December 11, Hohenheim.

Grethe, H., Dembélé, A., Duman, N. (2011): How to Feed The World's Growing Billions, Understanding FAO World Food Projections and their Implications. Study for WWF Deutschland and the Heinrich-Böll-Stiftung, Berlin.

HLPE (2013): Biofuels and food security. A report by The High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome.

IPCC (2006): 2006 IPCC guidelines for national greenhouse gas inventories, prepared by the National Greenhouse Gas Inventories Programme. Eds. Eggleston, H. S., Buendia, L., Miwa, K., Ngara, T., Tanabe, K. IGES, Japan. http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html

Ivanic, M., Martin, W. (2006): Potential Implications of Agricultural Special Products for Poverty in Low-Income Countries. Draft World Bank paper, October, 16.

Laborde, D. (2011): Assessing the Land Use Change Consequences of European Biofuel Policies. Final Report Prepared for the European Commission DG Trade. Implementing Framework Contract No TRADE/07 A 2. http://re.indiaenvironmentportal.org.in/files/file/biofuelsreportec2011.pdf.

Laborde, D., Valin, H. (2012): Modeling Land Use Changes in a Global CGE: Assessing the EU Biofuel Mandates with the MIRAGE-BioF Model. Climate Change Economics 03 (03) (August).

Leopoldina (Nationale Akademie der Wissenschaften) (2012): Bioenergie – Möglichkeiten und Grenzen. Stellungnahme. Halle (Saale).

OECD/FAO (2012): OECD-FAO Agricultural Outlook 2012-2021. OECD Publishing and FAO. http://dx.doi.org/10.1787/agr_outlook-2012-en.

Prins, A.G., Stehfest, E., Overmars, K., Ros, J. (2010): Are Models Suitable for Determining ILUC Factors? Bilthoven, The Netherlands: Netherlands Environmental Assessment Agency, PBL Publication 500143006. http://pblweb10.prolocation.net/sites/default/files/cms/publicaties/500143006.pdf.

Searchinger, T., R. Heimlich, R. A. Houghton, F. Dong, A. Elobeid, J. Fabiosa, S. Tokgoz, D. Hayes, Yu, T.-H. (2008): Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change. Science 319 (5867) (February 29): 1238–1240.

Searchinger, T. D. (2010): Biofuels and the Need for Additional Carbon. Environmental Research Letters 5 (2): 024007.

USDA (2011): EU-27 Annual Biofuels Report. GAIN Report Number NL1013.

WBGU (Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen) (2008): Welt im Wandel: Zukunftsfähige Bioenergie und nachhaltige Landnutzung.

Winters, L. A. (2002): Trade Liberalisation and Poverty: What are the Links?
The World Economy 25(9): 1339–1367.

Winters, L. A., McCulloch, N., McKay, A. (2004): Trade Liberalization and Poverty: The Evidence So Far. Journal of Economic Literature 42(1): 72-115.

Wissenschaftlicher Beirat Agrarpolitik beim Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz (WBA) (2007): Nutzung von Biomasse zur Energiegewinnung – Empfehlungen an die Politik.

Wissenschaftlicher Beirat Agrarpolitik beim BMELV (WBA) (2012): Ernährungssicherung und nachhaltige Produktivitätssteigerung. Stellungnahme.

Witcover, J., S. Yeh, Sperling, D. (2013): Policy options to address global land use change from biofuels. Energy Policy 56 (May): 63-74.

World Bank (2013): Database. http://data.worldbank.org/