Biofuels in the European Union and Indirect Land Use Change

A Review
of Scientific Studies
and Political Proposals

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Acknowledgement

The present expert opinion was initiated by the German Bioethanol Industry Association (BDB[e]). The findings and statements made in this expert's opinion are the sole responsibility of the authors and have not been influenced by the initiator of the project in any manner whatsoever.

List of Abbreviations

BDB[e]	–	German Bioethanol Industry Association
BLE	–	German Federal Office for Agriculture and Food
CGE	–	Computable General Equilibrium (Model)
COSIMO	–	Commodity Simulation Model
EC	–	European Commission
EU	–	European Union
FAO	–	Food and Agriculture Organization
FNR	–	Specialized Agency for Renewable Resources
FQD	–	Fuel Quality Directive
IFPRI	–	International Food Policy Research Institute
ILUC	–	Indirect Land Use Change(s)
JRC	–	Joint Research Center
LUC	–	Land Use Change(s)
MIRAGE	–	Modeling International Relationships in Applied General Equilibrium
OECD	–	Organization for Economic Cooperation and Development
OVID	–	Association of the Oilseed Processing Industry in Germany
PEM	–	Partial Equilibrium Model
RED	–	Renewable Energy Directive
GHG	–	Greenhouse gas(es)
UN	–	United Nations

Summary

The point of departure for the present expert opinion is the public discussion of the merits and demerits of determining ILUC factors for biofuels. To this end newer, prospective scientific studies on this topic shall be evaluated. The criteria are the methods and models employed, existing information and data, the assumptions made and the results obtained. Moreover, political proposals that are based on these studies shall be evaluated.

The agronomic models that are employed have met with wide scientific acceptance. They exhibit a high detail of degree. Nevertheless, they only represent a simplification of a much more complex reality. However, in the various analyses these models are linked with other methodological tools. These other tools and their links require resolute further development in order to obtain a degree of acceptance as is already essential to agronomic models.

The information and data used to reinforce the agronomic models are described in a transparent manner. The data and their sources have been tried and proven for a long time and represent part of the wide recognition that these models have attained among the scientific public. In contrast, the quality of the data used outside of such agronomic models is comparatively poor. This means that the calculable ILUC factors must be judged as very uncertain and hardly reliable. In many cases even an exaggeration of the ILUC factors will probably derive the data thus generated.

The argument concerning indication of comparatively high ILUC factors just expressed can also be attributed to the underlying assumptions. There are numerous indications that the GHG emissions calculated in the final analysis have to do with the defined assumptions.

The arguments with regard to the models and methods, the data, information and assumptions already allow for the conclusion that considerable uncertainties must be reckoned with despite a careful scientific approach in the work reviewed – in particular in the work of the IFPRI and JRC. This uncertainty is also revealed in the results obtained. In the final analysis the evaluated studies only provide room for possibilities in which LUC and the resulting ILUC factors triggered by the production of biofuels in the European Union may be found; however, it should be noted that such room is measured more toward the “upper limit.”

From a scientific perspective the studies require further development. Even the authors of the analyzed studies argue in favor of such substantial further development. Against this background the political handling of scientific work should be criticized. The current, new ILUC research does not provide reliable information, e.g. with to ILUC factors. However, the present expert opinion shows that lower ILUC values than indicated may be expected.

1 Problem and Aim

Both the European Union (EU) and Germany have ambitious goals when it comes to energy policy. Thus, for example, apart from a general reduction in energy consumption, 20% percent of the overall energy requirement is to be covered by renewable energies by the year 2020 (cf. for example EC, 2012a; FNR, 2012). In this case renewable energies are, among other things, to initially compensate for 10% of local fuel consumption. In the European Union as a whole 20% of greenhouse gases emissions (GHG) are to be avoided through the use of renewable energies, and in Germany even as much as 40% (see again EC, 2012a; FNR, 2012). These represent very ambitiously motivated goals – particularly in terms of climate policy – which present enormous challenges to the respective national economies of the European Union. These challenges have also been taken up by the bioethanol industry which, particularly in Germany, has thus far received support from policymakers as well.

In spite of these social targets one can observe, both in public discourse and in the political debate, that the biofuels sector in the European Union – and the bioethanol industry in Germany in particular – are exposed to mounting pressure. The following arguments are advanced with particular frequency (see among other things, Searchinger, 2013):

- Areas for the production of energy plants would not be available for the production of food and feed; the result would be land use changes (LUC).
- The supply of soft commodities would also become more limited.
- This would ultimately not only drive up the price of agricultural products and thus also intensify the problem of hunger – in particular in the developing countries – but in parallel would also lead to so-called indirect land use changes (ILUC).

Precisely the effects of ILUC are currently the subject of frequent and very controversial debate: In concrete terms the question concerns the quantitative significance that should be attributed to the production of biofuels for those indirect land use changes that must be regarded as particularly relevant for greenhouse gas emissions (GHG) (cf. Stern, 2007), and whether a derivative policy initiative should be the result:

- On the one hand the political signals are becoming both audible and visible. For example, there is the European Commission proposal (EC, 2012b) which states that in an EU context ILUC-factors as sustainability criteria are to be incorporated into corresponding directives such as the Renewable Energy Directive (RED) and the Fuel Quality Directive (FQD). Through such a factor the clearing of rain forests, rededication of grasslands into arable land as well as other LUC and the associated output of GHG as a result are directly attributed to the production of bioethanol and biodiesel in the European Union. This is justified through knowledge of the latest scientific studies.

- In contrast there is the argument on the part of the various sectors that produce bioenergy and/or their associations; according to these arguments the scientific studies on which the political signals are based are still not reliable enough and the political decision to implement an ILUC factor is accordingly arbitrary and in any case premature (cf. among other things, Grain-Club, 2013; OVID, 2013).

The present expert opinion sets out between the poles of public discourse on the merits and demerits of an ILUC factor. To this end relevant newer scientific studies on this topic are evaluated. This involves the work of the International Food Policy Research Institute (IFPRI), documented in Laborde (2011), the Joint Research Center (JRC), documented in Heiderer et al. (2010) and Marelli et al. (2011) and the European Commission (EC), documented in EC (2012a). In the following these studies are to be examined from the perspective of agricultural economics while elaborating upon their strengths and weaknesses. For this purpose four target questions shall be initially formulated:

1. Which statements can be made about the respectively employed methods and models?

2. What data are used and is the corresponding information reliable?

3. What were the fundamental assumptions that had to be made and how realistic are they and/or are such assumptions based on scientific standards?

4. What are the scenarios that are calculated and how realistic are the results calculated with the respective scenarios?

Within the overall scope of answers to these four questions the present expert opinion should also finally answer a fifth and central question:

5. To what extent can the methodological principles and empirical results of the studies on ILUC and the underlying (un-) certainties be employed for policy decisions, and can the already proposed policy options with regard to ILUC factors for biofuels thus actually be sufficiently justified?

The analysis is accordingly structured, even though all five questions cannot always be clearly separated from one another. In the following chapters the methods and models of the studies are discussed (Chapter 2), the data and information considered (Chapter 3), the assumptions judged (Chapter 4) and the scenarios as well as the derived results evaluated (Chapter 5); finally, implications are drawn for pending, concrete political decision-making (Chapter 6). Whenever possible, the focus of the discussions is placed on the production of bioethanol in the European Union and accordingly highlighted wherever relevant.

2 Discussion of the Models and Methods Employed

The discussion shall begin with the work of the IFPRI (which flow into Laborde (2011)), as this study also provides the basis for the work that is to be analyzed from the JRC and the EC. The corresponding methods employed by the IFPRI have a long tradition. The central core is formed by the model "Modeling International Relationships in Applied General Equilibrium" (MIRAGE). MIRAGE represents a computable general equilibrium (CGE) approach that has been used very successfully in agricultural economics research for at least ten years (cf. Hedi-Bchir et al., 2002). When cast in general terms, such CGE approaches represent a recognized scientific standard and are successfully used for countless questions involving agricultural economics; in particular when it is important to illustrate the interaction between regions and the various sectors of a national economy. Insofar the choice of such an approach – also in order to illustrate aspects of bioenergy policy in the European Union and elsewhere, that not only concern the agricultural sector – may as a rule be initially regarded as useful.

Against this backdrop the MIRAGE approach used in Laborde (2011) provides for sufficiently good regional coverage and, for a CGE, it has quite a large depth with regard to the analyzable sectors; a depth that is wanting in many other CGE models. This is made possible because the basic MIRAGE model was extended with a "biofuels" component. All of the essential subsectors of biofuels production are mapped. From the perspective of bioethanol production in the European Union, reference should certainly be made to the de facto lack of separation of the use of sugar beets and/or sugar cane at the market level as both raw materials – in contrast to processing products – are actually not handled. However, this is a fundamental problem in the market modeling of agricultural economics which is due, in particular, to the specific trade-offs on the raw sugar market and the mapping of such in market models (cf. also for example Noleppa and Hahn, 2013).

Like every other economic model the MIRAGE model is, of course, also a simplification of the actual complexity. The author makes this unequivocally clear and makes reference to the particularly relevant simplifications for the calculable results. Yet it must be questioned whether these simplifications are appropriate in the concrete case of the most accurate mapping possible as far as the effects of biofuels production are concerned. From our standpoint three aspects are worthy of particular note:

- On the one hand, with the tools employed in Laborde (2011) no ILUC effects are actually shown at all; but rather only LUC effects. The author even regards this as a crucial limitation of the model. ILUC effects can only be indirectly deduced by the attentive reader; for example, if additional use of areas that have thus far been unspoiled are made the subject of discussion and/or designated as arable land.

- On the other hand there is insufficient regional differentiation in the case of several critical model variables. This applies, for example, to land rents (remuneration of soil as a factor): In all regions the same, i.e. uniform, land rents are assumed for each so-called agro-ecological zone. However, this also applies to many of the central elasticities and thus the mathematical functions and computing algorithms on which the method is based.

- And finally the method does not permit sufficient specification of crop farming technologies which (a) make multiple harvests per year possible and/or (b) cover crop rotation decisions over time. The respective regional agrarian system that is thus represented is – figuratively speaking – comparatively inflexible, and this naturally limits the significance of the results which, as in this case, are based on a comparatively long time horizon up to 2020 and/or would be taken into corresponding consideration when it comes interpretation of the same. Langeveld et al. (2013) only recently pointed out how important such remuneration in kind is – precisely when it comes to the problem of bioenergy, i.e. the area compensations which may ensue.

Reference should also be made to a special methodological feature which is uncoupled from MIRAGE in Laborde (2011), the concrete application of which does not insignificantly affect the results. In order to minimize the factors of uncertainty in the analysis (more on this later in Chapter 4), as clearly specified by the author, the attempt is made to expose this uncertainty by means of so-called Monte Carlo simulations. This means that the level and probabilities of deviation from this level – that is, possible indicator attributes – are specified for different central model variables and/or parameters. These attributes are then combined with a randomizing procedure for the different variables and/or parameters. One ultimately obtains frequency distributions for the resulting levels of the target variables from these combinations such as, for example, land use changes and carbon dioxide emissions. This is a customary approach which has been tried and proven in many cases in agricultural economics. Thus the method as such is largely uncritical; nevertheless, the concrete execution should be questioned (cf. also Chapter 4).

Heiderer et al. (2010) and Marelli et al. (2011) initially exploit the data generated with MIRAGE, i.e. with an established agricultural economics model. In doing so the authors on the one hand combine the agricultural economics approach of Laborde (2011) with one which most likely can be designated as a “biophysical” – and thus in principle a scientifically determined – model, which the authors themselves refer to as a “spatial allocation procedure.” Apparently the aim is to determine the smallest scale LUC changes (and thus the effects of carbon dioxide emissions) as a result of changes in market conditions as they also represent a demand for bioenergy. On the other hand, the MIRAGE results thus accentuated are compared with correspondingly accentuated results of another agricultural economics model, i.e. the established AGLINK commodity simulation model (COSIMO) approach.

Before the actual “innovation” in the work of Heiderer et al. (2010) and Marelli et al. (2011) is to be discussed, several fundamental characteristics of AGLINK-COSIMO (cf. also Vannuccini, 2009) must be considered (there will not be a repeated discussion of the methodological pros and cons of MIRAGE that are also relevant in this case; reference shall be made to the arguments already stated above):

- What is involved is a so-called dynamic "partial equilibrium model" (PEM); thus an equilibrium model as well. Contrary to CGE approaches, PEM concepts generally map the agricultural sector with greater detail (cf., for example, McCalla, 2010 for a fundamental comparison of CGE and PEM approaches). Supply, demand and foreign trade for individual interdependent agricultural commodities markets and agricultural regions are explicitly mapped. This accuracy in detail also becomes clear by way of comparison: Where MIRAGE maps only eleven regions, there are twice as many regions and/or more than 40 individual countries or subregions with AGLINK-COSIMO; and where MIRAGE only explores seven markets (with relevance for the production of bioenergy), a total of 40 product markets are explicitly contained in AGLINK-COSIMO. This provides for clearly improved mapping of the interactions and market interdependences within the agricultural sector. In general, however, this happens at the expense of mapping the interactions of the agricultural sector with the other sectors of the respective national economy, and thus here as well. On the one hand, it makes it more difficult to integrate the sector for the production of biofuels into the model approach; on the other hand, however, it also does not make it impossible.

- In fact the concrete PEM is highly recognized in scientific research and is frequently employed, including for mapping bioenergy aspects. Thus, for example, the annual forecasts of the Organization for Economic Cooperation and Development (OECD) and the Food and Agriculture Organization (FAO), last published in OECD and FAO (2013), are based on this model approach. Furthermore, many other PEM concepts in agricultural economics research use data and/or structural contents from AGLINK-COSIMO, and thus also models from the authors of this expert opinion (cf. among other things, Noleppa and Hahn, 2013; Noleppa and von Witzke, 2013).

From an agricultural economics perspective it may thus be noted that the AGLINK-COSIMO model used in addition by JRC and, above all, particularly well-described and explored in Heiderer et al. (2010), represents a solid and profound methodological basis for the question being examined.

This MIRAGE and/or AGLINK-COSIMO approach, which may be designated as the scientific standard, is as previously mentioned then combined by JRC with a "spatial allocation procedure" which first of all represents an interesting scientific innovation, but has yet to be widely accepted – thus not yet representing a scientific "standard." In our opinion scientific research is also still a long way off from establishing a generally recognized standard in this case. This should be determined on the basis of the following facts:

- In principle with the selected procedure it is possible to draw conclusions about small-scale effects that are triggered by wide area, effective political measures or through other global challenges on agricultural commodities markets. This may represent important information, for example, in the identification of particularly vulnerable spheres for certain problem areas, e.g. within the context of soil erosion, biodiversity, acclimatization, etc. Nevertheless, the question is whether this biophysical breakdown of wide area information (MIRAGE and AGLINK-

COSIMO actually only offer data at the national and supranational level) is really necessary and expedient for this concrete case of interest when it comes to the determination of LUC and/or ILUC and the resultant GHG emissions and/or a then highly aggregated ILUC factor. In order to use a comparison: In agricultural economics one might consider, for example, placing the aggregated market responses of all of the individual agricultural enterprises in Germany and elsewhere (which would have to be individually modeled) in relationship to the attendant developments of the world market price for wheat which, however, is generally measured as of the port at the Gulf of Mexico. In technical terms this is certainly possible with the computing algorithms available – but is it really also expedient?

- In order to clearly state the case: The innovative “spatial allocation procedure” from the JRC should not be called into question in light of today’s technical possibilities and data availability, and it certainly may be legitimized when it comes to answering many questions of smaller scale. However, in determining LUC, and ultimately, highly aggregated ILUC factors, e.g. for the European Union, it represents a case of methodological “overshooting.” This is also made clear by the fact that at the end of their methodologically very complexly described approach, it even appears advisable to the authors to only indicate and discuss the results – actually generated on a small-scale – on a highly aggregated national and supranational level. Thus it remains unclear why – within the meaning of the targets of the JRC studies – this procedure was actually applied.

- Apart from the deceptive accuracy thus produced in the final analysis it should be pointed out that from a methodological standpoint implementation of the concrete “spatial allocation procedure” per se requires that very many small-scale data packets that all have different spatial grids and time references be linked with one another. In this connection the authors make reference to a number of methodological compromises that have to be made. Although these compromises are not always understandable from the perspective of agricultural economics, they nevertheless make it clear that information partly disappears, is again partly generated through external expert opinions and then has to be adjusted once more (whereby now and again it remains unclear how such adjustment is precisely performed or affects the result as a consequence).

- In short: The justified impression that the “spatial” sciences are only just beginning their standardization cannot be denied. This has implications for concrete analysis. In the final analysis then – although corresponding data are available for several spatial grids – ‘set aside’ land, for example, is no longer shown at the market level; which indeed plays an important role precisely when it comes to assessing bioenergetic options. This should have a serious impact because several million hectares of set-aside land are known of for the EU alone for the relevant reference date at the beginning of the new millennium in the JRC approach. Even in the year 2007, when mandatory set-asides were lifted, nearly four million hectares were still removed from agricultural production (European Commission, 2007). In addition there are huge expanses of land set-aside in the

USA (fourteen million hectares; cf. Riffell et al., 2008) and also in Eastern Europe for this period. The buffer function of these areas where bioenergetic production paths are of greater importance is therefore not adequately appreciated in generating the result.

Finally, a brief comment should be made with regard to the methodological instruments in EC (2012a). This particular statement is brief because the study basically defies substantial evaluation of the methodological instruments. In fact in EC (2012a) the concrete model tools used to perform the "impact assessment" discussed with the study are in no way revealed, apart from several references to performance of a descriptive analysis and recourse to expert opinions. Thus it cannot be said whether EC (2012a) also employs solid tools for agricultural economic analysis as in Laborde (2011), Heiderer et al. (2010) and Marelli et al. (2011), paired with still other methodological tools that require resolute further development. Fundamental reproducibility, which is given in particular for MIRAGE and AGLINK-COSIMO from the perspective of agricultural economics, must first be expressly required for EC (2012a). Such reproducibility will only be possible by requesting disclosure of the methodological facts and then a deeper scientific analysis of the methods and results in EC (2012a) can take place rather than that which appears to be opportune within the scope of this expert opinion.

The following short summary of the discussion of the methods and models therefore focuses solely on the IFPRI and JRC studies: In principle the agronomic models that are employed have met with wide scientific acceptance; in particular they exhibit a high degree of conceptual detail; nevertheless they continue to represent a simplification of complex reality; the agronomic models are linked with other tools in the analyses; however, these other tools require resolute further development in order to obtain a degree of acceptance as is already essential to agronomic models.

3 Discussion of the Existing Information and Data

Data and assumptions form the information pool from which model results are generated for a system of reference that is supposed to reflect reality. The discussion here will first involve objective knowledge on which the methods and models addressed in Chapter 2 are based in order to map the reality in the best possible manner. Observed conventions with regard to unascertained knowledge, i.e. likewise required for the use of methods and the calibration of models, are designated here as assumptions and first discussed in Chapter 4. However, it must be stressed that a sharp division between fact and convention is sometimes not always possible here in particular.

Again the point of departure should be a discussion of the situation with regard to data in Laborde (2011):

- On the whole, useful data are employed for empirical population of the model approach. This is because of the genesis of scientific analysis with MIRAGE which has lasted more than decade. Here the scientific mainstream prevailed;

use is made of official statistics and numerous data from recognized "peer-reviewed" work and academic databases; and this is a welcome development.

- This essentially also applies to the extensions of MIRAGE in order to be able to map the bioenergy sector. Here reference should be made, for example, to yield data per unit of area which employ useful projections for the "baseline." However, a data point should be questioned precisely from the perspective of bioethanol production in the European Union – in the case of sugar beets a yield of somewhat more than seventy tons per hectare is used for the year 2020; currently, however, seventy tons per hectare are already obtained in the three-year average of the European Union (cf. FAO, 2013). Potential yield increases, the way they are reasonably included in the case of other cultivation, should be applied here as well. In all other respects that would reduce the pressure on the respective area and thus the calculated (I)LUC.

- In Laborde (2011) a lot of information on model support through stakeholders within the scope of consultation processes had to be furnished particularly for bioenergy as a component. In fact the author makes explicit reference to this. However, it sometimes remains unclear where this employment of experts exactly took place and what concrete knowledge was obtained as a result; therefore a more precise evaluation cannot take place here. Yet it may be presumed that this also applies in particular to the immediately usable agrarian areas in several regions of the world, e.g. in the Commonwealth of Independent States (CIS). In this connection reference should also be made once again to the already discussed topic of (insufficient) inclusion of land set aside. In any case such information characterized by insufficiently described transparency from "external consultation" always offers room for interpretation. Conflicts of interest – particularly with regard to the results that are to be generated – cannot be excluded, at least for individual providers of information.

What IFPRI did for the provision of data for MIRAGE can also be said for AGLINK-COSIMO in the JRC concept. The data employed and their sources have been tried and proven for a long time and represent part of the wide recognition that this PEM approach has attained among the scientific public. Further evaluations are unnecessary. The complete data are also not disclosed here in this concrete case, which makes comprehensibility more difficult, in particular for readers who are unfamiliar with the PEM approach.

Apart from these arguments, which nevertheless essentially speak in favor of the fundamental expediency of much of the data employed – in particular with regard to the JRC agronomic models – the following points of criticism also must be emphasized for the data that is to be related to the "spatial allocation procedure" in the JRC approach and as a whole quite probably exaggerates LUC effects and/or ILUC factors:

- The approach employed in Heiderer et al. (2010) and Marelli et al. (2011) is primarily based on geographical, biological, physical and chemical data. Insofar as it may be stated from the perspective of agronomists the corresponding individual data and data packets are described in comparatively inscrutable fashion; comprehensibility is only possible in individual cases.

- Often adjustments are made in order to be able to perform calculations at all. This has to do with evidently large structural and definitional discrepancies in the case of the various data records that are used and in the end related to unit areas of varying sizes. In the above reference has already been made to the varying spatial grids and time references of the different packets. This results in problems of calibration. Thus some of these unit areas actually cannot be based on consistent data at all. As a consequence facts and assumptions that have to be made are often and in general actually not capable of being differentiated from each other at all (cf. Chapter 4). In this special case reference is once again made to the partial neglect of land set-aside.

- Furthermore, many of the then required data considerations in this connection appear to be quite arbitrary and/or based on pragmatism. In any case the praiseworthy, very transparent description of the approach by the authors ascertained here once again fails to reveal any consideration with possibly existing scientific knowledge; or is it the case that specific scientific knowledge is still so fragile that more accuracy is not possible?

- The authors are thoroughly aware of the specific data dilemma, and they address it openly and clearly on several occasions – precisely, for example, with regard to the applicable yields per unit of area and GHG emissions values (cf. also Chapter 4). What is relevant for both data points is, for instance, the fact that effects which result from differences between high-impact or intensive and low-impact or conservative tillage methods (which today are widespread in modern agricultural production systems) cannot be taken into consideration. Conservative methods which are known to produce only small, if any, reductions in yields – but occasionally large GHG savings effects – are therefore not mapped in a manner that is sufficiently useful. To use still another example, old data records on rain forest clearings are used perforce as otherwise no reasonable grid creation appears possible in the case of the spatially-based method, fully aware of the fact that there are currently lower clearing rates (and thus the rates of release of carbon dioxide) (cf. among other things, UN, 2010). ILUC factors are thus inevitably determined more toward the "upper limit."

In light of these arguments it is not surprising that the authors of the JRC admit the following: The results derived from the model approach should not be regarded as a true picture of real and potential land uses and/or LUC because there are numerous and large data uncertainties in the entire modeling process and also precisely characterize the principal determining factors of land extensions for agricultural purposes (and thus ILUC) (Heiderer et al., 2010).

Since here again reference must be made to the virtually complete lack of transparency with regard to the concrete model-based analyses in EC (2012a), Chapter 3 can basically be concluded as a result of all of this and in accordance with Finkbeiner (2013) as follows: The quality of the data used for calculation of the ILUC factors outside of the agronomic models is comparatively poor and means that the calculable ILUC factors presumably must be judged as very uncertain and hardly reliable. In many cases even an exaggeration of the ILUC factors will probably derive from this generation of data.

4 Discussion of the Underlying Assumptions

The argument concerning indication of comparatively high ILUC factors just expressed can also be related in part to the underlying assumptions as the following remarks on several aspects will repeatedly prove through selective demonstration.

Without reservation both Laborde (2011) as well as Heiderer et al. (2010) and Marelli et al. (2011) initially acknowledge the fact that numerous model parameters are based on very rough estimates and that the “baseline” and/or reference scenarios determined with the models are therefore comparatively uncertain. Among the essential factors of uncertainty in his own analysis Laborde (2011) includes:

- the assumed yield development and in particular the yields on land newly acquired for agricultural purposes;
- the assumed production functions (which illustrate the response to changed input quantities and relations as well as newly available technologies);
- demand trends for agricultural commodities;
- the exploitability of by-products in animal feedstuffs;
- the price sensitivity and costs of land (re)allocations; and finally
- the carbon bond in soils and agro-ecological (vegetation) zones.

Nearly all of these addressed model variables and parameters are of special interest from the perspective of calibration. In Heiderer et al. (2010) and Marelli et al. (2011), who are known to use data from Laborde (2011) while including implicit uncertainties, additional factors of uncertainty result within the scope of the “spatial allocation procedure” in relation, for example, to the characterization of soil qualities, climate factors and land use delimitations.

The fact that the respective authors (again with the exception of EC, 2012a) specify these uncertainties represents recognized scientific practice and demonstrates an awareness of reality with regard to the exploitability of the results of the respective analyses and also makes it easier for the reader to interpret their results. This is additionally simplified through transparent description of all of the essential facts. That is not always the case for many scientific studies when it comes to applied economics, thus making it possible to conduct a constructive, critical analysis of the available studies, which once again should be underscored.

Within the scope of the implications to be drawn here for political decision-making in the EU only several obvious arguments are to be extracted from this general context and briefly addressed in the discussion:

- In Laborde (2011) additional demand for bioenergy is realized on the respective markets through (a) increasing production and (b) changes in the case of other demands. When it comes to the latter provision of bioenergy industry by-products, particularly in the animal feed industry, accounts for a decisive share. Various feed concentrates are “waste products” from bioenergy production which, in part, induce sacrifice of previously required areas for fodder cereal, oil seed and leguminous plants, sometimes even pasture. Although the latter should not be over-interpreted, partial area substitution is in fact relevant. This is because of the fact, for example, that the share of usable flours from crushing procedures involved in the primary product is clearly too low, at least in the case of several primary agricultural products, although only somewhat in the case of others (cf. by way of alternative the largely accepted data from FAO, 2012). As a consequence less area is substituted in the calculations and the partial LUC effect and thus the resulting ILUC factor is greater than it actually should be under more realistic assumptions.

- In Chapter 2 the Monte Carlo simulations in Laborde (2011) were already characterized as an effective means with which to minimize the uncertainty of the modeling and interpretation of the results. In this concrete case the essential assumptions must be considered. Although the author clearly represents the factors of uncertainty that are particularly important for the results, only several of them are incorporated into the corresponding Monte Carlo simulations. The focus lies with model variables and/or parameters that directly determine LUC. However, many other uncertainties were not taken into consideration, in particular those involving carbon dioxide emission factors.

- Scientific literature is appropriated evaluated in order to arrive at corresponding distribution functions in the case of those considered factors of uncertainty that determine LUC. However, then there is a degree of not inconsiderable simplification: Thus, for example, only regional differences between developed countries and emerging economies are included in the line of calculation. This simplification negates important differences, but may sometimes be due to the circumstance that many of the required elasticities were analyzed and derived for developed countries using statistical methods, however only rarely for developing countries and emerging economies which in turn, however, can mean a lot for the real occurrence of global ILUC because there the reservoirs of land are often relatively high compared with land potentials in developed countries. Thus an effect that aggravates ILUC develops in parts of the modeling.

- For a model parameter “elasticity of substitution between non-land inputs and land” it is, for example, important to pay more precise attention to comparatively capital-intensive production methods as in the EU and land-intensive technologies as in North America; and – in order to cite still another, second example: the “shift in the share of land extension occurring in primary forests” will presumably be very differentiated if one considers, for example, Brazil and other emerging economies as well as EU Member States; however, in Laborde (2011) the fundamental assumption in this regard is for all regions and at the same level and also equally distributed, although it has been clear since Searchinger et al. (2008) that such a uniformity of land rededication was never given in any manner whatsoever, at least historically; and this will probably not be the case in the future as well.

- In addition, the level and distribution of other individual model variables and/or parameters for the Monte Carlo simulations should at least be analyzed.

With regard to level: Why is land expansion (for new agricultural areas), as is also the case for Heiderer et al. (2010) by the way, quite frequently at the expense of so-called primary forests which often – compared with other vegetation zones – store a particularly high amount of carbon; what then is actually the case with the often specified change to steppe landscapes for which relatively small carbon dioxide release rates are postulated in the studies? And, why is there a blanket assumption of a yield of 75% of already cultivated land as the base level in the case of newly cultivated land if in fact expected yield increases over time should reduce the pressure on land? And finally, are not several elasticities too narrowly defined, in particular those which increase land pressure as a function of the method when it comes to small values in view of substitution possibilities that often have already been exhausted in the particular region with regard to land in exchange for other inputs? More questions could be raised; as a whole, however, they point toward options in relation to the assumptions that have to be made, which ultimately should lead to less ILUC, but which are unable to do so per se because of the defined specification.

With regard to distribution: In principle the question should be asked with regard to the selected distribution of random events in the Monte Carlo simulations as to why probabilities are determined in order to generate (as a whole by the way once again favoring high LUC) skewed distribution if Laborde (2011) himself states that one actually knows nothing about the concrete probabilities of the instancing of certain characteristic values. Why then is this "scientific looking" necessary if a normal and simple Gauss distribution would have sufficed in order to take the phenomenon of "uncertainty" into consideration, but would nonetheless weaken the ILUC factor in many scenarios?

- However, one aspect that has only been briefly addressed in the above is far more crucial than questions of level and distribution when it comes to the Monte Carlo simulations. The designation of ILUC factors and/or emission coefficients is, after all, based on LUC, and the existing uncertainty implied in their calculation is accounted for after a fashion in Laborde (2011) by means of the Monte Carlo methods. However, ILUC factors are then at least just as closely coupled to the concrete definition of carbon release rates for each unit area. Laborde (2011) also attests a high degree of uncertainty in this case; nevertheless, the "carbon stock" is apparently left constant in the simulations. Thus this inherent uncertainty is left out of the corresponding analyses in spite of its crucial importance when it comes to determining the ILUC factor.

- It is essential that this be pointed out because the "carbon stocks" on which the respective assumptions are based should be regarded in a particularly critical manner. Laborde (2011) employs comparatively high levels of sequestered carbon, for example, for land that is not put to agricultural or other use, i.e. unspoiled; levels which exceed the calculative assumptions in the majority of cases, e.g. Tyner et al. (2010). Thus the resulting carbon dioxide emissions coefficient from LUC and/or ILUC tends to be overestimated vis-à-vis scientific approaches geared toward more conservative statements, e.g. also in Noleppa (2012), Noleppa and Hahn (2013) and Noleppa and von Witzke (2013).

- In this connection the studies of the JRC should also be discussed in addition to the work of IFPRI. At first glance it would appear that somewhat lower carbon rates are used per unit area. However, here too a closer look reveals that the result is particularly influenced by the conversion of forests into arable land. In the final analysis this means that any data on carbon per unit area, except for the specific assumptions for forest areas, should be of comparatively little interest. Of course the carbon release rates for the conversion of forests to arable land are comparatively high, compared for example to conservative assumptions (cf. again Tyner et al., 2010).

- Apart from this the question that should be asked for all of the analyzed studies is whether normal agronomical land use leads to a reduction of the carbon content in soils in general. This should be clearly contradicted: In light of the stated data with regard to carbon balances would not all soils then be bereft of their organic substance and gradually erode within a few years? In this connection reference should also be made to the above discussion with regard to the failure to include modern "low tillage" and "no tillage" methods in many of the world's farming systems that are particularly suitable when it comes to storing carbon and minimizing the release of carbon dioxide. Thus such effects that minimize ILUC factors are missing.

Although with all of the necessary concentration on the assumptions in Laborde (2011) the studies of Heiderer et al. (2010) and Marelli et al. (2011) have been accorded selective treatment, the following two points at least may still be specified and/or called into question:

- On the one hand, assignment of regional areas to special vegetation systems and thus allocation of potentially relevant carbon release in the JRC studies appears arbitrary now and again. An example: Why are 60% of the so-called open forests actually covered with as much as 30% in trees, and 40% of such forests with even more than 30%? Where is the scientific proof of this? On the other hand, yield allocations for various land management systems, that appear to be quite uniform, are problematic even with different cultivation intensities. Even the inclusion of organic fertilizers for "no tillage" measures are provided with the same yield factors as in the case of "full tillage" measures, knowing that – due to the more or less delayed biological conversion processes of the source material – such inclusion and thus the respective yield effects should clearly differ from each other and in fact also do in practice.

- On the other hand, the fact that the carbon stocks of annually cultivated plants are equal to zero in the JRC studies (and probably in Laborde, 2011 too, but not so obviously) must be touched upon. The fact that integrated crop farming systems are most certainly capable of building up carbon stocks (see, among other things, Core et al., 2012) is completely negated. This is crucial for the calculation as the accumulated carbon dioxide release is thus greater and/or the concurrent carbon dioxide sequestration that accompanies the release processes is lower than what should be realistically assumed.

Thus there are numerous indications that – based on the assumptions made – the GHG emissions calculated are in the final analysis comparatively high, which naturally drives up the ILUC factor. To what extent this applies to the design of the methodological tools in EC (2012a) remains a largely open question for the already repeatedly stated reasons which cannot even begin to be answered here.

5 Discussion of the Scenarios and Results

The arguments with regard to the models, data and assumptions already allow for the conclusion that despite a careful scientific approach, in particular in the work of the IFPRI and JRC, several uncertainties must be reckoned with. However, that is also not surprising. This field of research continues to be new and must still be developed. The analyses considered here are a reflection of this.

The apparent uncertainty is also revealed in the results obtained. In order to be able to evaluate them the respective scenarios still have to discussed:

- Scenarios are calculated by Laborde (2011) in various ways. In fact the aforementioned Monte Carlo simulations (approximately 1,000 simulations runs are calculated altogether) may already be designated as such.

- Furthermore, there are two different liberalization scenarios in Laborde (2011). In principle these scenarios, like all scenarios otherwise – including those in the other analyses – are subjectively defined and therefore do not lend themselves to objective evaluation. Nevertheless one is given to question the relationship that the free trade scenarios have to reality, although it should be noted that this hardly has any influence on the level of the (uncertain) results.

- Heiderer et al. (2010) also employ the (earlier) IFPRI scenarios which we not be further discussed here because with her update of Heiderer et al. (2010) Marelli et al. (2011) directly adopts the scenarios from Laborde (2011) and they have already been characterized in brief.

- Reference must also be made two scenarios examined by the JRC which use AGLINK-COSIMO and which employ different levels of disaggregation for mapping grain in the individual analyses. Apparently it is not possible for the authors to appropriately map corn as a raw material for the production of bioethanol in all of the defined model regions. This should certainly be regarded as an additional and very special data limitation in the JRC approach. The degree of detail for the relevant scenarios that is required for meaningful conclusions – particularly for bioethanol – is thus not obtained.

- Common to all of the scenarios of the IFPRI and JRC is that they attempt to adequately model valid political objectives of the EU when the studies were prepared. There can be no objection to this. The transparency is also unobjectionable – it may be affirmed that all of the IFPRI and JRC authors describe the respective scenarios with great transparency and thus comprehensibility. All in all a good overview of possible future prospects (based on the assumptions made) is provided; however, no more than that.

In the following then the individual results of the respective scenarios shall not represent the point of interest, but rather the consequences derived from their observation over all scenarios together with the results of model-based calculations. The following conclusions are to be drawn:

- The large variation in the concrete results is conspicuous. One is first inclined to attribute this to the concrete scenario definition, the models and parameter selection. However, the determined ranges, in particular for the target variables, that determine the ILUC factor which is of particular interest here, are enormous. Can it really be the case that the use of established and recognized agronomic models results in (I)LUC which, for example, amounts to 0.8 million hectares in the one instance, but then accounts for 5.2 million hectares in another and cause additional global emissions of carbon dioxide which are supposed to be more than 200 million tons on the one hand, but on the other more than fivefold that amount, i.e. more than one billion tons?

- Any attempt to answer this question involves at least two aspects: On the one hand it is obvious that the uncertain data situation and thus the adopted data conventions and, above all, assumptions are crucial for this broad variation; the authors are also aware of this fact and make repeated reference to it. However, that is also because of the models and procedures employed on the other hand. As a rule the economic models use exponential functions and thus arrive “on the margin” of greater effects than, for instance, in the case of a linear mean value analysis as is often characteristic of calculatory approaches. The further one then moves away from the reference system in such a log-linear algorithm, the more drastic the deviations must become. This is completely uncritical in a cleanly formulated, i.e. theory-based economic model because only marginal costs and marginal utilities then determine decision-making in this case. However, in the concrete studies of interest log-linear economic models are combined with scientific coefficients and biophysically determined, linear methods of analysis. That then leads to results that may be regarded as doubtful at least, but which are absolutely critical for the content of the analyses.

- In concrete terms what is naturally involved is the emission factor from (I)LUC which is attributed to individual primary agricultural products as a result. Actually one should believe that this rather technically dependent factor might vary between crops, but be in the approximate same order of magnitude within a crop across all scenarios since a crop should always have similar space requirements and is unable to occupy completely unlimited space. However, this is obviously not the case. Thus, for example, in the specified studies carbon dioxide emission factors from (I)LUC were calculated for wheat (without considering uncertainties by means of, for example, Monte Carlo simulations) that lie between just over 10 and nearly 40 g of carbon dioxide per MJ from primary agricultural products. The ranges are similarly wide in the case of other crops as well. In this case feedback that must be obtained through research is required both in terms of model theory and in terms of procedure. At this point in time a critical view of this result in particular would at least have been desirable, especially since a tendency toward excessively high ILUC factors had already been indicated.

- Apart from the concrete level of the respective target variables of the analysis, which cover a large range, the Monte Carlo simulations indicate additional uncertainty: If, for example, the determined standard deviation permits enormous deviations from the mean value to sometimes appear plausible, then this only suggests that the (average) results are actually not reliable. That is true particularly since the Monte Carlo simulations, as described above, attempt to expose only one – and not even the most important – part of the implied uncertainty; namely, the carbon content of vegetation systems.

In view of the premature state of scientific knowledge of the subject under investigation and the associated uncertainties it must be stated that in the final analysis we in no way know the level and, at times, not even the direction of carbon dioxide flows caused by the biofuels production that is of interest here.

Even if one wanted to regard the obtained results as a reasonably accurate reflection of reality (as already stated – the IFPRI and JRC authors at least expressly advise against doing so, and stress tests that would increase the reliability of the results were not conducted), other problems continue to exist and/or questions remain open and at least require explicit attention when it comes to interpretation of the results:

- As far as the various scenarios are concerned it would make sense to discuss, for example, of the share of biodiesel and bioethanol in energetic biofuels production: The assumed relationship for the EU is approximately 4:1 in the respective scenarios. For this reason reference is made to the fact that according to recent figures, at least for Germany, a principal producer of biofuels within the EU, that the relationship is currently more like two to a third (BLE, 2013). Laborde (2011), on the other hand, expects such a close relationship only as of the year 2020, i.e. the target and not the initial year of the analysis. However, since bioethanol displaces less land (because the source materials have a higher usable energy density per hectare), a degressive effect on LUC and an effect that lowers the ILUC factor should be ascertainable through corresponding additional observation of this development already in progress.

- Ultimately the carbon dioxide emissions should again be less than indicated if for ILUC instead of 20 years as the basis for the greenhouse gas balance, but rather a longer period – say a period of three to five or even more decades – is used in which in the reverse case an ecological system is able to more or less completely regenerate in the absence of human influence. Although this period of 20 years has met with wide acceptance in the overall analysis – because of its stipulation through relevant political directives (cf. EC, 2012a) – it remains scientifically unfounded nevertheless. A sensitivity analysis that extends the relevant period would have been helpful here as well.

- And finally, it was already indicated and/or reference was made to the fact that in the actual sense of the term no ILUC effects at all, but instead only LUC effects are shown in the IFPRI and JRC studies. Nevertheless the reader who is familiar with the methods is at least able to approximately infer land conversion determining ILUC (i.e. unmanaged) from unspoiled vegetation systems into managed agricultural systems: To the extent derivable, they amount to only approximately 1% of the ILUC effects also expected by the authors even without the additional production of biofuels up to the year 2020 (cf. Laborde, 2011: p. 36 and p. 56). The smallest share of ILUC in the target year 2020 is then attributed to bioethanol. In other words, biofuels are a less relevant determinant. This applies even more so in the case of bioethanol.

This appears to be of particular interest for the pending political decision-making, likewise an outcome of EC (2012a) that is to be mentioned here as well in a concluding discussion of the results:

- In the above it was already emphasized that EC (2012a) neither grants access to the concrete methods, nor to several central data and assumptions. Insofar it is not possible to evaluate whether or not the political projects proposed in the study, i.e. more or less substantially, but always intervening in the production of bioenergy, are right or wrong. Nevertheless there is surprising and striking result in EC (2012a): In a scenario of "no policy action needed" (various possibilities for political intervention are defined as scenarios) political targets formulated with RED and/or FQD with respect to avoidable GHG emissions have already been achieved. From a scientific perspective within the meaning of appropriate consideration of the ends and means, this would not indicate a need for political action. The question to be asked is why the authors of the EC study fail to regard this as generally opportune?

- Against this backdrop and the less than transparent representation, the "impact assessment" of the European Commission provided with EC (2012a) cannot be regarded as a sound scientific analysis; perhaps instead as a group of arguments in anticipation of a possibly desired change of policy in the future.

It remains to be stated that in the final analysis the evaluated studies provide room for possibilities in which LUC and the resulting ILUC factors triggered by the production of biofuels in the European Union may be found; but no more than that. On the contrary, (I)LUC and carbon dioxide emissions often appear to be calculated in a manner that locates both central target parameters of political decision-making "at the upper limit" of the actual area.

6 Conclusions for Making Policy Decisions

Prior to the actual conclusions drawn from this analysis it should be noted that the authors of the present expert opinion by no means negate the fact that LUC and, above all, ILUC represent real phenomena which, however, has existed already since the initial days of agricultural use, but has only now grown in the public perception because of the increasing destruction of intact, unspoiled ecological systems and GHG emissions have become the subject of discussion and found their way into the focus of interest. We agree, for example, with Stern (2007), Searchinger et al. (2008), Tyner et al. (2010) and a number of other colleagues in terms of the risks associated with (I)LUC for economic, social and, above all, ecologically sustainable development. These risks cannot simply be discounted and must be minimized precisely by means of suitable regulatory framework conditions.

Taking this into consideration, ten conclusions and/or recommendations for action should be noted:

1. Political efforts to regard ILUC as part of the climate balance of bioenergy sources are legitimate. They even necessarily follow from the Renewable Energy Directive because the latter stipulates that the European Commission must needs evaluate inclusion of an ILUC factor when calculating GHG emissions, whereas the basis shall be provided by the most recent scientific knowledge (cf. European Parliament and the Council of the European Union, 2009).

2. However, it is questionable whether the execution of this evaluation to include an ILUC factor must also result in immediate inclusion of such an ILUC factor in the climate balance of bioenergy sources. In fact there are still several aspects to the contrary in light of the imponderables of scientific analysis presented and even repeatedly stressed by the authors of the respective studies, again most recently by Laborde and Lahl (2013).

3. In our opinion it should again be emphasized that the scientific analysis of ILUC – in particular, but not only within the scope of biofuels production – is still a new technical academic discipline. The first substantial, broadly reflected work appeared only five years ago (Searchinger et al., 2008). Even if there has since been a lively exchange of experience among academics in cooperation with scientists and stakeholders from politics and industry – which also led to the attested scientific substance of the studies analyzed here – it must be affirmed that the existing quantitative results remain largely unsubstantiated. With regard to LUC and ILUC factors they are exaggerated in part and thus are still not very reliable.

4. For one thing this is because of the models and methods. On the one hand they have already been tested, but in this concrete case they still require substantial and resolute further development. The methods and models used in the various academic studies represent a high scientific standard when it comes to agronomic components. However, the calculatory and biophysical procedures linked to these components still require further scientific underpinning. In addition, the interfaces between theory-based log-linear economic models and

other rather linear scientifically determined models must also be further developed. To state it in clear terms: Science is still at the stage of method development and adjustment to a recognized standard. However, such a standard is still a long way off.

5. This is also reflected in the data and information employed as well as the assumptions made in the various studies. Although myriad numerical facts were inferred from official statistics and "peer-reviewed" work, the situation as far as data is concerned remains insufficient as a whole and beset with numerous gaps. At the moment these gaps are being filled through the transfer of "expert knowledge" and assumptions that are not always reproducible and thus too are not objectively justifiable. Subjectivity (motivated by special interests) and multiple uncertainties, which thus far have only just begun to be eliminated i.e. exposed, continue to exist at least in part.

6. All of this has an impact on the results of the work and, above all, reflects the fact that science still has "a good way to go" before dependable information within the meaning of reliable knowledge can be generated. Thus there appears to be a need for political action, then one that is first and foremost concerned with research policy that aims at further development of the existing expandable substance.

7. Against this backdrop any policy-induced analysis that goes so far as to – not only as required by the Renewable Energy Directive – evaluate the ILUC problem, but beyond that already determine concrete ILUC factors for political decisions cannot be characterized as reasonable, but rather arbitrary.

8. It is not the scientific studies that are doubtful, because they only represent the still incomplete, actual level of knowledge. What is doubtful is the political treatment of the various studies. In order to establish an ILUC factor a largely reliable and thus robust methodical and data basis is still wanting. The present state of scientific knowledge is not a sufficient basis for a legislative process as is currently pending. The risk of inadvertent steering effects, i.e. market distortions and misallocation of resources (see also further down) of insufficiently reliable policy decisions (or "mistaken" policy) should be noted.

9. Apart from the fact that in the concrete case (the connection between bioenergy and ILUC) still existing methodical and data uncertainties make political decision-making appear to arbitrary, a completely different question arises with regard to the special relevance of determining ILUC factors particularly for the production of biofuels. Biofuels are only one of many determinants that may lead to ILUC. Singular, politically motivated "punishment" of biofuels production should be rejected for this reason alone.

The fact that ILUC happens is the result of an increase in demand and the scarcity of supply on international agricultural commodities markets in general. In such a context all of the special factors that either curtail the supply or increase the demand are, without exception, “relevant for the system”; many of them even more so than biofuels (cf. also Noleppa, 2013). Put differently, if an ILUC factor for bioenergy is desired, then:

- one is also required for organic farming, because smaller yields per unit area also reduce the supply and thus cause ILUC effects;
- meat consumption would have to be taxed accordingly, particularly among men because they eat more meat than women; and more meat consumption means more soybean and more grassland at the expense of tropical rain forests;
- an ILUC effect would likewise have to be evaluated for reforestation and ecological restoration programs as well as for “greening” measures in the EU, because agrarian land that has been reconverted or hardly cultivated is replaced with new agrarian land elsewhere in the case of global markets;
- an ILUC factor would also have be applied to higher incomes, because with higher incomes there is even greater demand for food that requires a particularly high level of natural resources;
- agricultural enterprises and production methods in the EU that are more productive in terms of the amount of land required would have be to less burdened because their relative surplus production reduces the ILUC effect; and
- in order to cite a final example, research and development with regard to innovative agronomic technologies as well as the upstream and downstream sectors of the output chain would also have to be provided with an ILUC bonus.

This list could be set forth and corresponding ILUC factors would naturally then have to apply worldwide, and not only in the EU. Otherwise market distortions and changes in the competitiveness of individual agricultural sectors in the EU would be the inevitable consequence. In one of the studies examined here Laborde (2011) already expressed himself quite aptly, indicating that one should consider whether “Pandora’s box” should actually be opened.

10. Finally reference should be made to the following: Direct market intervention, as represented by the proposed particular options for political decisions is not an appropriate approach. As long as the complex system behind the emergence of ILUC is not more comprehensively explained and the respective methods made more reliable and certain, i.e. further developed, such regionally postulated negative market incentives will only result in shift effects and not even begin to solve the problem of ILUC and may even intensify it. It would make more sense to begin with the real causes of ILUC, i.e. the small and declining rate of growth of land productivity in EU agriculture.

Bibliography

BLE (German Federal Office for Agriculture and Food) (2013): Evaluation and Progress Report for the Year 2012: Regulation Regarding the Sustainability of Biomass Produced for Electricity and the Biofuels Sustainability Regulation. Bonn: BLE.

EC (European Commission) (2012a): 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'. Commission staff working document. Brussels: EC.

EC (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. Brussels: EC.

European Commission (2007): Grain: Council Approves Zero Set-Aside Rate for Sowing from Autumn 2007 and Spring 2008. Brussels: European Commission.

European Parliament and Council of the European Union (2009): Directive 2009/28/EC of the European Parliament and of the Council from 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. In: Official Journal of the European Union L 140/16 from 5 June 2009.

FAO (Food and Agriculture Organization) (2013): FAOSTAT: Production: Crops. Rome: FAO.

FAO (Food and Agriculture Organization) (2012): Technical conversion factors for agricultural commodities. Rome: FAO.

Finkbeiner, M. (2013): Indirect Land Use Changes in Life Cycle Assessments – Scientific Reliability and and Agreement with International Standards. Berlin: VDB and OVID.

FNR (Specialized Agency for Renewable Resources) (2012): Planting Renewable Resources in Germany 2012. Gülzow: FNR.

Grain-Club (2013): ILUC Directive Jeopardizes Rapeseed Planting and Protein Supply in Europe. Berlin: German Raiffeisen Union.

Hedi-Bchir, M.; Decreux, Y.; Guerin, J.L.; Jean, S. (2002): MIRAGE: un modele d'equilibre general calculable pour l'evaluation des politiques commerciales. In: Economie Internationale 89-90, p. 109-153.

Hiederer, R.; Ramos, F.; Capitani, C.; Koeble, R.; Blujdea, V.; Gomez, O.; Mulligan, D.; Marelli, L. (2010): Biofuels: A new methodology to estimate GHG emissions from global land use change: A methodology involving spatial allocation of agricultural land demand and estimation of CO_2 and N_2O emissions. Luxembourg: Publications Office of the European Union.

Kern, M.; Noleppa, S.; Schwarz, G. (2012): Impacts of chemical crop protection applications on related CO(2) emissions and CO(2) assimilation of crops. In: Pest Management Science 68, p.1458-1466.

Laborde, D.; Lahl, U. (2013): Joint opinion on indirect land use change by David Laborde, IFPRI, and Prof. Dr. Uwe Lahl, Technische Universität Darmstadt. Washington, DC: IFPRI.

Laborde, D. (2011): Assessing the land use change consequences of European biofuel policies. Final Report October 2011. Washington, DC: IFPRI.

Langeveld, J.W.A.; Dixon, J.; van Keulen, H.; Quist-Wessel, P.M.F. (2013): Analysing the effect of biofuel expansion on land use in major producing countries: Evidence of increasing multiple cropping. Biomass Research Report 1301. Wageningen: Biomass Research.

Marelli, L.; Ramos, F.; Hiederer, R.; Koeble, R. (2011): Estimate of GHG emissions from global land use change scenarios. Luxembourg: Publications Office of the European Union.

McCalla, A.F. (2010): Empirical approaches to trade modeling: computable general equilibrium and partial equilibrium. Davis, CA: University of California.

Noleppa, S.; Hahn, T. (2013): The value of Neonicotinoid seed treatment in the European Union: A socio-economic, technological and environmental review. HFFA Working Paper 01/2013. Berlin: HFFA.

Noleppa, S.; von Witzke, H. (2013): The Social Significance of Plant Breeding in Germany: Influence on Social Welfare, Food Supply, Climate and Resource Protection. HFFA Working Paper 01/2013. Berlin: HFFA.

Noleppa, S. (2013): Biogas Production and the “Food or Fuel” Debate: Description of the Situation and Model-Based Analysis. agripol research paper 2013-01. Berlin: agripol.

Noleppa (2012): Climate Change on the Plate: Nutrition, Food Loss, Climate Impact. Berlin: WWF Deutschland.

OECD (Organization for Economic Cooperation and Development); FAO (Food and Agriculture Organization) (2013): OECD – FAO Agricultural Outlook 2013-2022. Paris: OECD.

OVID (Association of the Oilseed Processing Industry in Germany): (2013): European Parliament Committee on the Environment, Public Health and Food Safety Sends Disastrous Signal. Berlin: OVID.

Riffell, S.; McIntyre, N.; Hayes, R. (2008): Agricultural set-aside programs and grassland birds: Insights from broad-scale population trends. In: Landscape Online 8, p. 1-20.

Searchinger, T. (2013): Understanding the biofuel trade-off between indirect land use change, hunger and poverty. Princeton, NJ: Princeton University.

Searchinger, T.; Heimlich, R.; Houghton, A.; Dong, F.; Elobeid, A.; Fabiosa, J.; Togkoz, S.; Hayes, D.; Yu, T.-H. (2008): Use of U.S. croplands for biofuels in-creases greenhouse gases through emissions from land-use change. Princeton, NJ: Princeton University.

Stern, N. (2007): The economics of climate change: The Stern review. Cambridge: Cambridge University Press.

Tyner, W.E.; Taheripour, F.; Zhuang, Q.; Birur, D.; Baldos, U. (2010): Land use changes and consequent CO_2 emissions due to US corn ethanol production: a comprehensive analysis. West Lafayette, IN: Purdue University.

UN (United Nations) (2010): Deforestation in decline but rate remains alarming, UN agency says. New York: UN.

Vannuccini, S. (2009): The OECD-FAO AGLINK-COSIMO projection system. Rome: FAO.

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