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October 31, 2010

From: **Institute for International Trade Negotiations**
Avenida General Furtado do Nascimento, 740, cj. 81, São Paulo, Brazil
Non-registered organization

By email to: **European Commission**
ec-land-use-change-biofuels@ec.europa.eu

Re: **Consultation on Indirect Land Use Change Impacts of Biofuels**
Comments by the Institute for International Trade Negotiations (ICONE)

In view of our commitment to renewable energy and sustainable development, ICONE and its associates are pleased to submit comments on Indirect Land Use Change and Biofuels. Our submission to the Public Consultation is composed of three different documents.

The document "Responses to the Consultation Document" contains answers to the four questions proposed by the Commission while in "Comments on the Reference Documents" we present comments on each of the analytical studies conducted. An Excel file containing the data used for the technical comments is the third document.

Underlying our comments are the following intentions:

(i) To contribute with data, information and technical arguments to the debate of how to treat iLUC under the RED in particular and to the debate about sustainability of agricultural-based biofuels in general;

(ii) To point out the limitations of the methodologies used in the studies and their implications regarding the final results found for LUC and GHG emissions with emphasis on Brazil;

(iii) By showing the limitations of the methodologies in the attempt to model Brazilian agriculture and sugarcane production, to help European policy makers and researchers to better understand the dynamics of the Brazilian agricultural sector and the implications of its expansion on land use change and conversion of native vegetation;

(iv) To provide data and parameters for the studies and models used , thus contributing to future improvements;

(v) To show alternative results for the published results by incorporating more accurate data and parameters on sugarcane, agriculture and land use change in Brazil.

I trust the EC will conduct detailed reviews of those documents and, along with my colleagues in Brazil, remain at your disposal for any questions or comments you may have.

Sincerely yours,

Andre M. Nassar

Institute for International Trade Negotiations

About ICONE

The Institute for International Trade Negotiations (ICONE) is an organization that has become a reference in studies and projects on global and Brazilian agriculture and agribusiness. Such credibility derives from the applied research in the economic and regulatory field. Accordingly, ICONE provides accurate, trend-anticipatory information on the production and trade plans of agricultural products and shows the ways of dealing with them. As a non-profit agribusiness think-tank, the Institute's work often functions as a base for the definition of public policies and for negotiating positions in international trade and other areas that are influential in the agricultural production and trade.

ICONE has five working areas:

- Trade policy and international negotiations
- Emerging economies and agriculture trade
- Agricultural modeling and projections, and land-use
- Agriculture, Trade and sustainability
- Market intelligence

Currently, ICONE is involved in projects and research on biofuels, land-use change, green-house gas emissions, certifications and private standards for trade. Among other capabilities, the Institute developed a land use model for Brazil, aiming to understand the expansion of the Brazilian agricultural sector and its behavior in the near future taking legal constraints into account, the market demand for food, fiber and fuel, and the need to engage in low carbon agriculture. The Brazilian Land Use Model (BLUM) was developed by ICONE in association with the Food and Agricultural Policy Research Institute (FAPRI). Using BLUM, ICONE has submitted technical comments on the studies of the Environmental Protection Agency (EPA) for the US National Renewable Fuel Standards (RFS). This technical paper was analyzed by JRC in "Biofuels: a New Methodology to Estimate GHG Emissions from Global Land Use Change" (Hiederer et al., 2010), as well as in the literature review (Study 4). Several data and arguments presented in this submission were constructed along with the BLUM development.

European Commission Public Consultation on Indirect Land Use Change

Responses to the Consultation Document

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Responses and comments on the four questions raised by the European Commission are based on and substantiated by the document "Comments on the Reference Documents" attached to this report.

1) ***Do you consider that the analytical work referred to above, and/or other analytical work in this field, provides a good basis for determining how significant indirect land use change resulting from the production of biofuels is?***

We believe that publishing the results of all models and studies for public consultation was a good initiative on the part of the E.U. However, as we have argued in "Comments on the Reference Documents", results for sugarcane ethanol (LUC and iLUC factor) are still not satisfactory. Three main reasons justify the need for improving the models:

(i) Projections on sugarcane and ethanol yield, given that models are projecting smaller yield growth as compared to historical trends;
(ii) Poor analysis or lack of analysis on pasture intensification which leads to an overestimation of land use change resulting from the expansion of biofuels. Pasture is the largest land user in Brazil and there has been high cropland expansion in this land category in the current decade;
(iii) Lack of evidence supporting the criteria used to allocate marginal land demand over native vegetation. The main criterion was historical data that is either not accurate in some cases and/or based on the assumption that additional cropland due to biofuels expansion will determine a frontier advancement similar to what has been observed historically. The frontier advancement in the past resulted from several simultaneously acting variables and therefore its use as a coefficient for land extension is not appropriate.

Our specific recommendation is to improve IFPRI-MIRAGE and Aglink models with more accurate data on Brazil and have a rerun of the simulations. The authors of this document are available to provide all necessary data and expert advice for the European Commission.

As the European Commission has decided to address the issue of indirect land use change in the context of the Renewable Fuel Directive, so should the Commission also consider the issue in a broader perspective. Although economically iLUC is a defendable concept, the large discrepancies in the results of the studies carried out by the Commission reinforce the argument that good measurements of land use indirect impacts are hard to achieve. Comparing the results of economic models expressed in LUC units (Kha/Mtoe) with the results on GHG emissions (iLUC factor) calculated by the spatial allocation model (Hiederer et al., 2010) it is clear that the methodology to convert land use change in GHG emissions is crucial for the final result. Findings on iLUC factor can be four times higher (Hiederer et al., 2010, page 1) just by changing assumptions about the type of land converted, thus turning a complying biofuel with RED thresholds for iLUC into a noncomplying biofuel. Because of such several uncertainties associated to iLUC's measure and the need to combine different models to establish quantitative measures, it's our opinion that the EC cannot miss the opportunity to take advantage of the great efforts made outside the EU to assess iLUC's impacts. Our report is a summary of the main work developed in Brazil.

We came to the conclusion that once models and methodologies are improved, it will become clear that iLUC is not a conclusive topic on deciding for or against the adoption of biofuels. On the contrary, iLUC is a topic that can be managed with good policies, which can change iLUC factors estimated by models. At the moment, iLUC factors are associated to penalties on emissions that are not under farmers or biofuel producers' control. A better approach would be to set bonuses and rewards for good practices that reduce emissions. It is part of the role of the EC to recognize that land use changes are inherent to any agricultural or forest activity for producing food, fiber, feed or bioenergy; and although it is important to measure it in biofuels, these are much less responsible for land use change than other markets. An ILUC factor would not solve the problem of destruction of carbon rich habitats, which have other drivers. Finally, indirect unintended effects are not only caused by biofuels, or biofuels-stimulating policies; it is also caused by any policy, and most of all by the production process.

The following paragraphs summarize some key topics of the studies reviewed according to a breakdown by study.

From Study 1 (Fonseca et al., 2010)

AGLINK may be useful, although it requires advances:

- The global representation of land use currently lacks land use in Indonesia and Malaysia, potential suppliers of biodiesel from palm oil;
- Better understanding or explanation about its results, since one important finding lacks economic intuition: when the mandated is applied to aggregate biofuels without specifying ethanol and biodiesel shares, the biofuel mix shifts in favor of ethanol, but the global impact on arable land increases by a further 1.1 million hectares. Since some ethanol crops have higher yields than biodiesel crops, the area needed for biofuels should be lower if ethanol increases in the biofuel mix;
- It does not consider multicropping, as explained in section 6.12.2;
- It does not model pasture area, assuming that marginal expansion of cropland necessarily displace native vegetation ecosystems.

The current formulations of ESIM and CAPRI are not suitable:

- They lack global coverage of land use changes and agricultural markets;
- They assume sugar will be imported to be converted into ethanol, which may prove less efficient (and then less observable in the real world) than producing sugar ethanol from sugar-cane and importing it;
- Biofuel international trade is not represented in CAPRI.

From Study 2 (Al-Riffai et al., 2010)

MIRAGE may be suitable to provide a good understanding of land use changes and emissions from biofuels. However, it must be improved in several ways:

- Assumption about the value of marginal land productivity lacks scientific evidence and seems to overestimate land use changes and emissions;
- Baseline projections need to be revised to reflect observed data;
- The use of byproducts from sugarcane ethanol (bagasse) to generate electricity is not considered, although it is observed and is an increasing trend in Brazil.
- Soil carbon stocks need to be revised for specific regions and crops (e.g.: Brazil);
- The methodology to estimate marginal ILUC effects lacks a scientific explanation to the choice of shocking the model in 2020. It is important to know how a different choice of shocking date would impact the results;
- Technological progress in the crushing, distilling and biofuel production activities is ignored. Exogenous trends in yields improvement in such activities should be incorporated;
- The version of MIRAGE used here has substantial changes, including the land use module. It hasn't been peer reviewed yet;
- Land and fertilizer substitution are important aspects to take into account, but more investigation into them is required, e.g. estimates on elasticity;
- The choice of the elasticity of land expansion twice bigger in a particular region (Brazil) than in all others lacks scientific or empirical evidence. Some correction in this number is needed;
- The life cycle period lacks a scientific justification.

From Study 4 (Edwards et al., 2010)

The model comparison shows a wide range of results among models coming from similar shocks, which makes it difficult to reach the overall conclusion about the model results. However, it helps to identify those models whose results seem to be out of a reasonable range or cannot be understandable. That having been said, the comparison is useful to identify a general pattern regarding which kind of biofuel and feedstock systematically generates the lowest land use changes when the same pattern is observed in several models. The following aspects should also be considered:

- LEITAP results were both not reasonable and hard to explain or understand;
- The study forces the idea that models underestimate land use changes due to lack of consideration of decreasing yields in new cropland. Such idea was not based on reasonable scientific or empirical evidence.
- The absence of pasture in the models tends to overestimate conversion of natural vegetation, especially in Brazil (see section 6.12.3).

2) *On the basis of the available evidence, do you think that EU action is needed to address indirect land use change?*

The EU should carry out further research and investigation in order to decide whether it should apply an iLUC factor and/or consider simple and objective criteria to address indirect land use change, rather than creating a very complicate set of rules that would only raise uncertainties in the market and over-punishing less LUC intensive biofuels. Therefore, we believe that the EU does not have enough information to use a feedstock-based iLUC factor as the main measure to quantify iLUC of biofuels.

The studies carried out by the EC, though requiring several improvements were able to show that different feedstock have different LUC intensity. The EU should, therefore, recognize those differences; in doing so, the RED should promote the consumption of more efficient biofuels and stimulate the development of technologies that will promote the reduction of LUC impacts.

The following paragraphs respond the question from the perspective of the results found in the studies.

From Study 1 (Fonseca et al., 2010)

- We believe it is not possible to affirm that EU action is needed based on the results from AGLINK, ESIM and CAPRI.

From Study 2 (Al-Riffai et al., 2010)

- MIRAGE suggests that indirect land use change is important and highly dependent on the feedstock and biofuel types. Since the model indicates some feedstocks to be more efficient than others in reducing emissions, it is natural to expect that the EU should foster the more efficient ones.

From Study 4 (Edwards et al., 2010)

- The model comparison indicates, in general, that some feedstock and biofuels generate less land use changes than others. Hence, it is expected that the EU should foster those with lower land use changes.

From Study 5 (Hiederer et al., 2010)

- Once the study is improved in the issue of allocating marginal cropland expansion on native vegetation, and feedstock-based iLUC factors are calculated, the study will certainly be useful to guide EU actions.

3) If action is to be taken, and if it is to have the effect of encouraging greater use of some categories of biofuel and/or less use of other categories of biofuel than would otherwise be the case, it would be necessary to identify these categories of biofuel on the basis of the analytical work. As such, do you think it is possible to draw sufficiently reliable conclusions on whether indirect land use change impacts of biofuels vary according to: feedstock type? Geographical location? Land management?

Although the most important study in terms of measuring LUC GHG emissions (Hiederer et al., 2010) had calculated a scenario-based iLUC factor, rather than a feedstock-based one, all models simulations have shown, crystal clear, that the feedstock type helps to identify different biofuels in terms of impacts on land use change. However, establishing an iLUC factor at this stage will necessarily overstate LUC GHG emissions for all feedstocks, and more research is necessary to classify different categories of biofuels and its use in LCA results.

Although iLUC can vary according to geographical location, we believe that it has two basic problems that undermine its use as an iLUC assessing criterion: (i) it will necessarily over-punish feedstocks produced in countries with land availability and under-punish regions that have converted all native vegetation to agriculture before the entry force of the biofuels policy; (ii) it will punish countries with high potential to produce efficient biofuels (such as some African countries) that are not relevant current suppliers.

Land management is an adequate criterion if used in a positive manner, awarding bonuses for land practices that are more sustainable and more efficient in carbon uptaking. Differently from the iLUC factor, land management can be applied to individual companies.

The responses based on the analysis of each study are presented below:

From Study 1 (Fonseca et al., 2010)

- It does not allow for more definitive conclusions on the most desirable types of biofuels.

From Study 2 (Al-Riffai et al., 2010)

- The study identified the feedstock and biofuel types that account for lower and higher marginal emissions. It should be expected that the most efficient feedstock and biofuels should be encouraged (sugarcane and sugar beet ethanol). With the possible model improvements pointed before, the emissions efficiency of such types of feedstock should be improved.
- As a higher biofuel target reduces emissions savings from biofuels due to the use of less efficient feedstock, the use of more efficient feedstock categories should be encouraged at the expense of less efficient ones for higher biofuel mandates.
- Figures 9 and 10 show that average indirect land use emissions and direct emissions savings are more favorable with trade liberalization. Also, as the most efficient feedstock is the sugarcane, one important conclusion is that trade liberalization should contribute to lower emissions from EU biofuel mandates.

From Study 4 (Edwards et al., 2010)

- The model comparison indicates that sugarcane ethanol is the one promoting lower land use changes from AGLINK results, and that IMPACT model has systematically lower land use impacts than AGLINK for similar scenarios, but does not simulate sugarcane ethanol. It suggests that, if IMPACT could be used to simulate the sugarcane ethanol scenario, it would give a lower marginal LUC than AGLINK. That having been said and considering that the AGLINK sugarcane ethanol scenario presented one of the lowest marginal impacts, it is clear that this biofuel type is the one with lowest land use impacts, confirming the MIRAGE results from Study 2. In summary, sugarcane ethanol should be promoted.

From Study 5 (Hiederer et al., 2010)

- Unless feedstock-based iLUC factor is calculated, it does not allow too much conclusion on more desirable types of biofuel.

4) Based on your responses to the above questions, what course of action do you think appropriate?

The EC does not have enough information and accurate measures to adopt the iLUC factor as the main criterion to tackle indirect land use changes impacts and define a course of action to establish feedstock-based factors. However, based on the studies published for public consultation, all technical comments received and recognizing the need of improving the simulations, the Commission will be able to develop a program to get feedstock-based iLUC factors established in the near future. That will require postponing RED deadline of December 2010, thus allowing more time to improve the process and the credibility of any decision to be taken by the European Commission.

In any case, the EU approach to the role of the iLUC factor should be reviewed. Rather than establishing it as a penalty that might potentially take out a biofuel from the market, the iLUC factor should be established as a target to be complied with in a phase-in period. In parallel, the EU should promote discussions to define criteria to establish bonuses for well-known iLUC mitigating production practices.

From Study 1 (Fonseca et al., 2010)

- More research (models refinements to better represent land use coverage and changes, better understanding of models mechanisms).

From Study 2 (Al-Riffai et al., 2010)

- More research to improve parameters and science behind the model;
- Encourage sugarcane ethanol use to attend the EU mandate;
- Encourage the trade liberalization of sugarcane ethanol.

From Study 4 (Edwards et al., 2010)

- More research to improve parameters and science behind the models.
- Encourage sugarcane ethanol use to comply with the EU mandate.

European Commission Public Consultation on Indirect Land Use Change

Comments on the Reference Documents

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October 2010

Summary

1. Introduction

This report encloses comments on the following reference documents publicized by the European Commission for the "indirect land use change and biofuels" (iLUC) public consultation:

- Study 1 (JRC-IPTS): Impacts of the EU biofuel target on agricultural markets and land use: a comparative modeling assessment, Fonseca et al., 2010.
- Study 2 (IFPRI-MIRAGE): Global Trade and Environmental Impact Study of the EU Biofuels Mandate, Al-Riffai et al., 2010.
- Study 3: The impact of land use change on greenhouse gas emissions from biofuels and bioliquids -Literature review.
- Study 4 (JRC-IE): Indirect Land Use Change from Increased Biofuels Demand, Edwards et al., 2010.
- Study 5: Comments on the study "Biofuels: a New Methodology to Estimate GHG Emissions from Global Land Use Change", Hiederer et al., 2010.

The comments presented herein are concentrated in the models (IFPRI-MIRAGE; Aglink in JRC-IE paper, and Aglink in JRC-IPTS paper), scenarios and results that are related to sugarcane ethanol. Other models were also analyzed but in less detail. This report, therefore, is focused on the methodologies to measure iLUC with emphasis on Brazilian sugarcane ethanol.

This report has the following intentions:

(vi) To contribute with data, information and technical arguments to the debate of how to treat iLUC under the RED (Renewable Fuels Directive) in particular, and to the debate about sustainability of agricultural-based biofuels in general;

(vii) To point out the limitations of the methodologies used in the studies and their implications as to the final results found for land intensity (Kha/Mtoe) and GHG emissions;

(viii) By showing the limitations of the methodologies in the attempt to model Brazilian agriculture and sugarcane production, to help European policy makers and researchers to better understand the dynamics of the Brazilian agricultural sector and the implications of its expansion on land use change and conversion of native vegetation;

(ix) To provide data and parameters for the models contributing to their future improvements;

(x) To show alternative results for the published results incorporating more accurate data and parameters about sugarcane, agriculture and land use change in Brazil.

The spreadsheet "ICONE_EC iLUC Consultation_Comments_31oct2010_xlsx" containing several data and calculations described along the text is part of this report.

2. Main Findings

The key results of the 4 studies that are discussed therein are the following (one study is a literature review and does not bring quantitative results prepared by JRC or for JRC):

(i) From Edwards et al.: LUC of 134 Kha/Mtoe in scenario Sugarcane Eth Bra (Aglink-IE);
(ii) From Al-Riffai et al.: LUC of 111 Kha/Mtoe and iLUC factor of 17.8 gCO2e/MJ in MEU_BAU scenario;
(iii) From Hiederer et al.: 35% allocation of 481 thousand ha cropland expansion (from IFPRI-MIRAGE results) over closed forest and 30% allocation of 989 thousand ha cropland expansion (from Aglink-IPTS results) over closed forest;
(iv) From Hiederer et al.: iLUC factor of 34 and 41 gCO2e/MJ in IFPRI/BAU and IFPRI/FT scenarios and 63 and 64 gCO2e/MJ in IPTS/CG and IPTS/GM scenarios.

The alternative scenarios presented in this report are:

(i) LUC of 33.7 Kha/Mtoe rather than 134 Kha/Mtoe as calculated in scenario Sugarcane Eth Bra once included pasture intensification with leakage in the frontier and corrected sugarcane yield gain and world sugar production (see section 6.12.8 and attached spreadsheet for detailed explanations);
(ii) LUC of 18.8 Kha/Mtoe for the same scenario described above assuming no leakage of pasture lost in the frontier;
(iii) 83 thousand ha of cropland expansion in Brazil rather than 481 thousand ha calculated in IFPRI-MIRAGE study and 208 thousand ha rather than 989 thousand ha calculated in Aglink-IPTS study once pasture intensification is incorporated in the calculations (see section 7.5).

Although not discussed in detail in this report, two other reports elaborated by the same team responsible for this report are worth being mentioned. In NASSAR et al. (2010)[1] the estimated iLUC factor for Brazilian sugarcane ethanol was 7.63 gCO_2e/MJ and the land intensity associated to LUC was 25 Kha/Mtoe, as described in Table 2-1.

Table 2-1: Land use change GHG emissions and ILUC factor associated to sugarcane expansion in Brazil, 2005 to 2008

Emissions associated to LUC (Ton CO_2eq)	-46,884
Emissions associated to ILUC (Ton CO_2eq)	2,462,069
Total emissions (LUC + ILUC) (Ton CO_2eq)	2,415,186
Additional ethanol production (Ton of total recoverable sugar)	19,672,059
Energy content of additional ethanol production (Giga Joule)	248,330,532
ILUC factor (g CO_2eq / MJ)	7.63
Kha/Mtoe	25

Source: NASSAR et al. (2010)

ICONE (2009)[2] simulating impacts of RFS (EPA Renewable Fuel Standard) provisions on Brazilian ethanol using BLUM (Brazilian Land Use Model) has found an iLUC factor of 21.3 gCO_2e/MJ and a LUC of 43 Kha/Mtoe (results in that paper are neither expressed in gCO_2e/MJ nor in Kha/Mtoe but those measures can be calculated from them).

1 NASSAR, A. M.; ANTONIAZZI, L. B.; MOREIRA, M. R.; CHIODI, L.; HARFUCH, L. 2010. An Allocation Methodology to Assess GHG Emissions Associated with Land Use Change. Final Report (report and detailed spreadsheet available at http://www.iconebrasil.com.br/en/?actA=8&areaID=8&secaoID=73&artigoID=2107).

2 NASSAR, A. M.; HARFUCH, L.; MOREIRA, M. R.; CHIODI, L.; ANTONIAZZI, L.A. 2009; Impacts on Land Use and GHG Emissions from a Shock on Brazilian Sugarcane Ethanol Exports to the United States using Brazilian Land Use Model (BLUM). Report to the U.S. Environmental Protection Agency regarding the proposed changes to the Renewable Fuel Standard Program. Available at: http://www.iconebrasil.com.br/arquivos/noticia/1872.pdf

From a methodological perspective, this report listed several arguments showing the weakness of using historical data on land conversion and occupation to allocate marginal cropland land (additional land for crops as a result of a shock in biofuels demand) over native vegetation as done in Al-Riffai et al. and, though as an intermediary calculation, also in Hiederer et al. As argued in section 7.4 of this document, historical land conversion can be used to define average LUC but not for marginal LUC.

Both alternative results presented in this submission and the results brought by the two reports not part of this submission are very different from those presented in three of the five studies under public consultation. The exception is the IFPRI-MIRAGE report which found results with similar magnitude.

Authors signing this submission, therefore, recommend a complete revision of all results.

3. Study 1 (JRC-IPTS): Impacts of the EU biofuel target on agricultural markets and land use: a comparative modeling assessment, Fonseca et al., 2010

3.1. General comments

Three partial equilibrium models are used, AGLINK, ESIM, CAPRI. It simulates a baseline scenario assuming the EU biofuels target at about 10% by 2020, and a counterfactual scenario without mandatory target for biofuels. The differences in results between the two scenarios are attributed to the biofuel mandate in Europe. All models have limitations: partial equilibrium neglecting energy markets; they have incomplete land use representation, as palm oil land use in Indonesia and Malaysia and pastures are not endogenous; some have limited coverage of countries and world regions. Results are focused more on changes in the markets (supply, demand, trade and prices), although they discuss results in terms of land allocation and demand.

Results are presented in aggregate, making it impossible for external readers to evaluate the contribution of individual feedstock in biofuels production and marginal land required.

3.2. About all models

The authors acknowledge limitations in the models (page 94), being a fact that energy markets are not modeled (all models are partial equilibrium models). They affirm that total biofuel satisfying the EU's targeted share may be overstated in the baseline simulation, and consequently, the simulated land use may be overestimated.

3.3. About AGLINK-COSIMO[3]

AGLINK-COSIMO does not simulate land use effects in Indonesia and Malaysia. It means that not all land use impact resulting from this output expansion is *included* in the quantified global arable land use change. It seems to be an important limitation of the model, since those regions are recognized as important potential exporters of biodiesel from palm oil.

Page ix:

"By contrast, when the mandated share is applied only to aggregate biofuel use rather than to ethanol and biodiesel separately, the biofuel mix shifts in favor of ethanol, and the global impact on arable land increases by a further 1.1 million hectares."

Such result seems strange and need to be better investigated and understood. Some ethanol crops have higher yields than biodiesel crops, which means that the area needed for biofuels should be lower if the ethanol content is increased in the biofuel mix.

The model only projects land demand for crops neglecting land use for pastures. This is a strong limitation due to the fact that results were used in the study "Biofuels: a New Methodology to Estimate GHG Emissions from Global Land Use Change" (Hiederer et al., 2010). The implications of the absence of pastures are discussed in the section 7.5 of this report.

Given that land use effects by countries are presented in aggregate (Table 3.17, total area of wheat, coarse grains, oilseeds and sugar crops), it is not possible to evaluate the contribution of individual feedstock in the marginal demand for land. Crucial information that should be explicitly presented in tables has to be picked out from the middle of the text. On page 52 it is mentioned that the marginal land demand for sugarcane in Brazil is about 600 thousand ha, out of 989 thousand total marginal

3 Because AGLINK-COSIMO model had been used in two different studies, we refer to Aglink-IPTS when referring to the results of the study of Fonseca et al. and Aglink-IE in the case of Edwards et al.

land demands. Table 3.14 indicates an additional demand for land of oilseeds in Brazil of 410 thousand ha (baseline – counterfactual). The difference between total marginal land demand (989 thousand ha) and oilseeds land demand is 579 thousand ha (around the 600 thousand mentioned on page 52). Assuming that 100 percent of that difference is associated to sugarcane expansion and dividing that number by the additional ethanol production (3,065 million liters from Table 3.15), it is obtained an ethanol yield of 4.2 tons/ha. On page 3 4.34 tons/ha is mentioned as the current ethanol yield in Brazil. Therefore, the projected yield is lower than the current one, indicating that the model overestimates land impacts for sugarcane in Brazil (trends in sugarcane and ethanol yields are discussed in section 6.12.5.

Page 54

The authors comment that AGLINK-COSIMO does not consider multicropping. Multicropping is an important agricultural practice in Brazil and if it is not considered, land use results may be overestimated. The implications of multicropping in terms of land demand are discussed in section 6.12.2 using Aglink-IE results. It is also important to mention that wheat is a winter crop in Brazil, generally cropped after soybean harvest, therefore does not compete for land (that topic is also discussed in the same section).

Page 52

Authors comment the results about the sensitivity analysis on endogenous allocation between biodiesel and ethanol. They affirm that there is a shift towards ethanol, especially imported ethanol, implying a much higher area of sugarcane in Brazil (4.6% or 0.6 million hectares) to produce ethanol for export. Also, the additional planted wheat area exceeds the saving in oilseeds area in the globe. Thus, the global cereals area, oilseeds and sugar crops is greater by 0.1% or 1.1 million hectares.

Such results are quite strange, since sugarcane ethanol has higher yields. It would be expected that the global land area of cereals, oilseeds and sugar crops would be reduced, not increased.

3.4. About ESIM

It is stated that the current version of ESIM includes only individual representations of each of the 27 EU member states, Turkey and the USA. All other countries are aggregated into the single block 'Rest of the World'. It suggested that ESIM is limited to address land use changes.

Page x:

It is stated that the EU becomes a net exporter of biofuels (about 0.16 million tons oil equivalent). In principle, it doesn't make much sense from the economic point of view since the model is forcing an increase in the demand of biofuels in the EU, not in the rest of the world.

Page xii:

It is stated that the rates of technical progress for first-generation biofuels, their by-products, and for crop yield growth are exogenous and have been based on past trends, and are subject to considerable uncertainty. There are several studies suggesting an overall trend in crop yield growth in the long run of about 1% per year[4]. So, it doesn't seem that the uncertainty about crop yield trends in the long run is that considerable.

Page 64

Authors describe how the shock is implemented in ESIM:

4 As example, see Reilly, J. and K. Fuglie. (1998). "Future Yield Growth in Field Crops: What Evidence Exists?" Soil and Tillage Research 47: 275-290.

"In addition, EU targets with respect to the share of biofuels in total transport fuels as set out in the Renewable Energy Directive of December 2008 are met. This is achieved in the baseline simulation with the use of shift variables ('shifters'). The shifters enter as multiplicative factors attached to the trend parameters in the human demand functions, and in the oilseed crushing and biofuel production activities"

From above, it seems the shock is applied in the final demand and feedstock demand as also in the biofuel supply. Is it reasonable?

Page 68

Authors comment about the changes in biofuel production:

"Biofuel production in the baseline also increases to about 24.8 million tons oil equivalent by 2020, which exceeds actual demand and results in the EU becoming a net exporter of biofuels (about 0.16 million tons oil equivalent, compared to negligible imports in the base year) (Figure 4.3). Net imports of ethanol in 2020 in the baseline scenario are about 0.15 million tons whereas for biodiesel the EU starts to be a net exporter after 2013, with 0.3 million tons of net exports by 2020."

It seems the way the shock is implemented does not allow international trade to fulfill EU biodiesel demand. The production of biodiesel and ethanol in EU is more expensive than abroad (needs subsidies and tax cuts) and it would be more reasonable to import, or at least, be auto sufficient. So, it is strange that the EU becomes a net exporter of biodiesel.

Page 70

Authors comment that the demand for sugar for ethanol production is more than four times higher, and imports double to accommodate the stronger domestic demand.

It seems the model assumes that sugar will be transformed in ethanol, not sugarcane (maybe because sugarcane is not a product that can be exported and the model does not consider biofuel production outside the EU). In other words, instead of importing ethanol from Brazil, the EU will import sugar and produce its ethanol. It seems a very strange way to model sugarcane ethanol markets. We should think how it can affect the results.

Page 73

About the sensitivity of ESIM to changes in the crude oil price, Table 4.2 compares the results for the counterfactual with the higher oil price against those for the counterfactual with the lower price. Outcomes under the baseline are not involved in this comparison.

It doesn't seem to us that this sensitivity test makes too much sense, since it affects only the counterfactual (without the biofuel directive). It would be better if they had simulated the higher oil price in both scenarios.

3.5. Other comments

Page 18

Revising the literature, the authors say about the GTAP model: "The version of GTAP used in the studies by Hertel *et al*. (2008) and Taheripour *et al*. (2008), known as GTAP-E, has been specially extended to deal with biofuel and climate change policies. For these two exercises, GTAP-E is linked to AEZ, a global land use model that distinguishes 18 different agro-ecological zones. Unfortunately, the value of this addition cannot be fully exploited since the total land area used for crops, pasture and commercial forestry is forced to remain constant. This means that price-induced increases in cropland must be at the expense of pasture or commercial forests, and depletion of rainforests or other ecologically-valuable non-commercial land cannot be simulated."

It should be noted that the area assumed for commercial forestry in GTAP is much larger than the current managed forestry areas, since they consider timber land areas in natural vegetation available to produce wood.[5] It means that GTAP considers some of the effects of increasing the agricultural area, mostly due to expansion of deforestation on woodland from natural forests.

Page 63

Table 4.1 on page 63 shows the conversion factors in ESIM. The table shows that 1 ton of sugar is equivalent to 1 ton of ethanol. It seems ESIM converts sugar in ethanol, instead of sugarcane in ethanol, since ESIM does not consider biofuel trade. It is probably not reasonable to model ethanol markets like that and thus it is necessary to think how it would affect the results. Furthermore, the conversion is not correct, since 1 ton of sugar is equivalent to 1.39 tons of anhydrous ethanol.

Page 80

About the CAPRI model, it only deals with land use in Europe; biofuel trade is not represented and all biofuels are assumed to be produced in Europe. We might think of how it could affect the results, mostly because sugar is being traded with Europe to produce ethanol there. May it be the case that this overestimates the amount of sugar and its land use changes?

Page 97

Authors comment that direct and indirect land use changes potentially alter the greenhouse gases emitted by agriculture, since there are changes in the type of vegetation covering the land and/or changes in the degree of intensity of existing crop cultivation. They affirm that if land is switched from permanent pasture to arable use, net carbon emissions result. It may be the case that switching from pasture to arable will sequester carbon, as it has been noticed in Brazil, when switching from pasture to sugarcane fields. Experimental results show there is an average uptake of 41.1 t C/ ha when sugarcane is expanded over pastureland (Macedo, 2010)[6]. This is explained by the fact that sugarcane is a semi perennial crop and significant tracts of pastureland in Brazil are degraded.

5 See Lee, H.L, Hertel, T. W., Sohngen, B., Ramankutty, N. (2005). “Towards an Integrated Land Use Data Base for Assessing the Potential for Greenhouse Gas Mitigation”. GTAP Technical Paper n. 25, December 2005. On page 42 of this paper it is declared: “The timber types, which are country-specific combinations of management and timber species, are designated M1 through M14.”

6 Macedo, I. (2010) “Biomass and Soil Carbon stock changes in the expansion of sugarcane plantation in Brazil Center South Region”. Report to UNICA.

4. Study 2 (IFPRI-MIRAGE): Global Trade and Environmental Impact Study of the EU Biofuels Mandate, Al-Riffai et al., 2010.

4.1. General comments

A general equilibrium model is used (MIRAGE) to assess the land use changes and emissions from an EU biofuel mandate scenario, as also marginal land use changes due to increase in some specific biofuel types. There are many advances in the modeling part considering many important issues and aspects of the agricultural and bioenergetics markets and recognizing the many limitations in this kind of exercise.

4.2. Exogenous technical progress driving gains in crop yields

The authors do not explain how they estimated the exogenous technical progress reflecting the gains in crop yields, including sugarcane in the historical period (2004-2008) and in the simulation period (to 2020). It remains undetermined if such gains account for gains in the total recoverable sugar, in the case of sugarcane.

The gains assumed in the model in the baseline scenario for Brazil were compiled in the excel file tradoc_145960.xls and are displayed below.

Table B12: Land average productivity (2004 = 1)

		2004	2008	2010	2012	2015	2020
Sugar_cb	Brazil	1.00	1.12	1.11	1.13	1.21	1.36
Maize	Brazil	1.00	1.11	1.11	1.13	1.19	1.33
OthCrop	Brazil	1.00	1.11	1.11	1.13	1.19	1.33
OthOilSds	Brazil	1.00	1.11	1.12	1.14	1.21	1.35
PalmFruit	Brazil	1.00	1.10	1.09	1.10	1.17	1.32
Rapeseed	Brazil	1.00	1.09	1.09	1.10	1.17	1.31
Rice	Brazil	1.00	1.14	1.17	1.21	1.31	1.51
Soybeans	Brazil	1.00	1.10	1.10	1.11	1.18	1.32
Sunflower	Brazil	1.00	1.12	1.11	1.12	1.18	1.32
VegFruits	Brazil	1.00	1.12	1.12	1.14	1.20	1.33
Wheat	Brazil	1.00	1.09	1.09	1.11	1.19	1.34
Cropland	Brazil	1.00	1.06	1.11	1.21	1.30	1.43

About the reference or baseline projections, they may not be reasonable regarding some regions. Biomass and biofuel production and consumption in Brazil need to be compared to observed numbers in 2008 and forecasted by Brazilian institutions for 2010, 2015 and 2020. If the model produces numbers for 2008 reasonably close to the observed statistics, it can be a good indication of passing a validity test. But if 2008 forecasts from the model don't match reality, then the model is weak in representing the real behavior of the markets, and/or the simulated changes from 2004 to 2008 are not good representations of the important economic phenomena driving agricultural and biofuel production.

We have compiled below the sugarcane and biofuel production forecasted in the baseline scenario.

Table B5: Crop production (1000 mt)

		2004	2008	2010	2012	2015	2020
Sugar_cb	Brazil	416,103	459,346	513,886	597,596	708,675	913,385

Table B10: Biofuel production (in million toe)

		2004	2008	2010	2012	2015	2020
Ethanol	Brazil	11.38	11.91	14.55	18.00	21.96	28.51

Table B10b: Biofuel consumption (in million toe)

		2004	2008	2010	2012	2015	2020
Ethanol	Brazil	10.06	10.20	10.36	10.64	11.43	13.06

Table 4-1 presents real data for Brazil for 2004 and 2008. There are several inconsistencies both in 2004 (ethanol production and consumption) and 2008 (sugarcane area and ethanol production) between MIRAGE data and observed data. Those inconsistencies indicate that MIRAGE should be recalibrated in order to represent more accurately the situation of sugarcane and ethanol industry in Brazil.

Table 4-1: Sugarcane production, ethanol production and consumption (2004-2008)

			Source	2004	2008
Sugarcane Production					
	Total	1000 mt	IBGE	415,206	645,300
	For ethanol & sugar	1000 mt	Unica	386,090	569,063
Ethanol production		million toe	Unica	7.8	13.9
Ethanol consumption		million toe	ICONE	6.6	11.3

4.3. Sugarcane byproducts

The modeling approach doesn't consider co-products in sugarcane production in Brazil. The residual material from the sugarcane processing is known as bagasse. It is commonly used to supply energy for the process. But it can also be used to produce electricity to be sold to the grid. The use of sugarcane bagasse to generate electricity surplus is a common trend nowadays. The ability to export electricity is related to the technology employed at the mill. Using only bagasse as fuel mills can reach up to 70 kWh/t cane of surplus electricity[7,8]. The sugarcane trash increases the amount of bagasse, which is being recovered and transported to the mill for processing. This practice can substantially increase the electricity exports. In 2007, mills exported about 3.2 TWh, which corresponds to about 6.8 kWh/t cane crushed. In 2009, the electricity exports reached 5.9 TWh, corresponding approximately to a national average of 9.5 kWh/t cane[9]. This has happened because all new mills are equipped with high-pressure CHP systems, and many of the existing mills have been retrofitted. These more efficient mills are entering into long-term supply contracts with power distribution companies[10]. Looking ahead, when the additional sugarcane biomass (i.e., "trash") is used for power production, the electricity surplus values may increase more than 100 kWh per ton of cane (including bagasse and some of the straw that was previously burned in the field).

The electricity exported by the sugarcane mills can substantially reduce the GHG emissions of the national electricity supply system. Emissions avoided by bagasse-generated energy today are well represented by the emission factor for the Operation Margin (OM). Various methodologies have

7 NAE, 2005. Biocombustíveis. Cadernos NAE nº 2 (jan. 2005). Brasília: Núcleo de Assuntos Estratégicos da Presidência da República, Secretaria de Comunicação de Governo e Gestão Estratégica.
8 For further details, please see Technical-economic evaluation for the whole use sugarcane biomass in Brazil, [translation from Portuguese], Joaquim Seabra, Universidade Estadual de Campinas, July 2008.
9 EPE, 2010. Balanço Energético Nacional 2010: Resultados preliminares (ano base 2009). Empresa Brasileira de Pesquisa Energética, Ministério de Minas e Energia, Rio de Janeiro, RJ.
10 See "Brazil to invest $21.2 billion in cogeneration" in The Economist Intelligence Unit (1 December 2008).

been used to complete this assessment (simple or adjusted OM; dispatch data analysis; average OM) but the use of dispatch data is the most recommended. The emission factor may then be calculated as the weighted average of the emission factors for power generation units supplying 10% (of total dispatched energy) at the lowest priority dispatch (calculated each hour).

Since the additional excess bagasse is being used to avoid greenhouse gas emissions (from the national electricity grid), the avoided emissions shall be considered as a "reduction". It would represent a classical use for the displacement method.

Therefore, 9.5 kWh/t cane – with 85 L ethanol/t cane; 21.3 MJ/L ethanol; substituting for electricity generated (margin) by Natural Gas (emission factor of 590 kg CO2eq/MWh) – saves more than 3 g CO2eq/MJ ethanol today. This figure will increase significantly in the next years.

We strongly recommend that an electricity credit should be accounted for in the cane ethanol lifecycle analysis.

4.4. GHG emissions coefficients

On page 38 the authors affirm that "the study considered emissions from (a) converting forest to other types of land, (b) emissions associated with the cultivation of new land and (c) below-ground carbon stocks of grasslands and meadows. We rely on IPCC coefficients for these different ecosystems."

IPCC coefficients may not be precise enough to reflect the carbon content in the Brazilian ecosystems. The proposed calculation of the default values for sugarcane ethanol considers the carbon stock values reported by the IPCC. However, when considering carbon stock changes due to LUC in the sugarcane expansion areas in Brazil, two problems arise from the use of conventional "default" values from IPCC: (a) the semi-perennial nature of sugarcane cultivation, and (b) the type of "pasturelands" involved (a mixture of natural and planted pastures, with a large fraction of degraded areas in both). Macedo[11] largely details all those issues, with the experimental results available for carbon stocks for different land uses.

According to the experimental results from CTC (Sugarcane Technology Center)[12] - through 27 thousand measures, 1.1 million ha, over 20 years - the overall average for soil carbon stock for sugarcane crop at a depth of 0-25 cm is 41.61 t C/ha. Based on data in that research, the weighted average for sugarcane areas is 47.6 t C/ha at the standard 30 cm depth; and 71.8 t C/ha at 50 cm. These values refer mostly to burned sugarcane areas, and they are already much closer to perennial than to annual conditions according to the IPCC based results. For the near future most of the sugarcane will not be burned, leading to higher soil carbon stocks.

We strongly recommend the use of these experimental results, instead of the default values from IPCC baseline.

Although it is not explicitly mentioned, the paper induces us to conclude that no biomass and soil carbon uptake in sugarcane was considered. That topic is developed in more detail in section 7.6.

4.5. Estimates of marginal ILUC effects for each feedstock

On page 38 the authors affirm that

11 Macedo op. cit.. (2010).

12 Joaquim, A.C., Bertolani, F.C., Pereira, G.R., Donzelli, J.L. (2010). "Organic carbon stock in sugarcane cultivation soils in the mid-south region of Brazil". To be published.

" We estimate the marginal ILUC effects for each feedstock, measured in tons of CO2 emissions per metric ton and per Giga Joule of biofuel, resulting from a marginal extra demand of 106 GJ, i.e. around 0.1% of the consumption level at this stage, applied to the EU mandate level."

On page 103, Annex VII, they explain that the marginal shock is applied in 2020.

The marginal shock applied in 2020 may distort the emissions, if potentially less carbon intensive changes have already happened before 2020, for example, intensification in crop production. If it is applied in the first years of the mandate, or some intermediary year, the results could be different. In this way, the definition of the marginal shock lacks an economic rationale regarding the choice of the year receiving the shock application. The marginal estimated ILUC effect is specific for the end of the mandate. It would be a different marginal effect if computed in other alternative year of the model horizon.

4.6. Changes in yields in the crushing, distilling and biofuel production activities

On page 41 the authors describe that:

"We do not assume changes in the yield of the crushing, distilling and biofuel production activities."

It may underestimate overall productivity gains in the biofuel chains. If so, the CO_2 emissions would be lower.

4.7. Land and fertilizer substitution

Authors made some progress considering such possibility of substitution. However, there is a high uncertainty about the values of elasticity of substitution between land and fertilizers. It is an important topic for future research and it is hard to take any strong conclusion from the model without the use of any estimated number of such elasticity.

4.8. About the robustness of the model

On page 71 authors affirm:

"At the same time, this biofuels modeling project has demonstrated how the current limits to data availability create significant uncertainty regarding the outcomes predicted by these policy simulations. The model represents a state of the art simulation of the real world, but more data collection work will be required to reduce this margin of uncertainty."

Although the model represents a state of the art simulation, it hasn't been peer reviewed. There are so many changes from the original formulation of the MIRAGE model that it cannot be considered simply a variation of that model. The improvement of the energy sector as well as all the biomass sources and biofuels disaggregation need to be evaluated and validated by peer reviewed publication, including the land use change mechanisms (intensification and extensification) as well. As an example, the author references about the modeling of land use expansion are:

Bouet, A., L. Curran, Dimaranan, B., Ramos, M.P., and H. Valin, (2008). "Biofuels: Global Trade and Environmental Impact Study". Report for DG Trade. ATLASS Consortium.

Valin, H., B. Dimaranan, and A. Bouet (2009). "Biofuels in the World Markets: CGE Assessment of Environmental Costs Related to Land Use Changes." GTAP Conference Paper, XII Conference on Global Economic Analysis.

Many parameters of the model, as for example the land expansion elasticity and the elasticity of substitution among ethanol, biodiesel and fossil fuel in the CES composite of the transportation sector, were chosen without much economic intuition or explanation, since there are not current estimates for such parameters. In this way, more research is necessary to estimate parameters and validate economic relationships represented in the model.

4.9. Land use changes in the baseline scenario (no EU biofuels mandate)

Some land use changes in baseline scenario (no EU biofuels mandate) seem strange or inconsistent. Take the case of the Brazilian region as an example (below we have compiled the land use change data from Table B11 in the file tradoc_145960.xls for Brazil). It shows a strong increase in savanna and grassland (51% from 2004 to 2008). But such land use category shouldn't be associated to any economic use, and, as a natural area, couldn't be changing that much without any climate or environmental driver. At the same time, the land category named "other" is reducing, and even becoming negative in 2020. It is unclear what a negative land use area means. The numbers suggest that the "other" land category is being converted into a natural land or a cropland type.

Table B11: Land use (million km²)

		2004	2008	2010	2012	2015	2020
Pasture	Brazil	1.38	1.39	1.39	1.39	1.38	1.37
SavnGrasslnd	Brazil	1.22	1.35	1.42	1.50	1.62	1.84
Cropland	Brazil	0.59	0.63	0.65	0.68	0.75	0.89
Other	Brazil	0.39	0.32	0.27	0.22	0.11	-0.11
Forest_managed	Brazil	0.19	0.19	0.19	0.19	0.19	0.19
Forest_primary	Brazil	4.61	4.51	4.45	4.40	4.33	4.20
Forest_total	Brazil	4.81	4.70	4.65	4.60	4.52	4.39
Total	Brazil	8.38	8.38	8.38	8.38	8.38	8.38

4.10. Representation of pastures and the cattle sector

On page 78 the authors affirm that:

"We assume that fertilizers are used only as an intermediate input in the crop production sectors."

One of the possible ways to intensify cattle production is through the use of fertilizers in pastures. But the model doesn't allow such intensification practice. It means that cattle intensification may be underestimated by the model.

The evolution of land use for pastures in the baseline scenario is another evidence. As shown in the previous section, pasture area is slightly decreasing from 138.7 million ha to 137.1 million ha (1.2% decrease). Although beef production or cattle herd structure is not presented in the annexes of the study, this small reduction is inconsistent with historical data for Brazil. As discussed in section 6.12.3, pasture area has decreased 4 million ha from 1996 to 2008 (2.2% decrease), while beef production has increased 3.4 million tons (60% increase). Even if the representation of pasture area in MIRAGE does not match the real data for Brazil - analyzing Pasture and SavnGrasslnd classes in MIRAGE we conclude that natural grassland used for grazing in Brazil is included in SavnGrasslnd rather than Pasture class – pasture decreased projected by MIRAGE is too much conservative. Analyzing Pasture and SavnGrasslnd together, the results are even harder to be explained because total allocated land is increasing.

Table B9 (Sectoral TFP) shows that TFP increase for cattle in the baseline is the lowest among all agricultural sectors in Brazil. However, physical productivity of cattle in Brazil (beef per hectare, Table 6-5) is much higher than any other agricultural sector. Given that beef production per hectare is not addressed by MIRAGE, it cannot be guaranteed that cattle intensification projected in the baseline is aligned with historical trends. Brazil is already the largest beef exporter in the world with 25% market share. Unless MIRAGE is projecting a stronger growth in Brazilian world market share, projected pasture area should be decreasing at a rate higher than historical rate.

The high productivity gain in beef production discussed in section 6.12.3 has another implication. As shown in Table 6-5, growth of beef production in Brazil was much higher than the world demand for beef. If Brazilian production had increased at the same rate of world demand, the reduction in pasture area observed from 1996 to 2008 would be much higher. In other words, keeping demand constant, the increasing beef productivity would lead to a strong reduction in pasture area. That is the situation of a marginal analysis based on the difference between shock and baseline scenarios. Even if beef productivity would not be enough to fully compensate cropland expansion, in a marginal analysis, the substitution rate between crops and pastures must be much higher than the one found in the baseline scenario. Comparing the reference scenario with 2008 and BAU scenario with the reference, MIRAGE found more intensification in the marginal analysis, as we were expecting. However, given that pasture intensification in reference scenario seems to be underestimated, the same problem might be happening in the marginal scenario.

4.11. Intensification versus land use expansion

On page 91 and 92 the authors comment about the elasticities of land expansion being usually lower than the elasticities of land use substitution, suggesting the model will first try to intensify agricultural production before expanding land use. However, the results suggest that the model answer to the EU biofuel mandate with more land use expansion than intensification for some crops, as sugarcane (see Table 8, page 61 – attached below – the land use change is four to five times bigger than the yield factors increase and yield fertilizer increase), what means that the elasticities chosen do not imply higher responses in intensification, even though the absolute elasticity values so suggest.

It happens because the intensification process is governed by the CET function and its elasticity, which means that the changes in relative prices of alternative land uses determine the substitution among land uses. The land use expansion is determined by its elasticity applied to the ratio between current cropland price and its baseline price. It means the two elasticities are independent and have very different roles in the model. The simple comparison of their values does not allow any conclusion about which process tends to dominate. Given the many uncertainties related to the approach (land use supply curve and CET land substitution function assumed, elasticities), maybe the easiest way to validate the model is to compare its results for the period 2004-2008 with reality, and then try to calibrate the elasticities to better represent such period.

Table 8 Decomposition of production increase

	MEU_BAU				MEU_FT			
	Yield Factors increase	Yield Fertilis-er	Land use Change	Total Producti on increase	Yield Factors increase	Yield Fertilis-er	Land use Change	Total Producti on Increa-se
Rapeseed	0.32%	0.04%	0.54%	0.90%	0.34%	0.02%	0.61%	0.97%
PalmFruit	0.10%		0.21%	0.31%	0.10%		0.20%	0.30%
Maize	0.04%	0.03%	0.01%	0.08%	0.03%	0.03%	-0.01%	0.05%
OthCrop	0.01%	0.00%	0.00%	0.01%	0.02%	0.02%	-0.01%	0.03%
OthOilSds	0.01%	0.01%	-0.03%	-0.01%	0.01%	0.02%	-0.03%	0.00%
Rice	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Soybeans	0.04%	0.06%	0.12%	0.22%	0.05%	0.07%	0.15%	0.27%
Sugar_cb	0.66%	0.54%	2.67%	3.87%	0.62%	0.37%	3.98%	4.97%
Sunflower	0.11%	-0.10%	0.37%	0.38%	0.11%	-0.10%	0.39%	0.40%
VegFruits	0.00%	0.05%	-0.06%	-0.01%	0.00%	0.05%	-0.06%	-0.01%
Wheat	0.06%	0.05%	0.00%	0.11%	0.00%	0.04%	-0.09%	-0.05%

Source: Authors' calculations

4.12. The elasticity of land expansion in Brazil

From page 95, the elasticity of land expansion is set at the level of the elasticity of substitution between managed forest and cropland-pasture and is defined by region. It means that there is no scientific base for the choice of this elasticity. One alternative way to define such number when there is no information is to test several numbers and choose the one that best reproduces the historical trend (in this case, from 2004 to 2008). But it is important to compare the level of such elasticities for different regions of the model. The land expansion elasticity chosen for Brazil is at least twice bigger than the land elasticity chosen for other regions. Given the lack of scientific base for the choice of such high difference, and that other regions of the world have experienced deforestation rates (as related to their available natural land) as high as in Brazil, there is no way to justify the twice bigger expansion elasticity for Brazil.

4.13. Comparison of the marginal productivity to the CARB yield elasticity to land expansion

On page 98 the authors discuss:

"The variable LANDEXTZ is not a land-productivity as in the CET structure. That is why it is necessary to attribute a productivity factor to the new land converted to make it homogenous with the land already in use. A first approach was to multiply the area of land by the marginal productivity of land with respect to mean land productivity. Figure 17 shows the distribution curve that is used in the model in order to compute the marginal yield to apply. An index of average yield for cropland is computed by integrating the curve between the origin and the yellow dot and dividing by the x-axis value of the yellow dot. The marginal yield for expansion is then obtained by dividing the marginal productivity of managed land by the average productivity of cropland (this indicator is referred to as "yield elasticity to land expansion" in the GTAP/CARB study)."

The yield elasticity to land expansion in the GTAP/CARB study is a factor necessary to assure consistency inside any AEZ between total area before and after a shock[13]. This consistency problem

13 See Golub, A., Hertel, T., Sohngen, B., 2008. Land-use modeling in recursively-dynamic GTAP framework. GTAP Working Paper no. 48, Center for Global Trade Analysis, Purdue University. (https://www.gtap.agecon.purdue.edu/resources/download/3679.pdf)

was discussed by Golub et al. (2008, p.47) as a caveat related to the use of Constant Elasticity of Transformation (CET) functions:

"…it prevents us from tracking physical hectares as they move from one use to another. This is due to the fact that the CET function, true to its name, *transforms* hectares in one use to hectares in another use. And these uses have different values."

The solution GTAP has found to this problem was to specify a parameter to determine how much less productive would the new converted area be in comparison to the existing traditional cropland areas. They defined it as "yield elasticity to land expansion"; a ratio between the yields of the new land converted and yields in the traditional cropland area, and used the central value of 0.5, without any scientific estimation or explanation about this parameter. The MIRAGE model, however, used this same concept to define the land productivity of the natural areas converted to cropland through the land expansion equations. The authors affirm on page 98:

"However, we have relied on a much simpler approach in the final study. We assume that marginal land productivity in all regions is half the existing average productivity and will not change. This ratio is increased to 75% for Brazil. It is important to keep in mind that this assumption remains strong and recent research seems to show that recent marginal land extension was taking place on land with at least average level yields."

There isn't any scientific evidence to support the marginal land productivity numbers used in the MIRAGE model. Although this parameter has a similar function to the "yield elasticity to land expansion" used by CARB, CARB hasn't estimated it also. However, UNICA's letter of comments to CARB[14] has explored this parameter, suggesting a marginal land productivity around 0.9 in Brazil. It is in agreement with the recent work developed by Babcock and Carriquiry (2010)[15]. They have investigated the validity of the assumption made by CARB about land converted to cropland being less productive than traditional cropland areas. They conclude for Brazil as below:

"Thus, there is no obvious support for the hypothesis that the yield of newly converted land is less than the yield of new soybean land in Brazil. The evidence is not strong enough to conclude that land expansion has affected yield growth. However, if it has affected yield growth, then one would expect that soybean yield growth would be lowest in the regions with the most expansion. Figures 11 and 12 show that this simply is not the case."

Finally, Tyner et al. (2010)[16] have used a set of regional values for the marginal land productivity, at the AEZ level, obtained from a bio-process-based biogeochemistry model, known as the Terrestrial Ecosystem Model (TEM) (Zhuang et al., 2003)[17]. TEM is well-documented and has been used to examine patterns of land carbon dynamics across the globe including how they are influenced by multiple factors such as CO_2 fertilization, climate change and variability, land-use change, and ozone pollution.[18] So, the elasticity of crop yield with respect to area expansion in the Tyner et al (2009)

14 http://www.unica.com.br/download.asp?mmdCode=50F82F75-EA2D-4BB6-8832-B81C15EFFD8E

15 Babcock, B. A. and M. Carriquiry (2010). An Exploration of Certain Aspects of CARB's Approach to Modeling Indirect Land Use from Expanded Biodiesel Production. Center for Agricultural and Rural Development Iowa State University Staff Report 10-SR 105, February 2010.

16 Tyner, W. E., F. Taheripour, Q. Zhuang, D. Birur, U. Baldos, 2010. Land use change carbon emissions due to US corn ethanol production: a comprehensive analysis. Department of Agricultural Economics, Purdue University, Final Report, April 2010.

17 TEM is a process-based ecosystem model that uses spatially referenced information on climate, elevation, soils, vegetation and water availability to estimate monthly vegetation and soil carbon and nitrogen fluxes and pool sizes at the 0.5 by 0.5 degree of latitude and longitude. Zhuang, Q., A. D. McGuire, J. M. Melillo, J. S. Clein, R. J. Dargaville, D. W. Kicklighter, R. B. Myneni, J. Dong, V. E. Romanovsky, J. Harden, and J. E. Hobbie. 2003. "Carbon cycling in extra tropical terrestrial ecosystems of the Northern Hemisphere during the 20th Century: A modeling analysis of the influences of soil thermal dynamics," Tellus 55(B).

18 TEM has been also applied in combination with an economic model in some peer reviewed integrated analysis of biofuels impacts on the global emissions. See for example Melillo et al. (2009). Melillo, J. M., J. M. Reilly, D. W. Kicklighter,

improved version of GTAP vary across the world and among AEZs. They found that this approach reduces the impacts on land use changes, since the land conversion factors in several AEZs are higher than the single conversion factor of 0.66 and 0.5 used in earlier works. The conversion factors from the TEM model range from 0.51 to 1, depending on the AEZ. Brazil land conversion factors range from 0.89 to 1 and most of them are around 0.9. This means that previous marginal land productivity parameters in MIRAGE and GTAP were contributing to underestimate productivity of new land in regions as Brazil, and then, overestimating land use changes.

In conclusion, we believe that MIRAGE needs to be improved by using better data about the marginal land productivity.

4.14. Land use substitution approach

As discussed above and stated by Golub et al. (2008, p.47), the CET land transformation functions, as the ones used by MIRAGE, require a yield adjustment factor to allow the correct accounting of physical land units. However, there is nothing in the EU biofuel mandate report about such yield adjustment in MIRAGE. Only in Annex VI, page 93, the magnitude of substitution provided by the CET function is represented by hectares-productivity ratios. It is not clear what hectares-productivity means or how it is calculated. If some yield adjustment factor is used, it hasn't been discussed or presented.

4.15. The role of land extension coefficients

As discussed in more detail in section 0, a key issue to estimate GHG emissions is the type of land directly or indirectly converted to biofuel crops. Except for the conversion of pastures to cropland (discussed in section 4.10 above), which was determined by economic drivers (land rental), additional cropland demand were allocated in different ecosystems according to the coefficients used by EPA 2010 [19] (Table 19 of IFPRI-MIRAGE report). MIRAGE results indicate that 15% of additional cropland will come from forest primary (Figure 8).

EPA 2010 coefficients were established from 2001-2007 MODIS data. The share of forest conversion on total cropland expansion is very sensitive for the period under analysis. Given that deforestation rates are going down in Brazil since 2004 (see Table 7-1), it is expected that less crops are growing over forest than the coefficients presented by EPA 2010. A further discussion is presented in section 7.3.

It is also important to discuss the use of land coefficients established from historical rates of land use change in scenarios where only demand for biofuels feedstock is shocked. Conversion of native vegetation (primary forest, savanna, grassland, shrub land, etc.) to agricultural uses (crops and pastures), assuming that only economic drivers are determining the incorporation of new land, can be explained by two factors: competition by land among productive uses and increasing product demand. Assuming a situation with constant demand of soybeans and increasing demand for ethanol, it can be expected that sugarcane will "steal" land from soybeans and soybeans, therefore, will incorporate native vegetation land into production. In a situation where demand is growing both for soybean and ethanol, it is not an easy task to isolate the contribution of competition and additional demand in native vegetation conversion.

Physical evidences, such as 2001-2007 MODIS data and others discussed in section 7.3, indicate the pattern of land conversion in a situation where competition and growing demand are taking place

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A. C. Gurgel, T.W. Cronin, S. Paltsev, B. S. Felzer, X. Wang, A. P. Sokolov, C. A. Schlosser, 2009. Indirect Emissions from Biofuels: How Important? Science 326, p. 1397-1399.

19 EPA (2010). Renewable Fuel Standard Program (RFS2) Regulatory Impact Analysis. Assessment and Standards Division Office of Transportation and Air Quality U.S. Environmental Protection Agency (EPA-420-R-10-006).

simultaneously for several crops. Especially in regions with availability of land, such as Brazil (that argument might not be true for regions with no land availability), that situation is the rule and not the exception. Physical evidences, also, only indicate land conversion to cropland, without discriminating which crops were directly responsible for the conversion. The situation in Brazil is that 100% of native vegetation conversion to cropland presented in Table 19 of IFPRI-MIRAGE report is a result of directly conversion to annual crops (soybean and grains) and not to sugarcane (NASSAR, 2008 and RUDORFF, 2010)[20]. If the competition between sugarcane and other crops is not well known, which is a prerequisite to make possible the isolation of the contribution of competition and demand factor in the advancement of the frontier, applying historical conversion rates to shocks on ethanol may lead to wrongly measuring the land use change effects. There is no evidence that supports the assumption that a shock applied on a feedstock that contributes only indirectly to native land conversion through competition has the same pattern of historical conversion, in which competition and demand are taking place simultaneously. This is true both in terms of the allocation of additional land required for crops and, even more important, the proportion of the converted ecosystems.

Even if we agree that any additional cropland due to a biofuel shock will convert natural vegetation at the same rate as observed in historical trends, it is a strong assumption to considerer that the proportion among ecosystems will also be the same. Due to the small size of shock scenarios compared to historical evolution, the marginal land demand should lead to displacement of ecosystems that are easily available and achievable. In the case of Brazil, those are pastures and savanna, because they have higher proportion in historical trends. We can expect, therefore, that in a shock scenario the share of pastures and savannas displacement should be higher than historical trends.

IFPRI-MIRAGE, therefore, might be overstating forest land conversion to crop relying land coefficients on historical patterns. This topic will be raised again in section 0.

4.16. About the amortization period considered

On page 104 the authors discuss that an amortization period of twenty years is used to account annual carbon losses. It lacks any economic and environmental justification for such choice.

4.17. Access to the model

The model should be made public available for replication.

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20 RUDORFF, B.F.T; AGUIAR, D. A.; SILVA, W. F.; SUGAWARA, L. M.; ADAMI, M; MOREIRA, M. A. (2010). Studies on the Rapid Expansion of Sugarcane for Ethanol Production in São Paulo State (Brazil) Using Landsat Data. Remote Sensing, 2, 1057-1076.
NASSAR, A.M.; RUDORFF, B.F.T.; ANTONIAZZI, L.B.; AGUIAR, D.A. de; BACCHI, M.R.P.; ADAMI, M. (2008). Prospects of the sugarcane expansion in Brazil: impacts on direct and indirect land use changes. In: Zuurbier and Vooren (coord.), Sugarcane ethanol: contributions to climate change mitigation and the environment. Wageningen: Wageningen Academic Publishers, 2008.

5. Study 3: The impact of land use change on greenhouse gas emissions from biofuels and bioliquids -Literature review

The following references should have been quoted in the study:

- MACEDO, Isaias C. (2010). Biomass and soil Carbon stock changes in the expansion of sugarcane plantations in Brazil Center South region. Report to UNICA (União da Agroindustria da Cana de Açúcar). – to be published.
- NASSAR, A.M.; RUDORFF, B.F.T.; ANTONIAZZI, L.B.; AGUIAR, D.A. de; BACCHI, M.R.P.; ADAMI, M. (2008). Prospects of the sugarcane expansion in Brazil: impacts on direct and indirect land use changes. In: Zuurbier and Vooren (coord.), Sugarcane ethanol: contributions to climate change mitigation and the environment. Wageningen: Wageningen Academic Publishers, 2008.
- Babcock, B. A. and M. Carriquiry (2010). An Exploration of Certain Aspects of CARB's Approach to Modeling Indirect Land Use from Expanded Biodiesel Production. Center for Agricultural and Rural Development Iowa State University Staff Report 10-SR 105, February 2010.
- INPE – Instituto Nacional de Pesquisas Espaciais. Projeto PRODES. Available at: www.obt.inpe.br/prodes/

6. Study 4 (JRC-IE): Indirect Land Use Change from Increased Biofuels Demand, Edwards et al., 2010.[21]

6.1. General comments

The study compares the land use change results from different models regarding the marginal increment of alternative biofuel. Similar shocks are applied to each model and some decomposition of different factors affecting the land use changes is performed. Accordingly, the paper tries to access the different assumptions among models and the reasons for a wide range of results. Some models were identified as giving not well comprehended results.

6.2. IFPRI-MIRAGE results

On page 8, authors guess that IFPRI-MIRAGE results have a much larger fraction of extra production coming from extra yield than in other models, and affirm that it would require larger quantities of extra fertilizer. This kind of statement lacks scientific investigation in general and seems to be the authors' opinion.

6.3. LEITAP

On page 11, LEITAP is recognized as having issues. It means that the results from such model are strange or cannot be trusted.

On page 72, authors declare that they do not fully understand the LEITAP behavior related to by-products and food consumption, which reflects a lack of knowledge about the model. They also affirm that the LEITAP oilseeds sector is problematic. When results cannot be explained or are not understandable, there is a decrease of confidence in the model. Additionally, the authors also used their opinion without scientific knowledge to judge the parameterization of yields in new cropland.

6.4. Land use emissions

On page 9, authors estimate emissions in a very simple way, assuming that the carbon stock change is 40 tC/ha, based on IPCC default range of 38 to 95 tC/ha for conversion to cropland in the EU and North America. This is a very weak approach and doesn't allow any credible conclusion about ILUC. If we consider that most of the models estimate the land use changes at regional levels and by land use categories, wasting such information by using an aggregate carbon number for the world[22] doesn't make any sense.

6.5. Armington trade elasticities

On page 11, authors discuss that models using Armington elasticities are likely to overconcentrate crop production on the developed world, where yields are higher. The Armington elasticities in CGE models usually reflect econometric estimates given some time horizon. There is nothing wrong in using those elasticities since the elasticities reflect the time horizon in the analysis. Furthermore, sugarcane yield in Brazil stands among the highest in the world, thus invalidating the argument for Brazilian sugarcane ethanol.

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21 The authors of this document are grateful for the Joint Research Centre-Institute of Energy (JRC-IE) for sending detailed data about the Aglink run Bra-SC-ET (Marginal extra ethanol from Brazilian Sugarcane scenario). Section 6.12 is devoted to discuss Aglink results for scenario Bra-SC-ET.

22 Comments on the study of Hiederer et al. are discussed in section 7.

6.6. Wide range of estimates and the better feedstock

On page 83, figure 16 shows a wide range of results coming from different models. From the figure, LEITAP estimates tend to be the highest ones. Given the comments about a lack of understanding about LEITAP behavior and results, it seems that this model results cannot be taken into account. IMPACT usually shows the lowest land use changes for ethanol; however, this model didn't consider sugarcane ethanol scenarios. AGLINK shows consistently higher marginal LUC changes than IMPACT in those scenarios in common (wheat ethanol in both the EU and the US and coarse grain ethanol in the US). It suggests that, if IMPACT could be used to simulate the sugarcane ethanol scenario, it would give a lower marginal LUC than AGLINK. That having been said and considering that the AGLINK sugarcane ethanol scenario presented one of the lowest marginal impacts, it seems to be clear that this biofuel is the one with lowest land use impacts, confirming the MIRAGE results from Study 2.

6.7. JRC-IE estimates of marginal/average cereal yields in the EU

On page 102, authors affirm that JRC-IE has estimated the ratio of marginal/average cereal yields in the EU from EUROSTAT statistics. The procedure used in this calculation lacks scientific rigor and may be distorted by the fact that total arable area in the EU has decreased from 1997 to 2007 rather than having increased. It means that the 0.65 ratio of marginal/average cereals yield is not a good indicator to compare with the 0.66 GTAP assumed ratio between new cropland and old cropland areas.

6.8. Yields in new cropland

In the last paragraph on page 11, authors affirm that yields at the frontier of cultivation are significantly lower than yields assumed in the models, and this would underestimate land use changes from the models. They cite the EU case as an example. Actually, such consideration lacks scientific evidence and proof. The fact that almost all well suited land to crop production has already been converted can be true in the United States and the European Union. Yet in some regions of the world the observation suggests the opposite, that yields are larger at the frontier (Brazil is an example). Also, agricultural management drives yields. So, fallow land today, in general, may have lower yields than the crop area simply for not having received agricultural improvements.

The empirical data in Brazil shows that the crop yield elasticity with respect to area expansion should be around 0.9-0.95, rather than in the 0.5 to 0.75 range. The analysis of the empirical data is presented in Table 6-1, but first we outline the steps that were used to prepare the data:

a) Considering the time horizon from 2001 to 2007, the 558 IBGE micro regions were divided in new and traditional areas according to the growth in planted area for crops and allocated area for pastures. The 10 percent largest growth micro regions were considered new areas while the remaining micro regions were considered traditional areas.
b) Yields for new and traditional areas are compared to the corresponding year. For example, in 2007 the sugarcane yield in the new areas was 83.4 tons per hectare, while in the traditional areas it was 64.8 tons per hectare.
c) The measure that represents the yield elasticity with respect to the area expansion is presented in the last column of Table 6-1 ("2007-2001"). The values in this column are the ratio of the relation between 2007 and 2001 yields (new and traditional). Intuitively, in the case of sugarcane, this value suggests that a hectare in the new area of the crop yields 95 percent of the traditional area yield should the increment have taken place in the traditional area.

Table 6-1: Yield Elasticity with Respect to Area Expansion: Estimates for Brazil (tons per ha for crops and animals per ha for pasture)

	2001			2007			2007-2001
Activities(1)	Yield New Areas	Yield Traditional Areas	New/ Traditional Areas	Yield New Areas	Yield Traditional Areas	New/ Traditional Areas	New Area/Traditional Area(2)
Sugarcane	76.68	56.86	1.35	83.38	64.78	1.29	0.95
Soybean	2.77	2.59	1.07	2.84	2.75	1.03	0.97
Corn	3.46	3.17	1.09	3.70	3.74	0.99	0.91
Rice	3.42	3.09	0.91	3.80	3.79	1.00	1.11
Pasture (3)	0.76	0.95	0.81	1.34	1.12	1.20	1.48

Sources: (1) Considering 10% of the 558 IBGE micro regions that had the largest area increase between 2001 and 2007 (based on Pesquisa Agricola Municipal – IBGE data); (2) Yield relation for new areas with respect to traditional ones due to expansion between 2001and 2007. This measure is the equivalent to the crop yield elasticity with respect to area expansion; (3) Pasture yield is the ratio between cattle herd (based on Pesquisa Pecuaria Municipal – IBGE data) and pasture area (based on Brazil's Agricultural Census) for the years 1996 and 2006. The expansion was calculated based on the increase on cattle herd from 2001 to 2006.

On page 27, Figure 1 and authors´ discussion suggest that land brought into production gets increasingly less productive. It lacks scientific confirmation or even evidence at the world level, as also it ignores that technology improvements compensate such productivity loss, as explained above.

On page 57, authors affirm that AGLINK-COSIMO does not consider the differences between yields on existing and new crop-area, underestimating the indirect land use change. The assumption of lower yields in new crop-area is not confirmed scientifically and is expected to be highly dependent on the location where the expansion happens in the world (see section 4.13 for further discussion). As an example, UNICA's letter of comments to CARB has calculated that the yields in new areas in Brazil are between 0.9 and 1.05 of the yields observed in traditional agricultural areas.

On page 103 authors keep discussing the expected decrease in yields on expanding area. They cite DEFRA (1998) and Love and Foster (1990) studies about the lower productivity during times when the agricultural policy caused uncertainties. What those studies show is that yields decrease under uncertainty about agricultural policy and support, which is very different from yield changes under expanding crop areas. It shows that all the discussion on page 103 about yields lacks a scientific rigor to estimate the yields on new areas, suggesting that the conclusions by the authors are highly tendentious. They completely ignore that yields are a function of expected returns and agricultural management (inputs), not only soil and environmental aspects. As the authors say, they do a "rough" estimation of marginal yields of cereals in the EU. What is the usefulness of a rough estimate in a scientific study comparing models other than confusing the reader and showing a particular vision of something?

On page 113, authors conclude that the average yield of crops at the margin of cultivation in the EU wheat production is "clearly" less than 0.66 of the average EU wheat yield, which means all the models underestimate the LUC. This kind of conclusion is highly tendentious and was reached without any scientific approach. It is not acceptable that all the comparison of modeling efforts lead to such kind of conclusion devoid of any scientific rigor.

Specifically regarding sugarcane, the semi-perennial characteristics of the plant must be taken into account. Once planted, the ratoons give 5 to 6 harvests. Yields are higher in the second to fourth cuts and lower in the first and fifth harvest. Sugarcane yield is taken as the average of all cuts. Assuming, for example, 0.75 crop yield elasticity with respect to area expansion is, in the case of sugarcane, a strong simplification.

6.9. Increase in yields due to research spending

On page 108/109 the authors try to calculate the increase in yields as a consequence of higher research spending. Again, this kind of rough calculation lacks scientific robustness and just complicates things.

6.10. Other sources of emissions from land use changes

On page 12, authors discuss about other sources of emissions from land use changes, like agricultural intensification and use of inputs in new land. It is well known that agricultural management can reduce emissions, for example, the type of nitrogen fertilizer used and the way it is applied affect emissions. Those things are also ignored in the models.

6.11. Linear land use changes

On page 28, authors affirm that models are forced to assume a linear land use change answer from increasing biofuel production. It is not true for GTAP and MIRAGE models. One aspect that influences the non-linearity is the assumed decreasing yields in new land in both models.

6.12. Specific comment on AGLINK-IE results

The usefulness and desirability of an economic model relies on in its capacity to replicate the reality using the simplest possible representation of the phenomena under study (approach, theory, equations, and relationships). Aglink-Cosimo has some interesting simulations and results that are specific for the Brazilian agriculture. Despite the fact that the model is able to consider agricultural dynamics for Brazil (regionally, for some crops), there are important limitations regarding the structure and assumptions of the model, in addition to the fact that it does not capture key features of some sectors of the Brazilian agriculture.

The comments presented here are related to general issues which we recommend be reviewed or included in the Aglink-Cosimo to improve the model for measuring biofuel impacts on land use change. Our comments are related to the following topics: country regionalization; corn as a second crop; wheat as a winter crop; livestock sector dynamics; sugarcane yields and sugarcane expansion and its impacts on land use change. The following topics will deal with each of them.

Comments about the results are focused on the scenario Bra-SC-ET and rely on detailed data kindly sent to us by JRC-IE staff.

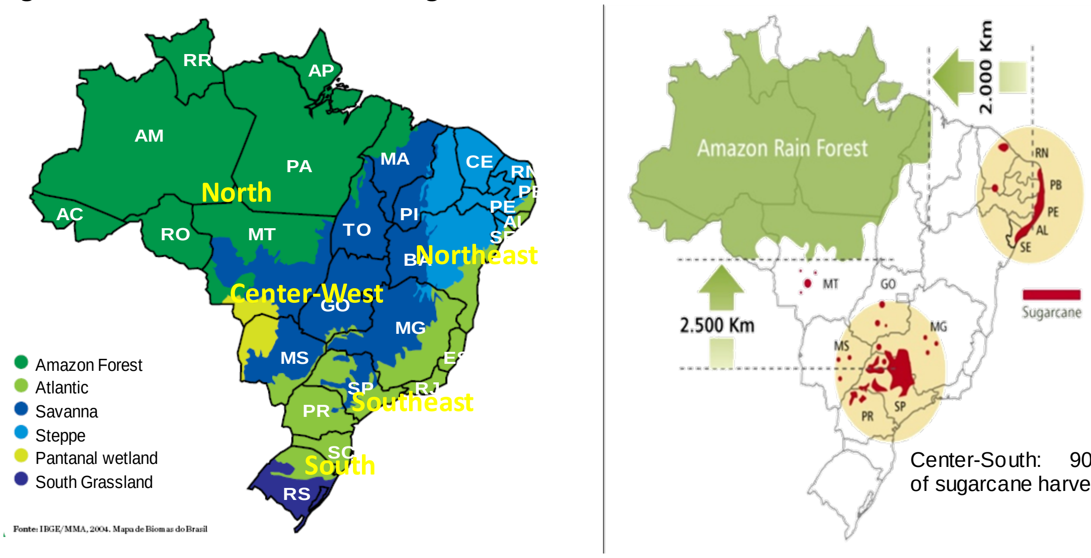
6.12.1. Country regionalization

Brazil has different regional agricultural dynamics depending on land suitability and historic occupation process. In general, Brazil has six biomes, each of them with different agricultural dynamics: Amazon Forest, Atlantic Forest, Cerrado (Savanna), Pantanal wetland, Pampa (South Grassland) and Caatinga (Steppe/Grasslands). The Center-South region concentrates most of the agricultural and biofuel production (see Figure 1 for the location of sugarcane production).

Sugarcane growth in Center-South region is taking place by 70% over pastures and almost 30% over other crops area (Figure 5-2) [23]. In order to estimate the land use changes effects due to ethanol production expansion in Brazil, it is necessary to understand the agriculture and pasture dynamics.

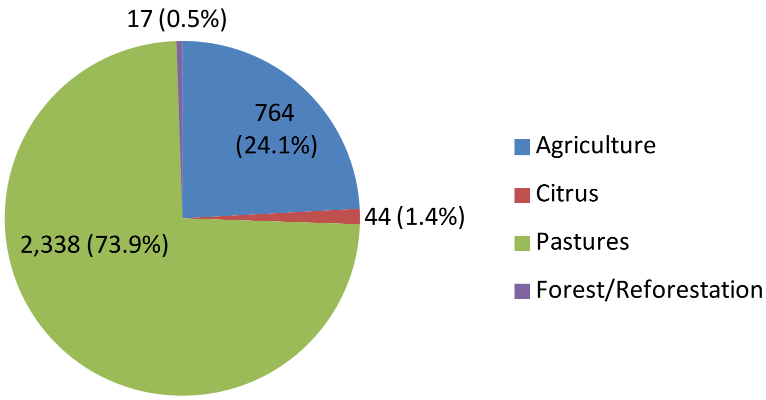
23 RUDORFF et al. (2010, op. cit.) and NASSAR et al. (2008, op. cit.) estimated that sugarcane expansion is displacing, roughly speaking, 50% pastures and 50% agriculture using MODIS data from 2005 to 2008 for Sao Paulo State and 2007 to 2008 for other Center-South states. Rudorf and CANASAT project team, broadening the analysis using data from 2000 to

Figure 6-1: Brazilian Biomes and Sugarcane Production



Sources: IBGE, MAPA, UNICA

Figure 6-2: Types of Land Use Converted to Sugarcane from 2000 to 2009, thousand ha (and %)



Source: personal communication with Bernardo Rudorff from CANASAT Project/INPE.

2009, found 70% pasture displacement. Although the data had not been published yet, Bernardo Rudorff gently authorized us to quote that data in this report.

Table 6-2 shows crops and pasture areas for 1996 and 2006 by region. In general, crops expanded mostly in the Center South region (Center-West, South and Southeast), while pasture increased in the North Region.

Table 6-2: Crops and Pasture Areas, 1996 and 2006 (million hectares)

	1996			2006		
Region	Crops	Pasture	Crops + Pasture	Crops	Pasture	Crops + Pasture
Brazil	41.8	177.7	219.5	59.8	158.8	218.6
North	2.0	24.4	26.4	4.2	26.5	30.7
Northeast	10.3	32.1	42.4	15.2	30.5	45.7
Center-West	6.6	62.8	69.3	12.2	58.5	70.7
South	12.3	20.7	33.0	15.1	15.6	30.7
Southeast	10.6	37.8	48.4	13.2	27.6	40.7

Source: Agricultural Census, IBGE
Note: the regions of the table are Brazilian political regions.

It is important to consider that Brazil has been intensifying the production of both crops and livestock. Understanding and including their dynamics in the simulation models is key for analyzing land use changes. Neglecting crops and livestock dynamics would result in wrong estimation on LUC and ILUC.

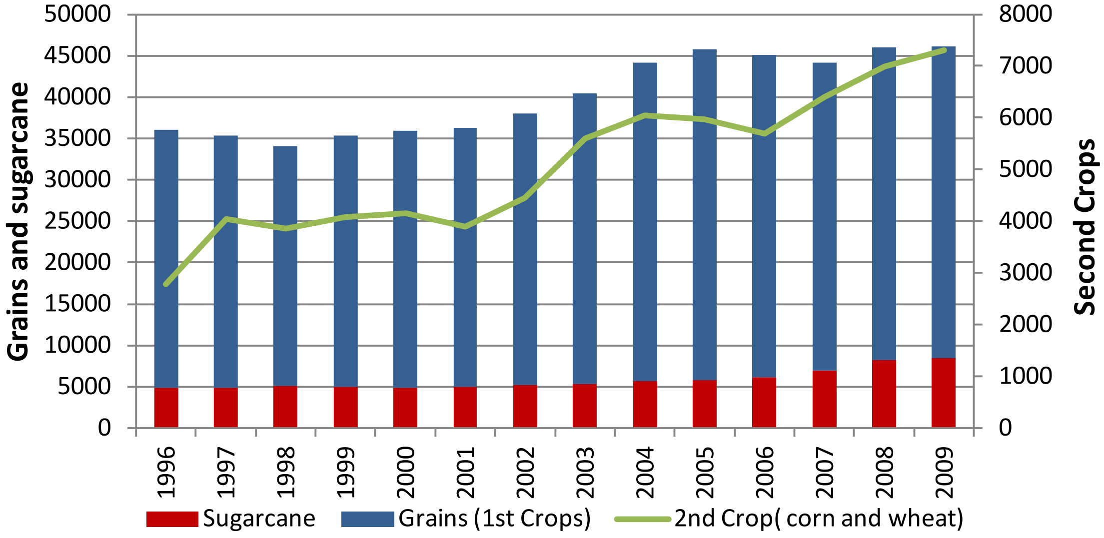
6.12.2. Considerations for multicropping

The comparison of the baseline and shock scenario of Aglink-IE results shows that the area and production of sugarcane in Brazil have increased while wheat and coarse grains area and production have decreased as a result of competition with sugarcane. Yet wheat in Brazil is a second crop and is cropped mainly over areas where soybean is cultivated as the first crop. Therefore, wheat doesn't compete for land in Brazil. In the case of corn, there are two crop seasons in Brazil. The first crop is grown from October until February, also called the "summer crop". The second crop is also known as "safrinha" and it is also cropped mainly over areas previously cultivated for soybean from February until June and consequently it does not compete for land either.

The production of the second crop of corn represented around 30% of total corn production in the last five years and its area has been significantly increasing for the last 10 years, at an average rate of 7% per year. On the other hand, the area of first crop corn decreased by 12% between 2001 and 2009, as an effect of partial replacement for soybean, which presented higher profitability during the period.

Figure 6-3 shows that, historically, Brazil has presented an upward trend in planted area for all crops (first and second crop of grains and sugarcane), except for crop shortfall years, which had impacts on the next harvesting years as happened in 2006 and 2007. In the last four years the increase of total crops (grains and sugarcane) has been driven by the growth in sugarcane area, which increased more than other first crops.
Second crop area increased about 161% between 1996 and 2009, having an important effect on Brazilian agriculture. The decrease in the area of first crop of corn due to higher competition with soybeans had no impact in production because it was more than compensated by the second crop corn. Thus, if the second crop corn is not taken into account in the total corn production, the land use change projections can be overestimated.

Figure 6-3: Sugarcane, first crops grains and second crop of corn and wheat in Brazil (1,000 ha)



Source: Conab

Table 6-3 shows that the area of second crop corn was significant in 2008, representing 35% of total corn area (first + second) and 24% of soybean area in Brazil. The coarse grains area in Aglink is higher than observed in Brazilian data, probably because the second and first crop of corn are represented as first crop, overestimating the amount of land allocated to corn production. Thus, in order to better represent the Brazilian agriculture dynamics and considering that second crop of corn area in Brazil is increasing while the first is decreasing, they should have been considered separately.

Table 6-3: Brazilian area of first and second crops

Area	2008	
	AGLINK	BRAZILIAN DATA
First Crops		
Sugarcane	7,584	8,210
Coarse Grains	15,465	9,636
Oilseed*	21,431	21,313
Rice	2,860	2,875
Cotton	-	1,077
Dry Beans	-	2,848
Wheat	2,372	-
Second Crops		
Corn	-	5,130
Wheat	-	1,852
Barley		98
Dry Beans	-	1,145
Total First Crops Area	49,713	45,959
Total Second Crops Area	-	8,225
Total Area	49,713	54,184

* In the oilseed category only soybean was considered.

Cultivation of sugarcane allows the adoption of a crop rotation system in the areas under reform. Sugarcane cycle starts with the harvest of the cane of first year and four sequential harvests from ratoons. After five years, the area is put in rotation, in general with crops from other families such as soybean and peanuts. Models in general ignore that characteristic, not only because they have harvested area in their databases, and not cultivated area (which would include areas under reform), but also because they do not explicitly model crops planted in rotation with sugarcane. Therefore, although sugarcane expansion leads to a displacement of other crops, it also allows production of other crops in rotation area (Table 6-4).

Table 6-4: Land Use for Sugarcane in South-Central States

State	Available for Harvest (ha)				Under reform (rotation)	Cultivated Area
	Ratoon	Reform	Expansion (1st year)	Total		
	2009/10					
Goias	405,310	16,395	135,148	556,853	29,095	585,948
Minas Gerais	539,407	29,990	96,279	665,676	40,391	706,067
Mato Grosso	220,594	26,112	17,568	264,274	17,303	281,577
Mato Grosso do Sul	280,282	13,315	121,587	415,184	10,355	425,539
Parana	573,215	23,154	35,565	631,934	33,192	665,126
São Paulo	4,190,036	385,941	321,801	4,897,778	344,710	5,242,488
	2008/09					
Goias	274,439	14,407	143,157	432,003	25,581	457,584
Minas Gerais	415,967	17,838	141,190	574,995	40,053	615,048
Mato Grosso	182,322	18,000	30,737	231,059	33,208	264,267
Mato Grosso do Sul	190,522	13,035	87,434	290,991	19,720	310,711
Parana	482,154	25,058	97,723	604,935	28,920	633,855
São Paulo	3,506,411	276,992	661,874	4,445,277	428,663	4,873,940
	2007/08					
Goias	212,875	10,407	85,559	308,841	19,452	328,293
Minas Gerais	326,957	15,705	120,306	462,968	20,164	483,132
Mato Grosso	174,114	18,127	25,524	217,765	19,913	237,678
Mato Grosso do Sul	153,621	12,484	46,446	212,551	14,407	226,958
Parana	391,864	14,747	107,350	513,961	26,528	540,489
São Paulo	3,040,725	284,390	636,814	3,961,929	287,993	4,249,922
	2006/07					
Goias	178,330	19,965	40,780	239,075	11,583	250,658
Minas Gerais	270,169	16,720	64,366	351,255	17,214	368,469
Mato Grosso	156,354	11,368	26,709	194,431	19,914	214,345
Mato Grosso do Sul	130,344	11,936	25,686	167,966	14,095	182,061
Parana	338,949	16,505	66,066	421,520	16,626	438,146
São Paulo	2,754,259	294,609	305,603	3,354,471	306,684	3,661,155
	2005/06					
Goias	121,512	733	68,733	190,978	25,047	216,025
Minas Gerais	207,758	14,431	66,506	288,695	20,127	308,822
Mato Grosso	153,298	11,325	25,711	190,334	14,181	204,515
Mato Grosso do Sul	125,211	6,165	14,171	145,547	14,259	159,806
Parana	311,800	17,745	26,570	356,115	22,124	378,239
São Paulo	2,594,585	246,426	205,958	3,046,969	317,735	3,364,704

Source: CANASAT (http://www.dsr.inpe.br/canasat/)

6.12.3. Livestock sector dynamics

There is strong evidence of cattle intensification occurring at the same time as the expansion of sugarcane, oilseeds, coarse grains, and commercial forests have been taking place in Brazil. It is important to consider that beef production intensification is given by the combination of three indicators: stock rate (heads per hectare), carcass weight (tons of beef per slaughtered animal) and slaughter rate (total slaughter related to the total cattle herd). In addition, different intensification rates are observed in different Brazilian regions, mainly explained by land availability and competition among crops and pasture. It can be expected that more competition among crops and livestock will lead to higher intensification of pasture area and, as a result, of beef production.

Brazil is a very important player in the world beef sector. From 1996 to 2008, Brazilian beef production and exports presented a yearly growth rate of 5.34% and 28.5%, respectively. As shown in Table 6-5, beef production has been increasing even with the decrease in pasture area of almost 4 million hectares for the period. In contrast, stock rate, carcass weight and slaughter rate increased significantly. Together, these indicators represented a very high yield increase of 61% (or a growth rate of 5.73% per year), in terms of tons of beef per hectare.

Table 6-5 – Brazilian Beef Production, Exports and Intensification Coefficients

Variable	Unit	1996	2008	Growth rate	Total Variation in the Period
Beef Production	Million Tons	6,186.9	9,765.4	5.34%	57.8%
Beef Net Exports	Million Tons	98.6	1,193.7	28.5%	1,111%
Pasture Area	Million Hectares	184,141	180,143	-0.14%	-2.17%
Slaughter Rate	% of Cattle Herd	0.1781	0.2175	2.57%	22.1%
Stock Rate	Heads/Hectare	0.8596	1.1111	2.69%	29.3%
Carcass Weight	Tons/Head	0.2194	0.2243	0.16%	2.24%
Beef per Hectare	Tons/Hectare	0.0336	0.0542	5.49%	61.3%
World Beef Demand	Million Tons	50,046	57,452	1.01%	14.8%

Source: IBGE, UFMG, USDA and ICONE

Considering all the numbers presented on the previous table, the following question should be addressed: how can beef production intensification be related to the expansion of crop areas? It is observed that cattle intensification dynamics in Brazil result from two effects: competition among crops and pasture as well as beef demand increase. Together with the boom in beef production, domestic demand and exports, it is essential that the regional dynamics be analyzed in order to take into account the direct and indirect effects of agriculture expansion (LUC and ILUC). Consequently, another question arises: relying on beef production intensification, it has to do with the production distribution among different regions in Brazil and with pasture area reduction. How to make such distribution and does such pasture area reduction in one region mean new area conversion in another, for cattle raising?

It is quite a tricky question if we look only to the fact that pasture area is being reduced in all regions, except in the Amazon. Is pasture increase in the Amazon (over natural vegetation areas) related to its reduction in the Center-South region, where there are more pressure for crops and sugarcane expansion? Is pasture expansion in the Amazon due to competition effect or beef demand pressure?

In order to answer these questions, one should analyze regional beef production in Brazil and make some assumptions in order to calculate the regional production reallocation. Table 6-6 shows the following columns:

(i) regional production observed in 1996 and 2008;
(ii) production growth rate from 1996 to 2008 (whole period),
(iii) calculated production induced by world demand growth rate (1.05% per year),

(iv) difference between the production induced by world beef demand (iii) and 2008 observed production (from column i),
(v) calculated implied area loss based on potential production loss and observed yields (based on the Amazon yield of 452.3 kg/ha, observed in 2005),
(vi) Additional area from 1996 to 2008 for the regions that presented production in 2008 higher than the potential (positive values calculated in column (iv)).

Table 6-6: Beef production in Brazil, "potential production" and reallocation effect

	Beef Production 1000 tons (observed) (i)		Annual Growth Rate (ii)	Production induced by world demand 1000 tons (iii)	Difference (based on 2008) 1000 tons (iv)	Implied area loss (v)	Additional area (vi)
	1996	2008	1996-2008	1.05%	(i)-(iii)	(1000 ha)	(1000 ha)
South	1,034	1,147	1.5%	1,172	-25	-549	
Southeast	1,763	2,368	5.0%	1,998	370		-3,279
Center-West Cerrado	2,061	3,520	4.8%	2,336	1,184		-7,470
North Amazon	637	1,520	9.9%	722	798		11,573
Northeast Coast	357	375	1.5%	405	-30	-656	
Northeast Cerrado	335	835	9.9%	380	455		-744
Brazil (total)	6,187	9,765	5.3%	7,013	2,752	-1,205	80
					Reallocation		6.68%

Source: IBGE, CONAB, ICONE.
Note: formulas used for the calculations presented in columns (v) and (vi) can be traced in tab "beef reallocation effect" in the attached spreadsheet.

It is reliable to consider that the Brazilian production will not increase as observed in the past 12 years. The domestic production was mainly driven by exports, increasing significantly its market share over time. However, for projected periods, as it has been observed since the last three years (starting in 2007), it can be expected that beef production in Brazil increases marginally and can be represented by the world beef demand growth from 1996 to 2008 (1.05% per year).

Considering the calculations presented in Table 6-6, regions South and Northeast Coast presented a loss on potential production by 25 and 30 thousand tons, respectively. Considering the North Amazon yield in tons per hectare, they represented together 1,205 thousand hectares on pasture area compensation (see column (v)). This production, however, can be compensated in all other regions that had potential production higher than in 2008. However, it is not clear how the less intense expansion of beef production of the South and Northeast Coast regions should be compensated in other regions. The other regions could have to compensate it by increasing their pasture yield or area expansion. Since there is no straightforward answer for this question we will present the calculations for both cases (totally compensated by yield or totally compensated in area) and assume that the correct figure should be in-between.

The following calculation assumes that all the production loss in the South and Northeast coast regions are compensated by area increase. In that case, the only region that increased pasture area from 1996 to 2008 was the North Amazon. Total net pasture area presented an increase of 80 thousand hectares, considering the difference from 2008 related to 1996. Dividing 80 to 1,205 thousand hectares, we can calculate that 6.68% of beef production loss converted in pasture area was compensated in the agricultural frontier. In other words, one hectare of pasture lost in traditional areas represents 0.0668 hectare in conversion of new areas.

It is also important to mention that this result is based on the assumption about how beef production can be represented in the future, based on past data. However, since the production is increasing in all regions even with pasture area reduction, this calculation can be considered as an overestimation of ILUC effects due to pasture area loss, since it is mostly demand growth driven and not competition effect. But for this purpose, we can argue that a 6.68% reallocation is more than enough to represent all the indirect effects (demand and competition compensation effects).

On the other hand, we can see that the loss of potential production in the South and Northeast coast regions is more than compensated by other regions. More precisely, any of the regions that have presented loss in pasture area has had an increase in meat production that is higher than the one induced by world demand growth. Therefore, if we assume that pasture could have compensated the production loss by increasing yield in other regions, we will end up with zero area compensation in the frontier.

6.12.4. Linearity

In view of all the arguments presented above, if we consider pasture intensification due to the competition among crops and livestock sectors in the models combined with winter crop production, the linearity assumption discussed in several sections of Edwards et al. (2010) paper is not true for Brazil. More competition among crops and pasture will more sharply reduce pasture areas. Also, more areas for specific crops according to different scenarios will lead to more areas for multicropping, which in turn reduces total demand for agricultural land.

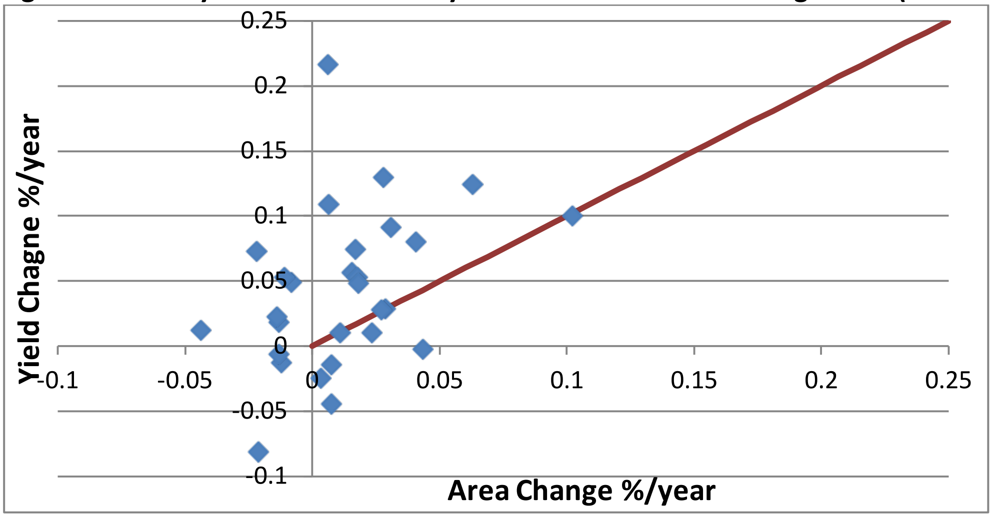
Another reason for non-linear results comes from the scarcity problem (economics theory). If a country is using more of its potential land for agriculture, more economic incentives are necessary in order to increase its share in land converted to agriculture.

6.12.5. Sugarcane Yield

The study considered that crops production in developing countries comes mostly from area expansion whereas in developed countries comes mainly from yield improvement. This assumption was justified by the study through the comparison between the growth rate of area and yield for cereals in the EU and sugarcane in Brazil (Figure 25, page 105). It shows that increased cereals area in the EU is explained mainly by growing yields, while sugarcane production growth in Brazil is explained by area expansion.

Yet Figure 6-4, which uses Brazilian data to compare the yearly growth rate in area and yields of sugarcane, shows that the increase of sugarcane production in Brazil is explained more by yield increases than by area (blue dots above the red line). Such consideration is exactly the opposite to that of the study. The blue dots indicate yield or area variation for a given year with respect to the previous year. The red is a 45^{o} line in which yield and area variations are equal. Blue dots located above the red line are the ones with yield variation higher than area variation, for a given year.

Figure 6-4: Yearly rate of increase of yield vs. area for Brazilian sugarcane (1980 to 2010)



Source: PAM and CONAB.

Ethanol yield for sugarcane in a given year is composed both by the yield of the crop (measured in tons per ha) and its sugar content, also known as Total Recoverable Sugar (TRS).

According to the results of the Bra-SC-ET scenario, sugarcane yield is lower than the observed values for 2008. The Brazilian National Bureau of Statistics (IBGE) shows that the sugarcane yield was 78.6 t/ha in 2008 (for the sugarcane sector as a whole). The annual survey of sugarcane mills shows that yield in sugar and ethanol mills was even greater (80.9 tons of sugarcane per hectare) for the same year[24]. Aglink-IE considered a yield of 76.6 t / ha for the same year. In addition to that, Aglink-IE considered a projected yield growth (in terms of tons of sugarcane per hectare) for Brazil at a rate of 0.75% a year. However, the growth rate of sugarcane yield was approx. 1.6% a year in the last decade, according to the Brazilian National Bureau of Statistics (IBGE). Data used for this estimate is available in the attached spreadsheet "ICONE_EC iLUC Consultation_Comments_31oct2010.xlsx", tab "Sugarcane yield".

Correcting both sugarcane yield in 2008 and expected growth at a trend of 1.6% a year, the correct sugarcane average yield for the period 2016-18 would be:

$78.6*(1.016)^7 = 87.8$ t/ha. This value is 7.2% higher than the model projected by Aglink-IE.

Another inconsistency was found for the conversion of sugarcane into ethanol. Aglink-IE considers a conversion of 78.7 liter of ethanol for each ton of sugarcane in 2008 and keeps this value constant through all the projected period. This assumption does not consider the share of hydrous ethanol in the ethanol mix in Brazil, as well as the growth trend in TRS per ton of sugarcane.

TRS is a measure of the energy content of the sugarcane[25]. Higher TRS is obtained over time due to different improvements in sugarcane production, such as improved varieties and good management practices. TRS can be converted into sugar or ethanol by using technical factors. According to CONAB[26], the following are the factors used for ethanol:

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24 Source: CONAB, 3º Levantamento de safra, December 2009.

25 Technical explanation about TRS can be obtained in the following publication: Macedo, I. C (organizer). 2007. Sugarcane's Energy: Twelve Studies on Brazilian Sugarcane Agribusiness and its Sustainability. Berlendis & Vertecchia and UNICA – União da Agroindústria Canavieira do Estado de São Paulo. São Paulo (available at http://english.unica.com.br/multimedia/publicacao/). See also SEABRA, J. E. A. Análise de opções tecnológicas para uso integral da biomassa no setor de cana-de-açúcar e suas implicações. Campinas: Universidade Estadual de Campinas, Faculdade de Engenharia Mecânica, 2008 (PhD Thesis).

26 See page 45 of the following study: Companhia Nacional de Abastecimento (CONAB). 2008. Perfil do Setor de Açúcar e do Álcool no Brasil. Brasília (available at http://www.conab.gov.br/conabweb/download/safra/perfil.pdf).

1 liter of anhydrous ethanol	⇒	1.7651 kg of TRS
1 liter of hydrous ethanol	⇒	1.6913 kg of TRS
1 kg of sugar	⇒	1.0495 kg of TRS

Van den Bake et al. (2009)[27] shows the growth trend in agricultural efficiency indicators. The paper mentions that the growth of TRS per ton of sugarcane has been important for the expansion of sugarcane ethanol production in Brazil. The average values are reported in Table 6-7.

Table 6-7: Agricultural Yield: TRS per ton of sugarcane

	1975-80	1980-85	1985-90	1990-95	1995-00	>2000
Agricultural yield (kg TRS/TC)	122-128	127-136	137-139	139-141	139-142	144-148

Source: Van den Bake et all (2009)

Although TRS in sugarcane in the latest two crop seasons has been lower than the average, especially due to weather conditions and the economic crisis (less use of fertilizers and herbicide), it has presented an upward trend of about 0.32% a year (between 1997 and 2008). It is also important to mention that due to the increase of the flex fuel fleet, almost all the ethanol production expansion is oriented to hydrous ethanol, which as compared with the anhydrous ethanol, has a higher conversion per kg of TRS.

Considering the values above and the relatively low TRS content of sugarcane in the crop season 2008/09 (which was 137kg TRS per ton of sugarcane), the conversion from sugarcane would be 77.7 liters of anhydrous ethanol or 81.06 liters of hydrous ethanol. Since the share of anhydrous ethanol in this crop season was 34%, the correct value for the conversion should be 79.91 in 2008 – i.e., higher than the value considered by Aglink-IE (78.7).

Using a yield growth of 0.32% a year as the correct conversion in 2008/09 and the share of 71% of hydrous (observed in the 2010/11 crop season), a more accurate value of 82 liters of ethanol per ton of sugarcane should be used. This value is 4% higher than the value used in Aglink-IE.

6.12.6. The proportion of yield and area in the production expansion

The supply elasticity for all crops from the AGLINK-COSIMO, calculated through the comparison of marginal and baseline scenario (Table 17, page 55), indicates which proportion of the extra crop production in the marginal scenario come from increasing yields. In the Bra-SC-ET scenario the expansion of crop production in Brazil is mainly explained by area expansion, about 85%. The other 15% of the extra production comes from yield increase.

Table 6-8 (see attached spreadsheet for detailed calculations) shows that the average annual growth rate of yield was higher than area's and part of the area and yield expansion in Brazil were stimulated by higher expected return. That result, based on empirical data, is opposite to the result presented in Aglink-IE run.

27 Van den Wall Bake, J.D., Junginger, M., Faaij, A., Poot, T., Walter, A. Explaining the experience curve: Cost reductions of Brazilian ethanol from sugarcane. Biomass and Bioenergy, 33(4), 644-658, 2009.

Table 6-8: Brazilian crops, 1996 and 2009

	1996	2009	average annual growth rate
Yield (ha/tons)	2.24	3.38	3.01%
Area (1000 ha)	31,168	37,660	2.39%

The crops analyzed include soybean, corn, cotton, rice, dry bean and sugarcane.
Source: PAM, CONAB. Elaborated by ICONE.

6.12.7. Comments about the AGLINK model and results

Aglink-IE is the only partial equilibrium model used to simulate ethanol from sugarcane and it estimates a LUC of 134 Kha per Mtoe.

Regarding the "marginal extra ethanol shock from Brazilian sugarcane" (Bra-SC-ET) in Aglink-IE model, we observed some "non-usual" results when compared with the evolution of the Brazilian agriculture sector during the last 10 or 12 years. Some of these can be considered as inaccurate results due to the assumptions structure of the model. This section will report the most important inconsistencies found in Aglink-IE model results.

Bra-SC-ET scenario shows that a shock in the Brazilian sugarcane ethanol consumption will decrease the production of other crops in the world (wheat, coarse grains and rice), as can be seen in Table 11 (page 51). If more sugarcane area is needed due to the increase in ethanol consumption, it is expected that it will take place over other activities' area and should be compensated in other regions. However, considering pasture intensification and second crop production, this cannot be considered true, as explained before.

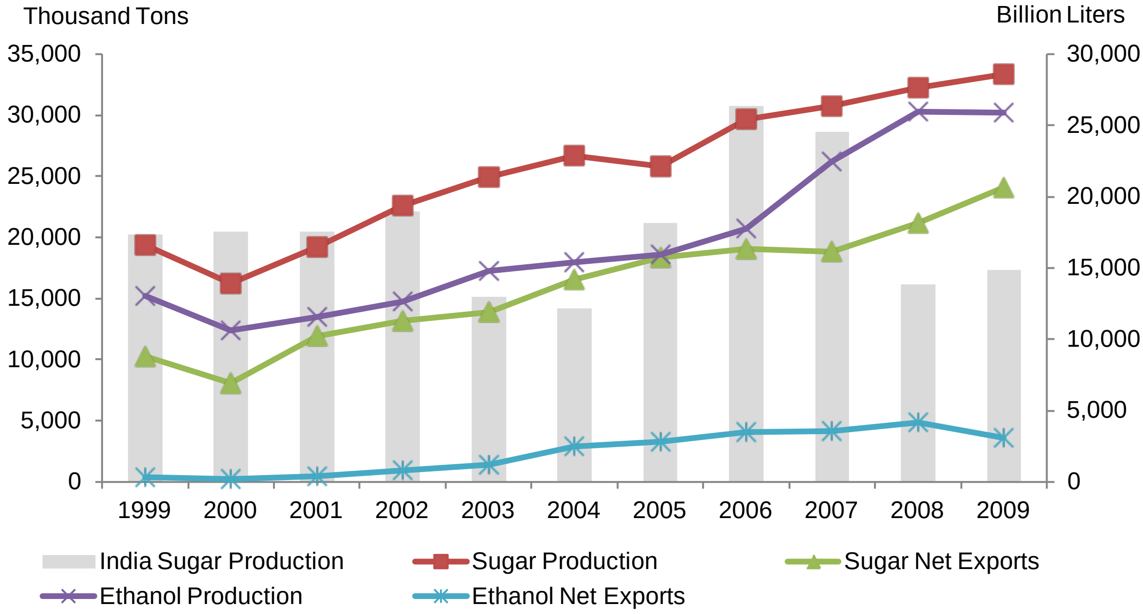
Another "non usual" result is the increase on sugar beet area worldwide and, even more important, in sugarcane area outside Brazil, after a shock on the Brazilian ethanol consumption. Brazilian sugarcane is strongly determined by ethanol and sugar prices. Ethanol and sugar prices are, at least in the long run, correlated because both are produced from the same feedstock (not only but mainly produced from sugarcane). A shock in ethanol market will lead to higher prices of ethanol and more sugarcane diverted to ethanol. Sugar prices should also respond to that shock. Given that Brazil is the marginal producer of both sugar and ethanol, because costs are lower in Brazil than in any other country, there is no economic reason that justifies lower response of sugar production in Brazil due to higher demand for ethanol.

The increase in ethanol production in Brazil seems to strongly compete with sugar, since sugar production was reduced after the shock. The results indicate the following dynamics regarding the shock on ethanol consumption in Brazil: there was an 88.2 thousand tons decrease in Brazilian sugar net exports, partly compensated by African and other Latin American countries net exports. The higher sugar exports of those countries were stimulated by higher prices on sugar, comparing to the baseline.

On page 59, a strange result is related to the area decrease in regions like "other Africa", Argentina and "other Asia" due to the Brazilian sugarcane scenario. As those regions compete with Brazil in grains and other agricultural production, a higher demand for land in Brazil to produce sugarcane for ethanol should result in less grains production in Brazil, which should increase production and land use in countries that compete with Brazil in grains production.

However, as shown in Figure 6-5, Brazil has always been able to increase both the production of sugar and ethanol from sugarcane. Due to its high competitiveness, Brazil has been a protagonist in the world sugar market, supplying additional amounts of sugar whenever a shortage occurred (e.g.: droughts in India). Another reason is that Brazil has the lowest production costs for sugarcane and sugar and at the same time the highest yield as compared to other producer countries. In addition to it, sugarcane for sugar production has long been increasing, in spite of the higher growth rates of ethanol production. Thus, the small size of the shock (100 million liters), which represents less than 0.38% of 2008 ethanol total production, could not explain the lower sugar production as compared to the baseline.

Figure 6-5: India sugar production, Brazilian sugar and ethanol exports and production



Source: FAPRI, USDA, UNICA and ICONE

Aglink-IE presented that around 61% of sugarcane production was reallocated from sugar to ethanol. According to the dynamic effect on Aglink model for Bra-SC-ET scenario, there was also an increase in oilseeds area and production in Brazil (respectively by 3.1 tons/ha and 9.3 tons), totally oriented to exports. Apparently, most of this increase comes from the decrease in sugar and other crops exports from Brazil and the need to compensate them in other countries, which might displace oilseeds area worldwide.

However, as explained before, this dynamic is not correct for Brazil, and these results would be different if the model had taken into account second crop production (especially for coarse grains and wheat) and pasture area intensification, as explained in the sections above. For example, around 24% of soybeans area (based on the Brazilian data in 2008) was used to grow corn as a second crop. If second crop was considered in the model, this corn area would produce an extra 5.6 million tons of corn in the baseline, representing 3.4% of the world total corn production for the same scenario. In conclusion, there is no explanation for the compensation of crops worldwide due to a shock in ethanol production in Brazil.

6.12.8. Conclusions drawn from Aglink-IE considerations: simple corrections on key parameters shows significant decrease in ILUC

An interesting exercise is to change Aglink-IE assumptions to ones more representative of the dynamics of Brazilian agricultural sector to compare LUC and ILUC effects deriving from ethanol consumption shock. The following paragraphs will show how simple corrections on key assumptions and parameters will generate values for ILUC that are significantly lower than the ones presented in

Edwards et al. The three most important corrections are: the consideration of pasture; correcting ethanol/ sugarcane yield; and keeping all the LUC within the Brazilian frontiers[28].

As shown in 6.12.3, pasture intensification has been observed in Brazil and part of it is due to higher levels of competition with crops. As affirmed in the referred section, pasture absorbs between 93% and 100% of the area lost to crops, due to production intensification. Additionally, Rudorff (see footnote 23) shows that 70% of sugarcane expansion occupied pasture. Therefore, our first correction is the inclusion of pasture intensification in the land use analysis. The calculation is presented in “Table 1: Including Pasture intensification” of the attached spreadsheet “ICONE_EC iLUC Consultation_Comments_31oct2010.xlsx”.

As presented in Edwards et al., Aglink-IE calculated an additional 8.32 Kha total area expansion in Brazil comparing shock and baseline scenarios. Sugarcane expansion is equal to 5.64 Kha, and the remaining 2.69 Kha are due to other crops expansion (those would be caused by a response to the world shortage of other products because of sugarcane expansion in Brazil). According to the parameters presented above, it is expected that 70% of sugarcane expansion (3.94 Kha) displaces pasture and 30% (1.69 Kha) displaces other crops. Using data published in NASSAR et al. (2010, op. cit.)[29], 74% of the crops expansion will displace pasture (around 1.25 Kha), and the remaining expansion will displace natural vegetation. Due to pasture intensification, only 6.68% of the area lost by pasture to other crops will be compensated over natural vegetation. Thus, as can be seen in cell B15 of tab “ILUC_Corrections1”, starting from 5.64 Kha sugarcane expansion in Brazil, only 0.79 Kha need to be compensated on the agricultural frontier.

As presented above (continuing in Table 1 of the sheet “ILUC_Corrfections1”), Aglink generates a feedback of 2.69Kha coming from other crops expansion in Brazil, after an ethanol demand shock. Following the same rationale as before, it is expected that 74% of it (or 1.99 Kha) occurs by displacing pasture. Since pasture accommodates 93% of this expansion (compensating only the remaining on the frontier), only 0.83 of the 2.69 kha expansion causes natural vegetation conversion. The inclusion of pasture in the analysis will reduce the 8.32 Kha of natural vegetation conversion to 1.62 Kha (0.79 + 0.83). Hence the inclusion of pasture has a significant impact on the ILUC results.

The next step is to make corrections in sugarcane yield. Calculations are presented in “Table 2: Correcting Ethanol Yield” (tab “ILUC Corrections1”). As presented before in section 6.12.5, the inaccurate figures for sugarcane ethanol yield overestimate sugarcane land demand by at least 11%. We can simply adjust the yield by dividing sugarcane area growth by 1.11 on cell B21. This correction reduces total crop expansion in Brazil by around 6%. Although significant, this correction has much smaller effect than the inclusion of pasture intensification.

Finally, our last calculation is devoted to recalculating the ILUC considering the two corrections above, but without any changes in Brazilian sugar exports. This correction also allows keeping world sugar production and consumption unchanged. According to this assumption, sugarcane area will be higher in Brazil (about 7.52 Kha), but other crops area would not expand in Brazil since there is no feedback from the world (and also due to multicropping in Brazil that will be enough to compensate coarse grains production and competition with sugarcane). Furthermore, it allows us to calculate all the ILUC within the Brazilian frontiers. The calculations area is presented in “Table 3: Constant sugar exports” of the same table.

The adjusted area of sugarcane expansion is now 12.60 Kha, instead of the original 5.63 Kha. Following the same steps explained above for sugarcane yield and pasture, the expansion on the frontier would be 1.79 Kha. This would be equal to approximately 33.7 Kha/Mtoe. That value is approximately 75% lower than the original value calculated by Aglink-IE (134 Kha/Mtoe).

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28 This section explains the calculations of sheets “IUC_Corrections1” and “IUC_Corrections2” of the attached Excel file.

29 See tab “Transition matrix 2005-2008” on the spreadsheet attached to this document (EC iLUC Consultation_Comments_ICONE-FEARP-CTBE.xlsx).

As explained in section 6.12.3, it is reasonable to consider that pasture intensification absorbs any relatively small amount of crops expansion. The calculation presented in tab "ILUC_Corrections2" reproduces the same steps adopted in the sheet "ILUC_Corrections1", though considering that pasture accommodates 100% of the pasture area diverted to crops. Following this assumption, the ILUC would be 18.8 Kha/Mtoe (see cell H49), which represents 86% less than the original Aglink-IE results.

It is important to mention that this result is only a simple inference of how far Aglink-IE results are from a more accurate result. The 18.8 Kha/Mtoe is still overestimated, since it does not consider any intensification for crops (as multicropping), or reduction on consumption. As we explained earlier, winter crops are very important in the yield response, especially for corn. More accurate ILUC estimations, especially for sugarcane ethanol, would need models that better represent the Brazilian agriculture.

7. Study 5: Comments on the study "Biofuels: a New Methodology to Estimate GHG Emissions from Global Land Use Change", Hiederer et al., 2010

7.1. Lack of documentation with respect to the databases created

Because the study only presents final and aggregated results, it is not possible to analyze data on land cover and land use used in the study. A very brief description of the datasets created is presented in item 3.1. Although the explanation is clear, no database was provided for evaluation by external people.

It is clear in the study that the analysis was performed at the grid level. However, JRC crop share table, JRC land cover data and conversion to cropland table (discussed on page 74) could have been provided in tabular form at country level for verification.

Because detailed data were not provided, it is unclear how MODIS land cover data were combined with FAO statistics (pages 13 and 14). Were MODIS land cover data for "cropland" replaced by FAO statistics? How was FAO pasture data treated in the analysis given that only the conversion of natural vegetation to cropland was taken into account? How was the possible overlapping between pastures and shrub land, savanna and grassland (aggregation of IGPB classes) treated? How was the conversion of pastures to cropland treated?

7.2. Period for defining land cover conversion trends

The period bracket from 2001 to 2004 was used to define historical land cover conversion trends. The period chosen clearly overstates natural vegetation conversion for Brazil. Both deforestation rates and cropland area have strongly increased from 2001 to 2004. Accumulated deforestation for that period was 2.7 million ha/year and 1.7 million ha/year for the subsequent period. As a whole, deforestation rates show a consistent down trend since 2005.

Table 7-1: Brazilian Biomes: Annual Deforestation Rates (1,000 hectares)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Amazon Biome	1,823	1,817	2,165	2,540	2,777	1,901	1,429	1,165	1,291	746
Savanna	n.a.	n.a.	n.a.	817	891	482	351	444	376	299
Atlantic Forest	n.a.	n.a.	n.a.	26	26	26	27	27	27	21
Cropland expansion (annual and perennial)	1,118	-182	2,874	3,949	4,576	1,282	-1,755	-225	3,189	1,377

Source: INPE/PRODES (http://www.obt.inpe.br/prodes/); LAPIG/UFG (http://www.lapig.iesa.ufg.br/lapigsite/index.php); SOS Mata Atlantica (personal communication and http://www.sosmatatlantica.org.br/index.php?section=atlas&action=atlas); IBGE (Producao Agricola Municipal for 2000 to 2008 and Levantamento Sistematico da Producao Agricola for 2009).
N.a.: not available.

Besides that, land cover data from 2001-2004 have been extensively discussed in the context of the Renewable Fuel Standard conducted by U.S. Environmental Protection Agency. EPA submitted the satellite imagery analysis, which also included land cover data extracted from MODIS for 2001-2004, to a peer review evaluation[30], and there was consensus among the reviewers about the shortened

30 ICF International. (2009). Emissions from Land Use Change due to Increased Biofuel Production: Satellite Imagery and Emissions Factor Analysis. Peer Review Report (available at www.epa.gov/oms/renewablefuels/rfs2-peer-review-land-use.pdf).

period and about the lower resolution of 1 km imagery. For the RFS 2, 2001-2007 period and 500m resolution datasets were used.

7.3. Conversion of Natural Vegetation to Cropland

A key element of the report is the pattern of land conversion to cropland established from 2001-2004 MODIS land cover time series. That pattern was the main information used to allocate marginal cropland demand obtained from IFPRI-MIRAGE and IPTS-Aglink models. Figures 35 and 45 induce the conclusion that the 35% and the 30% closed forest conversion to cropland in Brazil were mainly determined by MODIS land cover series (as presented in figure 23, group A). Although the allocation of cropland expansion was developed in a spatial model (figure 23, group C), the report indicates that the split of economic demand by MODIS land cover classes was crucial to determine the spatial allocation.

The amount of closed forest conversion to cropland presented in figures 35 and 45 indicates that JRC results overstate closed forest conversion. The study recognizes on page 130 that JRC approach is very conservative. Several evidences support the conclusion that the spatial allocation methodology lead to an overestimation of the conversion of forest land to cropland:

(i) Although Morton et al.[31] (2006, figure 4) found results that support JRC conclusions (out of 16,370 km2 of cropland expansion in Mato Grosso State from 2001 to 2004, 4,670-5,463 km2 took place over forest), longer and more updated series indicate that this proportion is not confirmed for different periods and for all micro regions in the Amazon biome;

(ii) Unfortunately, the report does not make available any data on MODIS land cover series. However, on page 74 it is mentioned that the conversion to cropland table was inspired by EPA 2009[32] report and based on 2001-2004 MODIS land cover time series. Table 2.6-27 from EPA (2009) report presents the share of each type of land converted to cropland in a given country. For the case of Brazil the numbers are: 4% forest, 18% grassland, 74% savanna, 4% shrub. As mentioned on page 129 of Hiederer et al., EPA calculated, directly from MODIS imagery, 32% of forest converted in Brazil from total cropland expansion. The 32% forest conversion found by EPA, however, is a calculation based on an assumption that 64% of savanna and grassland conversion would partially (49% in the case of savanna and 39% in the case of grassland) grow over forest as a result of pasture replacement. That procedure, called by EPA as step two (pasture replacement) brought 4% forest conversion to 32%. From JRC results (figures 35 and 45) we conclude that they followed the same procedure used by EPA. That procedure clearly overstates the amount of forest conversion to cropland in Brazil. One such evidence is EPA´s revised DRIA launched in 2010. EPA (2010, op. cit.) (Table 2.4-40) using 2001-2007 MODIS data found 18% forest conversion to cropland[33] in Brazil, confirming that the JRC results for forest conversion are overestimated.

(iii) Data on Soybean Moratorium initiative[34] indicates that only 1.7% (6.7 thousand ha) of the deforested area from 2007 to 2009 of a sample of polygons (302 thousand ha of deforestation in the Legal Amazon region) were partially or fully occupied with annual crops[35]. Given that the polygons were selected based on the municipalities where soybean crop is strongly expanding

31 MORTON, D. C., DEFRIES, R. S., SHIMABUKURO, Y. E., ANDERSON, L. O., Arai, E., DEL BON ESPIRITO-SANTO, F., FREITAS, R., and MORISETTE, J., 2006, "Cropland Expansion Changes Deforestation Dynamics in the Southern Brazilian Amazon," Proceedings of the National Academy of Sciences of the USA103:39, 14,637-14,641.

32 EPA (2009) Draft Regulatory Impact Analysis: Changes to Renewable Fuel Standard Program. Assessment and Standards Division Office of Transportation and AirQuality U.S. Environmental Protection Agency.

33 Average for Brazil. Full datasets are available in the “Air Docket EPA-HQ-OAR-2005-0161”, file “EPA -HQ-OAR-2005-0161-3152.2.xls”.

34 See http://www.abiove.com.br/english/ss_moratoria_us.html for full datasets.

35 RUDORFF, B. F. T.; ADAMI, M.; AGUIAR, D. A. d.; MOREIRA, M. A.; MELLO, M. P.; FABRINI, L.; AMARAL, D. F.; PIRES, B. M., Monitoring the soy moratorium on Amazon biome by remote sensing. Remote Sensing 2010. (submitted)

in the Legal Amazon region, the sample is highly representative for evaluating forest conversion to cropland in the most recent years. Soybean Moratorium data shows that the drivers of forest conversion have been changing over time. While Morton et al. identified that 14.3% of total deforested areas from 2001 to 2004 were occupied with crops, the current rate is 1.7% as mentioned above, besides the fact that deforestation as a whole has decreased significantly in recent years.

(iv) Based on land use substitution matrices developed by NASSAR et al. (2010, op. cit.), out of 3.3 million ha expansion of crops from 2005 to 2008, the following distribution of land conversion were established: 81.6% over pastures, 9.6% over savanna and 8.8% over forest (see calculations in sheet "Transition matrix 2005-2008" of the attached excel file). Enlarging the period using data from 2002 to 2008, when grains expansion was more significant, the share of forest conversion to cropland would go up to 20.7% (64% over pastures and 15.3% over savanna yet much lower than the results presented in figures 35 and 45 of the JRC report). One important feature of this report is that it shows that different regions in Brazil have different patterns of land conversion due to cropland expansion.

Having in mind the strong reduction in deforestation rate and lower conversion of forest to cropland in recent years, combined with the observed production increase in all agricultural products, there is no reason to believe that JRC methodology is correctly allocating cropland expansion over other land uses. Results found by JRC and presented in figures 35 and 45 are supported only by Morton et al. because the author analyzed a period and a region with the highest deforestation and cropland expansion rates. JRC results are not supported by more up to date evidence. The consequence of an overestimation of forest conversion can thereby be observed in the results for GHG emissions, which are overstated as well.

7.4. The difference between historical agricultural expansion pattern and scenario analysis

As discussed in section 4.15, there is no economic reasoning supporting the idea that the pattern of land conversion in a marginal scenario will follow historical trends (or average trends). For that, it would be necessary to: (i) separate the competition effect (which is the indirect effect caused by the expansion of sugarcane in Brazil given that sugarcane do not compete with native vegetation) from the demand effect of the other products, because both can cause frontier expansion, and (ii) it is also necessary to make a case to show that the indirect effect is able to lead to a conversion of different ecosystems in a proportion similar to the historical trends.

In the case of ethanol demand in Brazil, the spatial land use allocation should take into account the substitution effects and direct conversion dynamics, which are completely different from the historical occupation patterns for all crops. It was explored in sections above that sugarcane mostly displaces pasture and crops with an insignificant direct effect on natural vegetation. For the analysis to be consistent, the allocation pattern should also isolate the effects of biofuel expansion which in the past derived from the demand for other products. Only then would it be possible for the models and allocation methodologies to replicate such differences in their simulations (considering that the shock must be only on the biofuel sector, for example).

Another reason for the overestimation of LUC and ILUC effects based on historical patterns is related to the assumption that the competition among crops and pasture will remain the same in the future or in a marginal scenario. This is not correct when the current reduction on deforestation rate and the increase in agricultural intensification (multicropping and beef production intensification) are considered, as shown in the previous sections. Furthermore, in observed historic pattern all the activities suffered both the indirect effects and pressure from demand to expand. Marginally, no demand pressure should be expected on the other activities. Only the feedstock used for biofuel production has a stronger demand effect. This tends to create a different expansion pattern, where the other activities (such as pasture), are subjected to the competition by biofuel crops; however, there is no pressure to recover the land over natural vegetation (there is no demand pressure in the baseline - marginal scenario analysis). Also, it is not reasonable to believe that Brazil will continue to increase its share in the world agricultural production for the next 10 years, since it has already increased significantly.

In that sense, the allocation methodology presented in NASSAR et al. (2010)[36] has measured sugarcane regional expansion and identified the substitution patterns of those regions. It has then been able to isolate the demand effect and track only the competition or indirect effect of sugarcane over natural vegetation. As expected, it resulted in a much lower ILUC factor than the one presented by JRC.

As cited in HIEDERER et al.(2010, pages 129-130), for an ethanol demand shock of 4 billion gallons simulated for EPA Renewable Fuel Standard public consultation[37], BLUM presented a 5% extra demand for land allocated over primary forest (in the Amazon biome). The main explanation for the lower leakage effect coming from sugarcane expansion, comparing to JRC results, is that BLUM takes into account regionalization, pasture intensification, sugarcane expansion dynamics and multicropping, together with potential land available for agricultural production and legal restrictions. Also, this result includes constant demand for other crops and meats in the shock scenario comparing to the baseline. BLUM reinforces that capturing the regional agricultural dynamics in Brazil is essential for a precise estimation of land use changes that would reduce modeling assumptions and eventually, their uncertainties.

Even if the JRC results are not really based on historical trends of land use change because variables as soil and climate conditions and availability of land were used to allocate marginal land demand, results found for Brazil do not match the logic behind the frontier expansion in the country. Because of the legal restrictions to convert forest into production, the Brazilian Forest Code requirements of forest preservation (80% of the farm in the Amazon Biome and ban on deforestation of the Atlantic Forest)[38] and the poor logistical conditions in regions with forest (logistics conditions are better in savannas regions, for example), it is expected that savanna will be the preferred ecosystem to be converted to crop in the future.

However, it is also important to mention that the implementation of new environmental restrictions, such as PPCerrado[39] tend to restrict the agricultural expansion even over the savannas, which might lead to an increase in agricultural intensification and reduce deforestation rates more sharply than observed in the past. JRC analysis, however, has ignored all current and future legal constraints in Brazil. Therefore, it has likely incurred in overestimating forest conversion.

7.5. Absence of Pasture

The previous item discussed the importance of an accurate estimation of the type of land converted to cropland. Another very relevant issue is the amount of cropland that will require conversion of native vegetation land. The spatial model developed by JRC takes marginal land demand from IFPRI-

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36 NASSAR, A. M.; ANTONIAZZI, L. B.; MOREIRA, M. R.; CHIODI, L.; HARFUCH, L. 2010. An Allocation Methodology to Assess GHG Emissions Associated with Land Use Change. Final Report (report and detailed spreadsheet available at http://www.iconebrasil.com.br/en/?actA=8&areaID=8&secaoID=73&artigoID=2107).

37 NASSAR, A. M.; HARFUCH, L.; MOREIRA, M. R.; CHIODI, L.; ANTONIAZZI, L.A. 2009; Impacts on Land Use and GHG Emissions from a Shock on Brazilian Sugarcane Ethanol Exports to the United States using Brazilian Land Use Model (BLUM). Report to the U.S. Environmental Protection Agency regarding the proposed changes to the Renewable Fuel Standard Program. Available at: http://www.iconebrasil.com.br/arquivos/noticia/1872.pdf

38 See SPAROVECK, G.; BERNDES, G.; Klug, I. L. F.; BARRETTO, A. G. O. P. (2010). Brazilian Agriculture and Environmental Legislation: Status and Future Challenges. Environ. Sci. Technol., 2010, 44 (16), pp 6046–6053.

39 See BRAZIL –Ministério do Meio Ambiente. Plano de Ação para Prevenção e Controle do Desmatamento das Queimadas no Cerrado. Brasília, set. 2010. Available at:
http://www.mma.gov.br/estruturas/182/_arquivos/ppcerrado_vcc_1_outubro_182.pdf

MIRAGE (8,209 km2 in the BAU Scenario) and Aglink-IPTS (52,372 km2 in CG run) and allocate that additional cropland over different land uses.

It has to be observed that the calculated land intensity (Kha/Mtoe) in IFPRI-MIRAGE (111 Kha/Mtoe) and in Aglink-IPTS (219 Kha/Mtoe) are very different and, as a consequence, emissions are larger in Aglink-IPTS simulation. IFPRI-MIRAGE, at least, explicitly simulates the substitution between cropland and pasture using an economic rationale. Net of pasture intensification, IFPRI-MIRAGE marginal land demand in BAU scenario is 7,202 km2, which implies a recalculated land intensity of 97.6 Kha/Mtoe. Aglink-IPTS has no analysis for pastures and, therefore, all marginal cropland has to be allocated over native vegetation uses.

Table 24 of JRC report indicates that land class grassland encompasses pasture. However, the JRC allocation methodology does not rely on economic variables. Conversion of grasslands to cropland, therefore, is only a function of physical and spatial variables. Allocating cropland expansion on native vegetation based only on physical and spatial variables is a strongly defensible methodological choice provided that all economic drives has been taken into account in the expansion of the agricultural sector (balance of cropland and pastures, given that pastures are also a productive land use being the main source of feed for livestock).

Given that JRC spatial model is not simulating the land balance of the agricultural sector (expansion of crop and pastures); because it departs only from additional land from crops, the correct methodological procedure would be to input marginal cropland net of pasture displacement and intensification. Although it is true that in some regions the competition between crops and pastures is not relevant and pasture intensification is negligible, in countries such as Brazil both are very relevant, as shown in section 6.12.3.

Applying the pasture land substitution factor and intensification factor presented in section 6.12.8, and using the same methodology presented in tab "ILUC_Corrections1" of the attached spreadsheet, marginal cropland demand net of pasture intensification for Brazil is:

Table 7-2: Including Pasture Intensification in IFPRI-MIRAGE and Aglink-IE simulations

	Marginal Cropland Demand (1,000 ha)			
	Brazil		**World**	
	Original	**Net of Pasture Intensification**	**Original**	**Brazil corrected**
IFPRI-MIRAGE	481	83	820	422
Aglink-IPTS	989	208	5,214	4,433

Source: IFPRI; JRC-IPTS; authors of this report.

A similar methodology can be applied to all countries in which pastures are used for raising cattle. Pasture accounts for a large stock of land and pasture productivity, although increasing, is still low.

A final comment is necessary with respect to suitability of pastures for crops production. The availability of areas allocated with pastures that are also suitable for annual crops is not a constraint in Brazil. There are several estimates of area allocated to pasture in Brazil. While 2006 Agricultural Census shows 158.8 million ha (Table 6-2), analysis using remote sensing estimate 211 million ha with pastures (managed and natural, Sparovek et al., 2010 [40]). Sparovek et al. (op. cit.) estimate that out of the 211 million ha with pastures, 61 million ha are suitable for annual crops production.

40 SPAROVEK, G.; BARRETTO, A.; KLUG, I.; BERNDES, G. (2010). Considerações sobre o Código Florestal brasileiro (available at http://www.imaflora.org/upload/repositorio/gerdspavorek_CF_junho.pdf).

7.6. Aggregated iLUC factor rather than feedstock specific

Differently from IFPRI, JRC decided to calculate an aggregated iLUC factor (Table 31, Hiederer et al, 2010) that applies for the scenario and not for individual feedstock. That choice, however, harms more efficient feedstock (higher ethanol production per ha) that individually would have a lower iLUC factor. Aggregated iLUC factors are not suited to be used, for policy purposes, because of this problem of unbalancing the penalty. Assuming a penalty of 34 gCO2e/MJ on sugarcane ethanol will certainly be harmful to the feedstock at a higher than necessary level.

One way to overcome that problem is by applying a discount on the average iLUC for more efficient feedstock. Another way is to distribute total land use emissions according to the contribution of each feedstock on total marginal land required, dividing by the marginal biofuel production of each feedstock. If projections of ethanol yield are corrected (in some cases it is not correct and have to be fixed as shown in section 6.12.5). More efficient feedstock will have lower iLUC factors.

7.7. Sugarcane biomass and soil carbon uptake

The study considers the above and below ground biomass carbon stocks (ABCS) for sugarcane and tree crops. Results indicate that if land use and land cover is converted into a sugarcane plantation, the mean annual carbon stock for sugarcane (4 - 5 t C ha-1) is accounted for in the emission balance. However, the sugarcane ABCS values used in the study are considerably lower than what is verified in Brazil. Amaral et al.[41], for instance, report that the carbon stock in the sugarcane biomass reaches 17.5 t C/ha (without burn).

Modeling results (Macedo, 2010, op. cit.), based on data for 21 years from stabilized sugarcane plantations in the Brazilian Centre-South Region, show that the above ground biomass / ha (total) varies along the harvesting season from 69 t stalks (wet) / ha total area, in April 1st, to 19.6 t stalks at the end of the harvesting season (average is 44.3 t stalks / total ha), returning to 69 t / ha next April 1st. From this, it can be estimated that the time averaged above ground Carbon stock is 9.4 t Carbon / ha. Moreover, the data available for root biomass indicates additional stocks of 3.5 t C / ha.

Therefore, we recommend the utilization of experimental results from the specific Brazilian case (for both biomass and soil carbon stocks) to properly estimate the total carbon stock changes associated to the land conversion into a sugarcane plantation.

7.8. Conclusion

The analysis carried out in this section demonstrated that the JRC spatial allocation methodology overestimates forest land conversion to cropland in Brazil and, due to the fact that pasture intensification was neglected, it also overestimates marginal land demand for Brazil.

41 Amaral, W.A.M.; Marinho, J.P.; Tarasantchi, R.; Beber, A.; Giuliani E. (2008). Environmental sustainability of sugarcane ethanol in Brazil. In: Zuurbier and Vooren (coord.), Sugarcane ethanol: contributions to climate change mitigation and the environment. Wageningen: Wageningen Academic Publishers, 2008.