Avoiding the streetlight effect: Rebuttal to 'Indirect land use change (iLUC) within life cycle assessment (LCA) – scientific robustness and consistency with international standards' by prof. Dr. Matthias Finkbeiner

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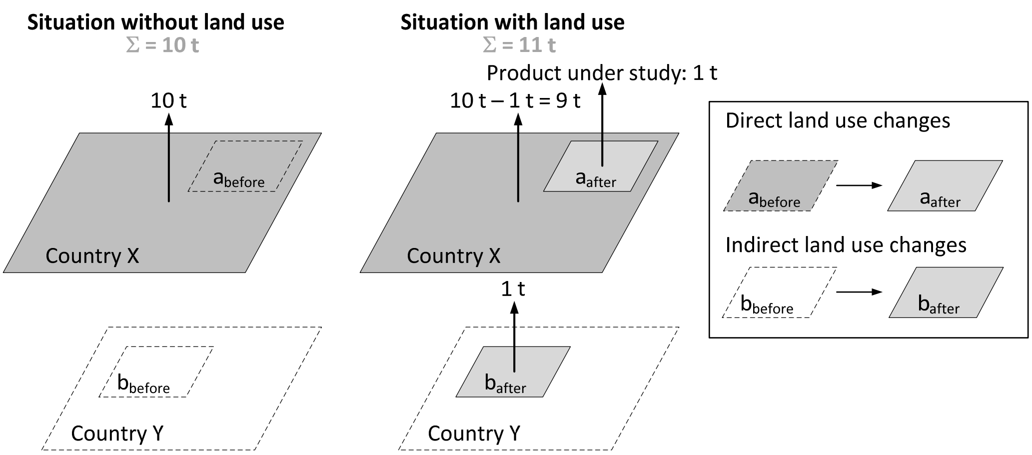
Background and objective of this document

It is arguably beyond controversy that shifting to a global bio-based economy, with an increased demand for food, fuel and fibre will put more pressure on land resources. However, when it comes to measuring this pressure at the product level, as it is done in life cycle assessment (LCA) and carbon footprinting (CF), this has been and still is subject to debate, especially regarding the modelling/estimation of indirect land use change (iLUC). In order to understand the concept of iLUC, it must be realised that there are two types of land use change (LUC) i.e. direct land use change (dLUC) and indirect land use change (iLUC). LUC as a whole can be defined as a change in the purpose for which land is used by humans. We talk about dLUC when the change takes places directly within the land that is being used, whereas we talk about iLUC when the change takes place elsewhere, as a consequence of our using the land locally. These two concepts are explained in detail in Box 1.

Modelling of iLUC has by far received most attention in the context of biofuels production (see e.g. Searchinger et al. 2008, Reinhard and Zah 2009, O´Hare 2009, Fargione et al. 2008, Schmidt et al. 2009), due to the increasing global interest on implementing policies to increase biofuel use as means to reduce greenhouse-gas (GHG) emissions. It is in this context that Prof. Matthias Finkbeiner recently published a report titled '*Indirect land use change (iLUC) within life cycle assessment (LCA) – scientific robustness and consistency with international standards*', where he addressed, based on existing literature and standards, whether iLUC "can be included in the LCA or carbon footprint (CF) calculations of biofuels in a scientifically robust and consistent way" (Finkbeiner 2013a, p. 7). Finkbeiner´s conclusion to this core question is a "no":

> *"there is no fact-based support for a scientifically robust and consistent inclusion of iLUC factors into LCA and carbon footprints (CF) assessments*" (Finkbeiner 2013b, key conclusion 4),
>
> and "*it is wise to address iLUC separately from LCA – at least for quite some time*"... "*Due to the different nature of iLUC and the material and energy flows typically assessed in LCA*" (Finkbeiner 2013a, Executive Summary).

An example of dLUC is when a barley field is transformed into a rapeseed field to produce rapeseed which is part of the product system under study. This change in land use is represented by the transformation from a_{before} to a_{after}. dLUC also includes emissions from the decomposition of organic matter in organic soils (peat) caused by draining and aeration, and emissions from recently transformed land due to changes in soil organic matter. The iLUC are illustrated as transformation from b_{before} to b_{after}.



Some LUC methods focus on historical dLUC (often the most recent 20 years) and then allocate / amortise the total emissions to the crops grown during this period of time. Examples of these guidelines that use this method are PAS2050 (BSI 2011), the GHG-Protocol (WRI/WBCSD 2011) and the PEF Guideline (EC 2012). Other methods focus on the current and future effect of current activities (e.g. Petersen et al. 2013).

Box 1. dLUC and iLUC (Schmidt et al. 2014).

The arguments for this conclusion are concisely summarised in seven bullet points in a 1-page document shared with the European Parliament (Finkbeiner 2013b):

> "*the data quality underlying iLUC factors is significantly lower than any other data used for LCA and CF" … "As there are no primary data available for iLUC calculations*" (Finkbeiner 2013b, key conclusion 1)
>
> "*numeric values of estimated iLUC emissions are misleading and contain systematic as well as statistical errors" … "And there is currently no way to determine which of the iLUC factors published is more accurate and informative*" (Finkbeiner 2013b, key conclusion 2)
>
> "*There is agreement among the scientific community that the current information content, reliability and integrity of exact iLUC factors are not on the quality level of well established economic models or robust scientific findings*" (Finkbeiner 2013b, key conclusion 3)
>
> "*The isolated application of iLUC for biofuels is scientifically not consistent*" (Finkbeiner 2013b, key conclusion 5)
>
> The "*credibility, robustness, integrity and reliability*" of LCA and CF would be damaged, "*Should policy makers decide to introduce speculative and inconclusive iLUC factors into environmental impact assessment*" (Finkbeiner 2013b, key conclusion 6)
>
> "*more focus and resources should be directed towards proactive mitigation of iLUC effects, rather than reactive introduction of sham iLUC factors*" (Finkbeiner 2013b, key conclusion 7)

This document provides a point-by-point rebuttal to prof. Finkbeiner's study. Our document is organised in the same order as the above "key conclusions". We find most of the specific arguments or "key conclusions" to be misinformed, and do not find the main conclusion of the study to be supported by the evidence and arguments put forth. We provide arguments to support that LCA/CF practitioners and decision makers should not turn a blind eye on iLUC. Our conclusion is that iLUC can indeed be included in the LCA or carbon footprint (CF) calculations of biofuels "in a scientifically robust and consistent way".

Point-by-point rebuttal

1. The quality of iLUC data

In the Executive Summary in Finkbeiner (2013a) there are three points that relate to the "key conclusion 1" of Finkbeiner (2013b):

> "*I. Indirect land use change cannot be observed or measured" and*
>
> *"II. The iLUC quantification is based on theoretical models that mainly rely on hypothetical assumptions and market predictions."*
>
> *"V. There are basically no primary data available for iLUC calculations; there is hardly any resolution with regard to individual crops or regions. The data quality underlying iLUC factors is significantly lower than any other data used for LCA and CF."*

What cannot be observed (or measured) is the "indirectness" of the LUC. The LUC itself is a well-established fact that can be observed and measured in several ways, e.g. by field or satellite observation. Linking the LUC to its indirect drivers is what LCA and CF models do, just like they do for all other indirect effects. An LCA or CF result is necessarily a "*theoretical, hypothetical value based on market predictions and a number of assumptions*" (Finkbeiner 2013a, p. 54). Product life cycles *are* artificial theoretical constructs and cannot be measured as a whole in the real world. Finkbeiner himself admits on p. 48 that statements based on LCA in general are impossible to prove. In spite of these limitations, LCA is widely used and accepted to assess the impacts of products and services. The results are not derived by observation and measurement, but instead are obtained by validating each element of the LCA or CF models through matching them against their real life counterparts, and by interpreting and reviewing the results critically. Thus, the inability to be observed and measured is something that iLUC shares with LCA and CF results in general. This cannot be used as an argument to exclude iLUC from LCA.

The quality (reliability, completeness and representativeness) of the data in iLUC models is not necessarily lower than that for other data used for LCA and CF. It is not uncommon even in peer-reviewed and published LCAs to find technology descriptions extrapolated from a single case study or from very different geographies, missing substance flows, missing mass balances, inputs represented by nearest proxy, and estimated data in general. Although this deplorable state is often neither documented, justified, nor necessary, it is usually accepted by reviewers and publishers alike. As for the iLUC models, it is sufficient to apply the same model as that used for LCA in general (Schmidt 2010), implying that no additional modelling uncertainty needs to be introduced. Leaving out the impacts from LUC clearly does not increase certainty of the LCA results. In general, low quality data is better than no data (We shall return to the issue of data uncertainty in section 3 of our rebuttal). Low data quality, both for iLUC and for LCA in general, can only be an argument for improving the data quality and refrain from drawing unsubstantiated conclusions, not an argument for excluding iLUC from LCA altogether.

2. On double-counting

The first half of "key conclusion 2" of Finkbeiner (2013b) states that "*numeric values of estimated iLUC emissions are misleading*". This appears mainly[1] to relate to the issue of double-counting, described in Section 4.2 of Finkbeiner (2013a), as summarised by the following two points in the Executive Summary:

> "*III. The economic LUC models cannot differentiate between direct (dLUC) and indirect land use change. There is no iLUC without dLUC. If every product on earth accounted for its dLUC, there is no iLUC – unless double-counted.*"
>
> "*IV. They suffer from a number of deficiencies and do not address the allocation of greenhouse-gas emissions from a particular agricultural field between the displaced and the displacing crop ('inter-crop-allocation')*"

Finkbeiner justifies this by means of an example (Finkbeiner 2013a, p. 44), which can be briefly summarized as follows:

- We have a sugarcane field, producing sugarcane for bioethanol production. Assume this sugarcane field expands by 1 hectare (ha) over land formerly used for pasture, and this indirectly triggers 0.2 ha of forest to be converted to pasture land (for beef cattle production), i.e. we have 0.2 ha of iLUC.
- If we assess the CF of both bioethanol and beef, these 0.2 ha of LUC would be included in both studies, thus leading to double counting, as follows: 0.2 ha iLUC for bioethanol, 0.2 ha dLUC for beef.

In our opinion the problem as presented by prof. Finkbeiner makes little sense. In fact, we argue that the described example illustrates a modelling error rather than a theoretical or practical problem:

[1] Other points that can cause misleading estimates of iLUC are discussed in Section 3 of this rebuttal.

In the example, two independent demands are modelled, requiring a total of 1.2 ha of land and in total causing a LUC of 0.2 ha. Beef is not an input to sugarcane production, but a separate product, with a separate demand. If all LUC is assigned to the "frontier land use" (here: pasture), then there is indeed no LUC left to distribute as indirect. If, on the other hand, land tenure is seen as an intermediate product, the LUC becomes an indirect effect of all activities that demand land, and both the sugar cane and the pasture receive an iLUC of 0.2ha/1.2 ha, i.e. 83% of the 0.2 ha is demanded by the sugar cane and 17% by the pasture. In both cases, no double counting occurs.

That the double-counting problem for iLUC is an artefact can be illustrated by the following analogy concerning an LCA of aluminium. Aluminium production is associated with a high electricity input, which causes high CO_2 emissions (Figure 1). These CO_2 emissions can then be called "indirect electricity emissions" from the perspective of the aluminium production. It is common sense that these emissions should be included in an LCA of aluminium, even if they do not take place in the aluminium production plant.

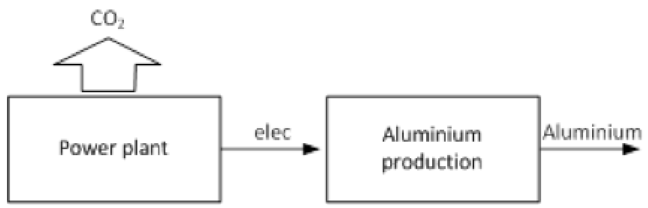


Figure 1. Indirect CO_2-emissions for aluminium production.

Thus, double-counting should be avoided by correctly scoping and modelling iLUC like any other indirect effect in LCA, not by excluding iLUC from LCA.

3. Uncertainty

The second half of "key conclusion 2" of Finkbeiner (2013b) states that "*there is currently no way to determine which of the iLUC factors published is more accurate and informative*". This is further elaborated in the Executive Summary of Finkbeiner (2013a):

> *"VIII. The uncertainties are dominated by systematic rather than statistical errors. As a consequence, there is currently no way to determine which of the iLUC factors published is more right than any other."*

This issue of uncertainty is also core to two further points of the Executive Summary:

> *"VII. iLUC values found in the existing literature vary in enormous ranges"*

> *"IX. There is a trend of an erosion of iLUC factors over time."*

We will first, in Section 3.1, analyse the options for reducing systematic model uncertainties and for distinguishing between good and bad models and results (iLUC factors), and then, in section 3.2, discuss the implications of the size and trend of published iLUC factors.

3.1. Model uncertainty

In contrast to what appears to be implied by the above statement VIII of Prof. Finkbeiner´s Executive Summary, both systematic and stochastic model uncertainties (errors) can be assessed scientifically. The validity of a model does not depend on its stochastic uncertainty (precision) alone. In fact, the accuracy of a model is related to (absence of) systematic errors (Figure 2); see e.g. Weidema (2009).

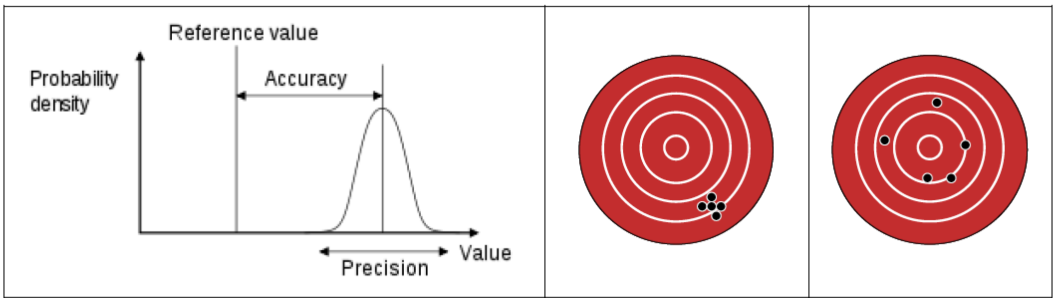


Illustration of the concepts of precision (i.e. uncertainty) and accuracy (i.e. representativeness plus methodological consistency)	**High precision, low accuracy. The results are biased.**	**High accuracy, low precision. The results are uncertain.**

Figure 2: Precision and accuracy (European Commission, 2010, p. 326).

In fact, Finkbeiner (2013a, Section 4.2) lists some of the "*unresolved challenges and gaps with regard to scientific robustness and consistency of iLUC quantification methods*". This exactly shows that the systematic model errors *are* known and that their relative merits therefore *can* be assessed and the models systematically improved. New methods are constantly being published, and by choosing among already published studies, one can reveal any desired range/variation among results. It may even be so that some of the cited studies in Finkbeiner (2013a) may end up contributing to scientific robustness for a particular iLUC factor in the future. We discuss each of the listed systematic model uncertainties in turn:

> *"that fundamentally different methods are applied to quantify iLUC"*

The use of different methods is not in itself a problem. Rather, more models that give similar results will increase their robustness. The parameters underpinning the variability of results can be identified/explored, which would contribute to the improvement of models.

> *"that all these methods rely on a large set of assumptions"*

While unnecessary assumptions should be avoided, making initial assumptions may be the only way to establish and test the robustness of a model, and delimit its empirical data requirement.

> *"that they react very sensitive to changes in the assumptions made"*

Identifying what assumptions are sensitive is the way scientific models are tested and priorities for improvements in data and models are determined.

> *"that all these models rely on market predictions"*

When studying iLUC, which is a market-mediated effect to a change in demand for land, including market reactions is necessary to obtain a robust model. Leaving out market reactions from the models would miss the point.

> *"that all these methods rely on historic trends to model a presumably non-linear future change of the system"*

This is a general feature of most LCAs. Using forecasted (scenario) data would of course increase both robustness and uncertainty, also in LCA in general.

> *"that the economic models cannot distinguish between iLUC and dLUC"*

It is not necessary for a model to distinguish between iLUC and dLUC, as long as all LUC is included and included only once. This issue was already discussed in Section 2 of this rebuttal.

> *"that they do not really take into account the strong regional characteristics (…) since the displacement could:*
> – *move previous agricultural production to areas outside of a country;*
> – *occur with significant time lags;*
> – *be distributed through global trading. [The location at which iLUC may occur is unknown]. The 'non-locality' of indirect effect is a result of the 'non-locality' of global commodity markets"*

This is exactly why global models are generally preferred. Geographical displacements and localisation of the actual LUC are included in all iLUC models but at different degrees of detail. Using longer time series is normal practice to include time lag.

> *"that they often ignore the challenge of allocation of LUC to by-products" and "that they often ignore other compensation measures like yield increases or changing diets"*

Model completeness (e.g. inclusion of displacement effects from by-products and agricultural intensification) is one of the characteristics that distinguish the quality of models. Identifying such completeness issues is the way to drive model improvements, and explains why models over time deviate less from each other.

In conclusion, we have shown that there *is* a way to distinguish the relative quality of models and thus a "way to determine which of the iLUC factors published is more right than any other".

3.2. The size and trend of iLUC factors

Finkbeiner (2013a) illustrates the uncertainty of iLUC factors graphically in his figures 8 and 9 (p. 50 and p. 51, respectively) where the iLUC factors for bioethanol and biodiesel, measured in g CO_2-eq./MJ, are compared to the corresponding emissions from fossil fuels, foods, and chemicals. The iLUC factors are represented as a min-max range, which we think is a very coarse approach for expressing uncertainty in this case, given that it gives the perception that any value within that range is equally probable. If on the other hand we look at figure 3 (Finkbeiner 2013a, p. 30) where the individual iLUC factors from different studies are displayed, we can see that some values (or value ranges) are more likely than others.

In Figure 4 (Finkbeiner 2013a, p. 31) there is a timeline showing that more recent studies have lower and less deviating iLUC factors. This is what makes Finkbeiner conclude that "there is a trend of an erosion of iLUC factors over time." A more positive perspective on this would be that there is increasing agreement over time, i.e. that models become better, which can hardly be an argument against including iLUC modelling in LCA.

On p. 52, Finkbeiner (2013a) then concludes that the "*enormous ranges of the currently published iLUC factors" … "clearly indicates the absence of any scientific robustness for claiming a particular iLUC factor"*. But this argumentation could equally well be used for excluding any equally uncertain aspect from LCA, such as toxicity, or the actual effects that global warming has on human health and ecosystems.

We may never be able to calculate 'exact' iLUC effects, in the same way that we may never have 'exact' LCA results. That should not prevent us from using the best information available to make decisions and to work on quantifying the uncertainties. Uncertainty may reflect real life variation or real lack of knowledge, or it can be reduced through improved models and data. In both cases, excluding the uncertain issues may make the results look less uncertain, but *a robust decision must be one that can withstand the inclusion of uncertain knowledge*.

4. Agreement in the scientific community

The statement in the Executive summary of Finkbeiner (2013a) that

> *"VI. There is full agreement in the scientific community that iLUC factors are highly uncertain"*

in the key conclusions document for the EU parliament (Finkbeiner 2013b) becomes:

> *"3. There is agreement among the scientific community that the current information content, reliability and integrity of exact iLUC factors are not on the quality level of well established economic models or robust scientific findings"*

While the arguably high uncertainty is a scientific issue, robustness of a finding depends on the decision contexts in which it is to be applied. We disagree that uncertainty should be an argument for systematically excluding iLUC from LCA and CF studies. Even with today's level of uncertainty, including iLUC gives us an indication of an extremely relevant hotspot that should not be overlooked. Also, doing so in a quantitative way provides us with more tangible information than when we decide not to use numbers[2]. The inclusion of iLUC makes LCA/CF studies of bio-based products more accurate, not less (Figure 2). In other words, we argue that studies of bio-based products should better be 'approximately right than precisely wrong'.

Chapter 3 in Finkbeiner (2013a) is devoted to a thorough analysis of the provisions in main LCA and CF standards with regard to iLUC, leading to the conclusion in the Executive Summary that

> *"XI. The lacking scientific robustness and consistency of iLUC is properly reflected in the existing international standards for LCA and CF"*

in that they abstain from the inclusion of iLUC factors into their assessment. As Finkbeiner states, the ISO 14040 and 14044 standards (ISO 2006a, 2006b) were published in 2006, before the iLUC debate had started. Then he reviews other LCA and CF standards that have been completed after the iLUC debate started, and all but one of them (the Japanese and Korean guidelines for carbon footprint) mention iLUC. In summary, these standards say:

- Product environmental footprint (PEF) guide : '*No widely accepted provisions exist for the calculation of emissions resulting from indirect land use change, so no specific recommendations or guidance are supplied here. These shall not be assessed in the PEF study*'. (European Commission 2012, p. 117).

- ILCD handbook : '*As no widely accepted provisions exist for indirect land use, but such are still under development by several organisations, no specific provisions are made at this point. The appropriate way how to integrate indirect land use changes is hence to be developed for the specific case, in line with the general provisions o consequential modelling. This is unless specific provisions would be published under the ILCD. Such provisions might be part of a future supplement*' (European Commission 2010, p. 173).

- French Environmental footprint (BPX 30-323) : '*...indirect land use change is not included until an internationally agreed method has been established*' (ADEME 2009).

[2] Quoting Lord Kelvin (Thomson 1883): *"I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the state of Science, whatever the matter may be."*

- ISO/TS 14067 : '*Indirect land use change (iLUC) should be considered in CFP studies, once an internationally agreed procedure exists*' (ISO 2013).

- PAS 2050:2011 : '*While GHG emissions also arise from indirect land use change, the methods and data requirements for calculating these emissions are not fully developed. Therefore, the assessment of emissions arising from indirect land use change is not included in this PAS. The inclusion of indirect land use change will be considered in future revisions of this PAS*' (BSI 2011).

In contrast to Prof. Finkbeiner, we find that these texts do not reject iLUC as an invalid concept that cannot be included in LCA/CF studies. On the contrary, many of them accept that it is a cause for concern. What they all say, though, is that *currently there is no agreement on how to assess iLUC*, and for this reason they abstain from including it. They actually leave the door open for inclusion once methods are more mature.

5. On single numbers and the stage of development of iLUC modelling

The first part of the "key conclusion 5" of Finkbeiner (2013b):

> *"iLUC factors are a hasty reaction in method development and remain an arbitrary choice for political decision-making"*

is repeated as *point XII* in the Executive Summary in Finkbeiner (2013a) and further qualified by:

> *"X. The lack of scientific robustness and consistency of iLUC models and their data make the provision of any single numbers for iLUC factors rather sham than substance."*

and in the concluding part of section 4.2 in Finkbeiner (2013a):

> *"The discussion reveals that the current iLUC quantification methods are still in their infancy, rather theoretical and not well-thought-out."*

We agree that the use of single numbers for iLUC is not - and never will be - good scientific practice. One cannot say anything certain about a number without uncertainty information. Also, it obvious that iLUC modelling is in a very early stage of development, since one of the first major scientific studies attempting to model iLUC was published just six years ago (Searchinger et al. 2008). In these circumstances we can expect that several approaches are developed, and that these lead to different results for the same problem. In due course, some of these approaches will be rejected whereas others might be further refined and succeed in being generally accepted by the scientific community; also, it could be that completely new ones appear. Something similar happened to LCA itself during the late eighties and early nineties, which led to the ISO standardization process. The effort of countless scientists and the support of many institutions around the world during the recent 20 years have resulted in LCA being considered nowadays the best approach for a comprehensive environmental assessment of products and services. Would it have been a good idea to reject LCA back then, on grounds of lack of maturity? Obviously not.

6. All indirect effects must be included to be consistent

The second part of "key conclusion 5" of Finkbeiner (2013b) states:

> *"The isolated application of iLUC for biofuels is scientifically not consistent"*

which is further qualified in the Executive Summary in Finkbeiner (2013a) as:

> *"XII (a). The isolated application of iLUC for biofuels is scientifically not consistent. (b) For a fair comparison of biofuels with fossil fuels, the same rules have to apply. If iLUC is considered for biofuels as indirect effect, the indirect effects of fossil fuels have to be considered as well. (c) A*

> *scientifically robust assessment of indirect effects cannot be limited to the arbitrarily chosen issue of land use change. Full scientific consistency requires "including all indirect effects or none". Any arbitrary selection of indirect effects is a value choice, not justified by science."*

This is then further elaborated in Section 4.2 of Finkbeiner (2013a).

On this point, we wholeheartedly agree. Both iLUC and all other first order indirect effects should be included in a consistent way in LCA.

If iLUC is a valid scientific concept, then it should be applied to all products, not just biofuels. Any product that demands land in order to fulfil its function is a candidate for inclusion of iLUC. Anything else would be inconsistent.

One indirect effect that is not always included in iLUC models is the intensification of cultivation. For example, agricultural biomass production can be increased either by increasing the area of land under cultivation, or by increasing the production capacity (yield) from land already being used. The former leads to land use changes such as deforestation, whereas the latter can be called 'intensification' and can be achieved in many ways, e.g. applying more nitrogen or phosphate fertiliser, using genetically modified organisms, implementing irrigation systems, applying integrated pest management, etc. (Schmidt 2010), without leading to e.g. deforestation.

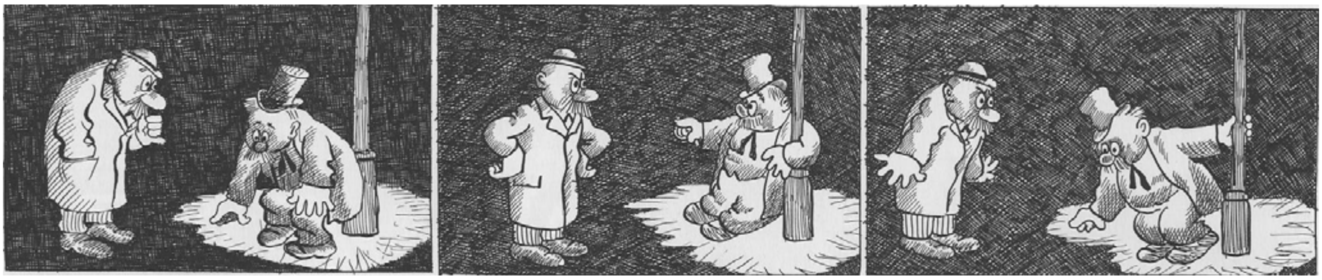
There should be *a priori* no limits to what LCA should cover, as it aims at being a holistic tool that tries to avoid 'burden shifting'. In fact, most effects in the life cycle of products are already indirect; all upstream and downstream effects of any activity can be categorised as indirect. In any case, the fact that some indirect effects are not yet included in LCA just reflects our current inability to do so, not necessarily an inherent inability of LCA to incorporate them. The current trend is for LCA to expand its coverage of impacts and its applicability range. Some examples of this are the inclusion of rebound effects, the differentiation of impacts with respect to time, development of social LCA, life cycle costing, the use of input-output databases, as well as the increasing number of biophysical impact categories that we can incorporate in the impact assessment stage.

7. The streetlight effect

The "key conclusion 6" of Finkbeiner (2013b) states that the:

> *"credibility, robustness, integrity and reliabiltiy" of LCA and CF would be damaged, "Should policy makers decide to introduce speculative and inconclusive iLUC factors into environmental impact assessment".*

We hold exactly the opposite to be true, that is, that damage to LCA and CF comes not from addressing challenging issues, even if they are not methodologically mature, but by deliberately omitting them, especially when these issues are within the traditional scope of LCA and CF (greenhouse-gas emissions from human activities) and when they appear to be of crucial importance for decision making in a particular context, like bio-based materials and fuels. It is our opinion that we as LCA and CF scientists would fail if we voluntarily apply an observational bias to the questions we are asked to answer, just like the drunkard looking for his keys under the street lamp (Figure 3).



A: Has the Gentleman lost something?
B: Yes, my keys.

A: Did you loose them right here?
B: No, it was over in the dark alley

A: But why do you look for them here then?
B: Well, here is a street light. It is much easier to see.

Figure 3. Drawing: Storm P. 1926. Reproduced with permission from the Storm P. Museum, Frederiksberg.

8. The false dichotomy of mitigation and assessment

The “key conclusion 7” of Finkbeiner (2013b) states that:

> *"more focus and resources should be directed towards proactive mitigation of iLUC effects, rather than reactive introduction of sham iLUC factors"*

While we agree that mitigation is important, we fail to find any arguments for mitigation and assessment to be mutually-exclusive alternatives. On the contrary, we find them complementary, and assert that robust quantification of iLUC effects is necessary in order to guide and monitor mitigation efforts. What inclusion of iLUC in LCA has already shown is that long-term and lasting mitigation of LUC is not achievable through product policies, but requires more permanent nature conservation measures. This finding is a result of *including* iLUC in LCA, not of ignoring it in LCA.

Conclusion

We have provided a point-by-point rebuttal to Prof. Finkbeiner’s study. With the exception of our agreement with the statements that “all indirect effects must be included to be consistent” (Section 6 of this rebuttal) and that “the use of single numbers for iLUC is not - and never will be - good scientific practice” (Section 5 of this rebuttal), we have failed to find convincing supporting evidence and arguments for Finkbeiner’s main and key conclusions.

The core disagreement appears to be on whether low data quality and large uncertainties should lead to the exclusion of the uncertain element, or whether the objectionable elements in all their uncertainty should rather be quantified and included to provide the best basis for decision making. Excluding, ignoring or describing the uncertain elements qualitatively may make the quantitative LCA or CF results look less uncertain, but it does not reduce the true uncertainty of the results. It is a disservice and an insult to decision-makers to assume that they are so much under influence of the streetlight effect that we need to trim uncertain elements from the decision basis. We assert that *a robust decision must be one that can withstand the inclusion of uncertain knowledge*.

We find that iLUC can be modelled in a way that is consistent to the way other indirect effects are modelled in LCA, and that both model and data uncertainties are known and can be managed. Our conclusion is that iLUC can indeed be included in the LCA or CF calculations of biofuels “in a scientifically robust and consistent way”.

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