Risk management

Identifying high and low ILUC-risk biofuels under the recast Renewable Energy Directive

Dr Chris Malins

January 2019

Acknowledgements

This project was funded by Transport and Environment. Cerulogy is grateful to the following for useful input to the report: Daan Peters (Ecofys); Stephanie Searle (ICCT); Laura Buffet (T&E); Aaron Berry and Verena Leckebusch (UK DfT); Robert Edwards (JRC); Aurea Nardelli (RSB); Bradley Saville (University of Toronto); Hugo Valin (IIASA). Front cover image by Jane Robertson Design.

Disclaimer

Any opinions expressed in this report are those of the author alone. Errors and omissions excepted, the content of this report was accurate to the best of Cerulogy's knowledge at the time of writing. Cerulogy accepts no liability for any loss arising in any circumstance whatsoever from the use of or any inaccuracy in the information presented in this report.

Summary

European Union biofuel policy has the goal of reducing the net greenhouse gas emissions intensity of EU transport, but under the Renewable Energy Directive (RED) this goal has been undermined by the lack of mechanisms to avoid or reduce indirect land use change (ILUC) emissions that occur when increased EU demand for agricultural commodities as biofuel feedstocks cause agricultural expansion. ILUC modelling for the European Commission has provided numerical estimates of these emissions for key biofuel feedstocks, and suggests that for crop-based biodiesel in particular indirect land use change emissions are likely to eliminate the climate benefits from fossil fuel displacement, with estimates of ILUC for palm oil biodiesel generally being the highest of all. This conclusion is supported by a review of the ILUC modelling that has been undertaken in the last ten years.

However, the recast of the Renewable Energy Directive (RED II), which comes into effect from January 2021, places the emphasis not on modelled ILUC estimates, but on the identification of 'high ILUC-risk' feedstocks, and the certification of low ILUC-risk projects. In this report, we consider the definition of high ILUC-risk feedstocks and which feedstocks would meet that definition, and review what an effective scheme for certifying low ILUC-risk projects might look like.

High ILUC-risk feedstocks

Under the RED II, biofuels from high ILUC-risk feedstocks will be progressively excluded from EU biofuel incentives between 2021 and 2030. High ILUC-risk feedstocks are defined in RED II as those for which a significant amount of expansion is observed into high carbon stock areas. The RED II identifies high carbon stock areas as wetlands and forests able to achieve at least 10% canopy cover. The European Commission is tasked to provide rules for identifying high ILUC-risk feedstocks in a delegated act by February 2019. This high ILUC-risk designation is to be applied at the feedstock level. This reflects a reasonable conclusion that it is possible to distinguish weaker and stronger links to conversion of high carbon stock landscapes between different feedstocks.

The idea of high deforestation risk commodities is explored in detail in existing literature, and provides an indication of which biofuel feedstocks may carry a high ILUC-risk. Previous studies on the contribution of demand led commodity expansion to deforestation consistently identify oil palm and soybeans as the most strongly deforestation-linked crops, with some studies also discussing sugarcane and maize. Analysis of FAOstat data supports this, showing that expansion of oil palm, soybeans and sugarcane occurs predominantly in countries that report significant rates of forest loss, whereas for maize and the other major biofuel feedstocks the fraction is much lower. Oil palm, soybeans and sugarcane are therefore identified as 'potentially high ILUC-risk feedstocks that warrant further assessment.

Remote sensing studies of the direct link between crop expansion and deforestation provide a basis to move from identifying a feedstock as potentially associated with deforestation to firmly demonstrating that a significant fraction of expansion of that crop occurs at the expense of high carbon stock land. For sugarcane, there is clear evidence that despite production growth in countries with net deforestation, expanded sugarcane area does not generally

come from forest or wetlands, and therefore that sugarcane should not be designated a high ILUC-risk feedstock.

For soybeans and oil palm, in contrast, the picture is one of ongoing conversion of high carbon stock land. The link between soybean production and deforestation has been weakened in the last decade following the adoption of a moratorium on soy expansion into the Amazon rainforest, but in other parts of Latin America studies show that a deforestation link continues. Based on documented links between soy and deforestation in Latin America, it is estimated that 12 % of soy expansion there is associated directly with deforestation, and therefore that at least 7% of global soybean expansion in the period 2012-15 occurred at the expense of high carbon stock land.

For palm oil, the link to deforestation and peat drainage is very strong, driven by a strong deforestation link in Indonesia where the majority of current oil palm expansion occurs, Based on the most recent assessments available, it is estimated that about 31% of oil palm expansion globally occurs on forested land, and 23% on peatlands (some of which overlaps with forest conversion).

The RED II does not provide a clear definition of when the level of loss of high carbon stock land associated with a feedstock ought to be treated as 'significant'. In this report, we provide an example of a threshold calculation based on estimating carbon dioxide emissions for every unit of additional feedstock production, based on observed land use histories. Under this analysis, both palm oil and soy oil would qualify as high ILUC-risk. While a threshold calculation is possible, the lack of a single authoritative source for land use change data could make threshold setting contentious – this report provides an example of a threshold assessment, under which both palm oil and soy oil would be categorised as high ILUC-risk. It may be that the most appropriate way to deal with the range of evidence available would be for the Commission to provide a clear specification of indicators it would consider, but make the final identification of high ILUC-feedstocks on a narrative basis informed by these indicators, rather than explicitly using a single threshold assessment. Based on the evidence documented in this report, we conclude that both oil palm and soybeans are associated with 'significant' conversion of high carbon stock land, and should therefore be categorised as high ILUC-risk.

Low ILUC-risk certification

While using some biofuel feedstocks comes with a high ILUC-risk, the RED II also allows for the possibility that feedstock producers can demonstrate that they have avoided ILUC. This involves having feedstock projects certified as having low ILUC-risk where it can be demonstrated that feedstock production avoids displacement of existing users. In particular, low ILUC-risk projects to produce feedstocks that normally have high ILUC-risk will not have their access to incentives limited, but they will still be subject to the cap that applies to all food-based biofuels. The RED II also calls for the European Commission to set out rules for low ILUC-risk project certification by February 2019.

The concept of low ILUC-risk biofuels has been discussed for a decade, and the Roundtable on Sustainable Biomaterials already offers an option to certify feedstock production as low ILUC-risk. Up until now there has been no direct regulatory benefit for low ILUC-risk projects, but the RED II changes that and could create a clear value signal for certification. It is important therefore that only projects that genuinely avoid displacement of existing feedstock users are able to be certified as low ILUC-risk under the Directive.

Low ILUC-risk projects can be grouped into two basic categories – unused land projects and productivity projects. Unused land projects work by producing biofuel feedstock on a piece of land that would otherwise not be in use. This might be land that has been abandoned in a region where the agricultural area is shrinking, land that has been contaminated by industry, or land that would normally be too unproductive or difficult to farm. Productivity projects work by increasing the amount of material being produced on land already being used. That could be by increasing the yield of an existing crop, by adding an additional cover crop, by shifting to a multicropping system or by integrating cropping with livestock farming. In all cases, low ILUC-risk projects would still be subject to the sustainability criteria set under the RED II.

For both project types, a challenge in certification is to set rules that prevent 'business as usual' feedstock production from being certifiable. If feedstock producers can get certified without having to take any action that would reduce displacement of other uses, they become 'free-riders' – benefiting from the certification without supporting the underlying goals of the low ILUC-risk policy.

For unused land projects, the most simple free-rider risk would be to allow any feedstock grown on land not farmed prior to a given cut-off date to be certified. Given that overall global agricultural area is expanding, this would allow large areas, including in tropical countries where agriculture is linked to deforestation, to be certified even though those areas may well have been brought into production anyway. It has been estimated based on current rates of expansion that by 2030 5 million tonnes of palm oil will be produced on oil palm plantations that were not there before 2020 and that did not replace high carbon stock landscapes or other crops, simply through business as usual expansion (Searle & Giuntoli, 2018). That's 5 million tonnes of palm oil that would otherwise have been available for food use. It is therefore important if displacement is to be avoided to certify only projects on land that would otherwise not have been cultivated.

For productivity projects, the simplest free-rider risk arises as a result of normal variability in yields. If all feedstock production that achieves yields better than the local trend were allowed to be certified as low ILUC-risk, this would allow farmers experiencing good weather in any given year to claim part of their production as low ILUC-risk, without actually undertaking any yield improvement exercise. Similarly to the case with free-rider unused land projects, if not addressed there is the potential for such free-rider yield gains to generate a very large quantity of nominally low ILUC-risk feedstock that in fact represents only business as usual agriculture.

For low ILUC-risk certification to work, therefore, certification rules must be developed in recognition of these risks, and with the goal of supporting only production that meets the requirement of the RED II by avoiding displacement of other feedstock uses. This requires the use of additionality requirements and appropriate metrics for determining low ILUC-risk certification. It requires rigorous oversight to ensure that projects are properly implemented and sustained. Should the European Commission approve any low ILUC-risk methodology or scheme that fails to rigorously demonstrate that displacement effects are avoided, not only will the results from that scheme be meaningless, but the availability of a weak certification framework would undermine the business case for real projects.

The most direct approach to assessing the additionality of low ILUC-risk projects would be to implement rules based on or similar to the requirements of the "Tool for the demonstration and assessment of additionality" of the CDM. This requires that a project must either be first of a kind or must demonstrate additionality by an investment analysis (showing that the project would not normally be financially viable) or barrier analysis (showing that non-financial barriers exist that would normally prevent a project from being undertaken). Such an assessment creates additional pre-project verification requirements, but is the gold standard for identifying additionality.

For some projects, it may also be possible to identify 'proxy' additionality assessments, relatively simple evidence that could show that a project was *probably* additional. For productivity projects, this might include demonstrating the link to biofuel demand by documenting a commitment from a specific biofuel facility to take delivery of all produced low ILUC-risk material. For a project on abandoned land, it could include demonstrating that there were large areas of land with more favourable agricultural properties in the local region. Any relaxation of additionality rules should only be undertaken with great care, as setting weak rules would undermine the entire framework.

For productivity projects, there is also a measurement challenge. Natural variability in yields makes it impossible to build a satisfactory crediting system based solely on comparing reported yields to calculated trends. This could be addressed by requiring as part of the project plan an assessment of the productivity improvement that can be reasonably expected from the measure adopted. In this report we suggest a new approach to low ILUC-risk certification, under which part[1] of expected additional feedstock production from yield improvement measures would be certified without reference to observed yields, with certification of additional material available where yields do indeed exceed a baseline. This approach would reduce the uncertainty for producers about how much of their annual production would be eligible for low ILUC-risk certification, and reduce the potential for high yields due to natural variability to generate certifiable feedstock.

It might be expected that some stakeholders will ask for low ILUC-risk status in recognition of good agricultural practice that is already in place, or for yield improvement projects that will happen regardless of any EU incentive for low ILUC-risk biofuels. Such calls are understandable, but must be resisted. Similarly, operators in regions with weaker deforestation links than the global average for a given feedstock may ask to be awarded low ILUC-risk status. Operating sustainable agricultural systems is laudable, but low ILUC-risk certification must not be turned into a prize for producers located in relatively sustainable agricultural systems – for such a certification system to work it must only reward truly additional feedstock production. Anything less will lead to cherry picking of the most sustainable feedstock for import to Europe, followed immediately by the same indirect land use change impacts that we are trying to avoid.

Building the high ILUC- and low ILUC-risk concepts into policy

Correctly identifying high ILUC-risk biofuels provides a regulatory tool to allow the European Union to move past the most egregious unintended consequences of its renewable fuel policy. A policy designed to reduce greenhouse gas emissions ought not to drive significant conversion of high carbon ecosystems, whether in Europe or elsewhere. The high ILUC-risk categorisation provides a basis to reduce those negative impacts, and complemented by incentives for advanced biofuels to move the EU's biofuel market into a new and more sustainable phase.

1 We suggest half.

The environmental gains from a policy that reduces demand for high ILUC-risk feedstocks are potentially significant. this report estimates that eliminating direct EU demand for palm oil as a biofuel feedstock could avoid 130-210 thousand hectares a year of deforestation and 100-150 thousand hectares a year of peat drainage in 2030, and that eliminating direct EU demand for soy oil as a biofuel feedstock could avoid 10-20 thousand hectares a year of deforestation in 2030.

On the other side of the equation, the low ILUC-risk framework could provide an opportunity for EU biofuels policy to take a role as a catalyst for improved land use and gains in productivity in agriculture more generally. Such gains would only be achieved through a robust system – a system that allows free-riders to be certified would fail both on environmental integrity and on creating incentives for good projects.

Recommendations

High ILUC-risk

- Given the lack of a single comprehensive source of land use change data, it might be appropriate for the Commission to detail the indicators to be considered in determining which feedstocks are associated with 'significant' conversion of high carbon stock land, but make the final identification of high ILUC-risk feedstocks on a narrative basis informed by these indicators, rather than using a single threshold assessment.
- Palm oil and soy oil are associated with levels of high carbon stock land conversion that we consider to be significant, and therefore we conclude that they should be categorised as high ILUC-risk.
- Improved satellite assessments of links between feedstock expansion and high carbon stock land conversion should be developed to inform the 2023 review of high ILUC-risk categorisations.
- The 2023 review should include an assessment of the drivers of any short term changes in deforestation or peat destruction rates, and whether those changes are likely to be sustained.

Low ILUC-risk

- All of the low ILUC-risk certification approaches reviewed here have shortcomings. The Commission must be prepared to develop a substantially new specification to deliver robust certification rules.
- To deliver on the policy goals of RED II, any low ILUC-risk certification scheme must be robust and able to rigorously identify projects that truly avoid displacing existing uses – this requires strong rules on additionality assessment.
- The rules set in the "Tool for the demonstration and assessment of additionality" of the CDM can be considered a gold standard. Requiring projects to be assessed against a comparable set of rules is the most direct way to ensure that low ILUC-risk projects are correctly identified.

- It may be possible for some project types to set relaxed proxy additionality requirements that would provide an adequate degree of confidence that low ILUC-risk projects would be identified – any such relaxation should be approached with caution, however, given that several proposals for such relaxed approaches in previous studies appear to offer completely inadequate assurance.

Contents

Summary **3**

1. Introduction **12**

1.1. Levels of support for alternative fuels under the RED II 12

2. Biofuels associated with high indirect land-use change emissions in indirect land-use change modelling **14**

2.1. Differences between ILUC approaches 16

2.2. ILUC results reviewed by Woltjer et al. (2017) 17

2.3. Results in Woltjer et al. (2017) that can be discounted 19

2.3.i) Wheat 19
2.3.ii) Maize 20
2.3.iii) Sugarbeet 20
2.3.iv) Sugarcane 20
2.3.v) Palm 20
2.3.vi) Rapeseed 21
2.3.vii) Soybean 21
2.3.viii) Sunflower 22

2.4. Weighted average ILUC results 22

3. Identifying high ILUC-risk biofuel feedstock **23**

3.1. Identification of potentially high ILUC-risk feedstocks in FAO data 24

3.1.i) Discrepancies between data reported to FAO and observed forest area changes 26

3.2. Other evidence on forest risk commodities 27

3.2.i) Feasibility study on options to step up EU action against deforestation (Ecofys, Milieu, & COWI, 2018) 27
3.2.ii) An assessment of deforestation and forest degradation drivers in developing countries (Hosonuma et al., 2012) 28
3.2.iii) Trading forests: land-use change and carbon emissions embodied in production and exports of forest-risk commodities (Henders et al., 2015) 28
3.2.iv) Historical deforestation due to expansion of crop demand: implications for biofuels (Edwards, Padella, Vorkapic, & Marelli, 2014) 29

3.3. Feedstock-specific evidence of expansion of biofuel feedstocks on high carbon stock land 31

3.3.i) Soybean 32
3.3.ii) Sugarcane 37
3.3.iii) Oil palm 39
3.3.iv) Palm fatty acid distillates as co-products 41

3.4. Identifying high ILUC-risk feedstocks 41
3.4.i) Example threshold assessment 43
3.5. Dealing with changing deforestation trends in the high ILUC-risk framework 44
4. Certification of low ILUC-risk biofuels – background 46
4.1. Additional production 47
4.2. Low ILUC-risk fuels in EU law 48
4.3. A background to low ILUC-risk biofuel approaches 49
4.4. Certification by the Roundtable on Sustainable Biomaterials 52
4.4.i) Yield increase 53
4.4.ii) Unused land 54
4.4.iii) Waste and residues 54
4.4.iv) Alternatives to an additionality assessment 54
4.5. Proposed low ILUC-risk approach from Ecofys (2016) 55
4.5.i) Yield increase (general) 56
4.5.ii) Yield increase through multicropping 57
4.5.iii) Unused land 57
4.6. CDM CO_2 offset certification as a template for low ILUC-risk certification 57
4.7. Proposals for regional low ILUC-risk certification 59
4.8. Yield increase and yield variability – illustrations 60
4.9. Characteristics of a robust low ILUC-risk certification 61
5. A new outline approach for low ILUC-risk projects 63
5.1. Increased yield for a single crop 64
5.1.i) Crediting project implementation 64
5.1.ii) Crediting project outcomes 66
5.1.iii) Example using new methodology on fictional project data 66
5.1.iv) Yield baseline 67
5.1.v) An alternative additionality approach for yield increase projects 68
5.2. Increased overall productivity by adding an additional crop to an existing crops and/or livestock system 69
5.2.i) Feedstock production strictly additional to an existing system 70
5.2.ii) An alternative additionality approach for adding an additional crop without affecting productivity of the existing system 70
5.2.iii) Feedstock production involving trade-offs with existing system 70
5.2.iv) An alternative additionality approach for adding an additional crop in a way that affects the yield of the existing system 71
5.3. Utilisation of unused land otherwise unlikely to be brought into production 71
5.3.i) An alternative additionality approach for unused land projects 72

5.4. Proposed high level criteria for certifying low ILUC-risk biofuel projects 73

5.4.i) General criteria 73

5.4.ii) Increased yield for a single crop 73

5.4.iii) Increased overall productivity by adding an additional crop to an existing crop and/or livestock system 75

5.4.iv) Utilisation of unused land otherwise unlikely to be brought into production 76

5.5. Example language on criteria for low ILUC-risk certification 76

6. Potential impacts of the high ILUC-risk/low ILUC-risk framework 77

6.1. Potential land conversion and carbon stock losses avoided by high ILUC-risk designations 81

6.2. Relation of the high and low ILUC-risk framework to other renewable fuel regulation 81

7. References 83

Annex A. References to high and low ILUC-risk in RED II 91

A.1. RED II recitals 91

A.2. Articles 91

Annex B. Examples of the impact of yield variability on low ILUC-risk certification 93

B.1. Illustration with U.S. maize data 93

B.2. Illustration using synthesised project data 97

B.2.i) Yield trend and historical 'observed' yields 97

B.2.ii) 'Observed' yields and low ILUC-risk feedstock crediting after project implementation 99

B.2.iii) Conclusions 103

Annex C. Example formal language on criteria for low ILUC-risk certification 104

C.1. Identification of feedstock production systems that are potentially low ILUC-risk 104

C.2. General criteria that must be assessed by a scheme for the certification of low ILUC-risk feedstock 105

C.3. Demonstrating that feedstock production has avoided displacement effects of food and feed crop based biofuels, bioliquids and biomass fuels 106

C.4. Determining the quantity of low ILUC-risk feedstock produced by a certified low ILUC-risk feedstock production system 109

C.5. Requirements for monitoring of low ILUC-risk feedstock production systems 112

1. Introduction

Land use changes, and associated losses of biomass and soil carbon into the atmosphere as CO_2, are a major contributor to land use change. Over the past 15 years European biofuel policy, while intended to deliver reductions in net greenhouse gas emissions by reducing fossil fuel combustion, has simultaneously put pressure on land use through increased agricultural commodity demand. Analysis of the drivers of deforestation suggests that over the period 2001-2015 30% of global deforestation could be directly attributed to increased commodity production, and that the rate of annual commodity-driven deforestation has been relatively steady at around 5 million hectares a year. Studies of the indirect land use change (ILUC) impacts of EU biofuel use suggest that over a twenty year time horizon biofuel policy may have done more harm than good for the climate (Laborde, 2011a; Valin et al., 2015). Modelling approaches have been developed to estimate expected ILUC emissions, but these are based on complex systems of assumptions that and are associated with considerable uncertainty (Plevin et al., 2010). The European Union has therefore chosen in the recast of the Renewable Energy Directive (RED II) not to follow the lead of the U.S. Environmental Protection Agency (EPA) and California Air Resources Board (CARB), both of which have included ILUC estimates in regulatory lifecycle analysis of biofuels, but rather to moderate targets for food based biofuels, and to introduce a new category of 'high ILUC-risk' biofuels for which support will be eliminated by 2030.

While the concept of high ILUC-risk is now firmly embedded in European law, there is not yet a consensus about which biofuel feedstocks will be placed in this category, or on precisely what level of ILUC-risk is considered too much. By February of 2019, the European Commission is asked to report on this question and propose a delegated act identifying which (if any) feedstocks will be included in this category. Alongside those definitions, the Commission is also expected to propose a detailed set of rules for the identification of biofuel projects that have 'low ILUC-risk', due to avoiding the displacement of other commodity provisioning services. A project certified as low ILUC-risk will be able to escape the removal of support for non-certified projects using high ILUC-risk feedstock.

This report considers the framework for these two concepts, reviews evidence on the association between key biofuel feedstocks and loss of high carbon stock land, and provides recommendations both for which feedstocks have the highest ILUC-risk, and for how a robust framework could be developed that allows genuinely low ILUC-risk projects to continue to be supported, while avoiding the creation of loopholes that would undermine the environmental protections in the Directive.

1.1. Levels of support for alternative fuels under the RED II

Under the RED II, alternative fuels become eligible for different levels of potential support determined by their sustainability characteristics, with the precise value proposition to any alternative fuel producer dependent on the details of Member State implementations. There are two targets for Member States created by the RED II in the transport fuel supply – an overall target for the use of renewable energy in transport, and an advanced biofuels sub-target for the use of biofuels from feedstocks specified in Part A of Annex IX. Fuels that may be counted towards these targets can expect to be eligible for direct or implied subsidies, often through obligations placed on fuel suppliers to supply a given quantity of fuel. The highest value of support may be expected for fuels from the Annex IX Part A feedstocks, which are eligible to be counted towards both targets at up to twice their energy content. Fuels from the residual oils identified in Part B of Annex IX are also to be counted twice, but may not count towards the advanced biofuels sub-target, and the maximum contribution of these fuels is limited. There is then a group of fuels to be counted only once, but with no limit to their contribution to the Member State target, which includes renewable fuels of non-biological origin (such as electrofuels), any biofuel from non-food feedstocks not listed in Annex IX, and (at the discretion or Member States) recycled carbon fuels.

Food based biofuels are likely to receive a lower level of support under RED II, as they are to be counted only once, and because their contribution to Member State targets is to be limited to a maximum of 7% of transport energy (with Member States given discretion to set this cap lower). Member States also have a degree of discretion to set differentiated levels of support for food-based biofuels depending on expected ILUC emissions. Within this overall cap on the use of food-based biofuels, support to the supply of biofuels from high ILUC-risk feedstocks will be constrained still further, with their contribution to targets to first be limited to the 2019 level of supply in each Member State, and then reduced to zero between 2023 and 2030. Biofuels from high ILUC-risk feedstocks can thus expect to lose access to subsidies by 2030 at the latest, and become uncompetitive with other alternative fuels and with fossil fuels. Individual projects producing feedstocks categorised as high ILUC-risk may, however, seek to receive a low ILUC-risk certification where it can be shown that production of the feedstock has been undertaken in such a way as to avoid any displacement of existing uses of materials. In such a case, biofuels produced even from a high ILUC-risk feedstock would be eligible for comparable support to other food-based biofuels.

2. Biofuels associated with high indirect land-use change emissions in indirect land-use change modelling

ILUC modelling for the European Commission, for regulators in North America and by other research groups suggests that there is a hierarchy of ILUC risk, whereby vegetable oil crops are expected to have higher ILUC than starchy crops, which are expected to have higher ILUC than sugar crops. Within the vegetable oils, review of available results shows that palm oil is generally anticipated to have the highest associated ILUC emissions, followed by soy oil and then by rapeseed and sunflower oils. Based on an EU-relevance-weighted average of ILUC results reviewed by Woltjer et al. (2017), palm oil has estimated ILUC emissions of 118 gCO_2e/MJ, soy oil has 94 gCO_2e/MJ, rapeseed oil 80 gCO_2e/MJ and sunflower oil 79 gCO_2e/MJ. The highest weighted average ILUC from this assessment for an ethanol feedstock is maize, with 38 gCO_2e/MJ.

One approach to estimate the carbon emissions that can be expected due to land use changes associated with biofuel support policy is to model indirect land use change using economic equilibrium models. The first ILUC modelling work was presented by (Searchinger et al., 2008) for U.S. maize ethanol, and since then the number of tools and analyses available has grown considerably as regulators, academics and stakeholders have sought to contribute to the debate.

In the U.S., estimated ILUC emissions have been included in regulatory assessment of the lifecycle emissions of biofuel use for nearly a decade. In the federal Renewable Fuel Standard, estimated ILUC emissions are based on modelling using the FAPRI and FASOM partial[2] equilibrium economic models, while in California under the Low Carbon Fuel Standard the GTAP general[3] equilibrium economic model has been used.

In the EU, several models have been used in studies to improve the European Commission's understanding of potential ILUC emissions, including: Aglink (Hélaine, M'barek, & Gay, 2013); ESIM and CAPRI (Blanco Fonseca et al., 2010); MIRAGE (Laborde, 2011b; Laborde, Padella, Edwards, & Marelli, 2014); and GLOBIOM (Biggs, Oliver, Valin, Peters, & Matthias Spöttle, 2016; Valin et al., 2015).

Given the wide range of evidence available, and that this evidence is not always consistent, it is not trivial to pick the most appropriate way to assess overall ILUC risk for each biofuel feedstock. In the recast RED II, ranges of estimated ILUC values are provided for groups of crops based only on the results of MIRAGE modelling (Laborde, 2011b) (Table 1). Based on

2 A 'partial' equilibrium model considers only one sector of the economy – in this case the agricultural sector.

3 A 'general' equilibrium model considers the whole economy, but will generally have considerably less detail in its representation of the agricultural sector than a partial equilibrium model would.

these values, one would conclude that oil crops for biodiesel have a higher expected ILUC emission than either sugary or starchy crops for ethanol production.

Table 1. ILUC estimates included in the RED II

Feedstock group	Mean	Interpercentile range derived from the sensitivity analysis
Cereals and other starch-rich crops	12	8 to 16
Sugars	13	4 to 17
Oil crops	55	33 to 66

While it may be appealing from the point of view of legislative clarity to provide simple point value ILUC estimates for biofuel categories, in policy analysis it is appropriate to consider the wider constellation of evidence available.

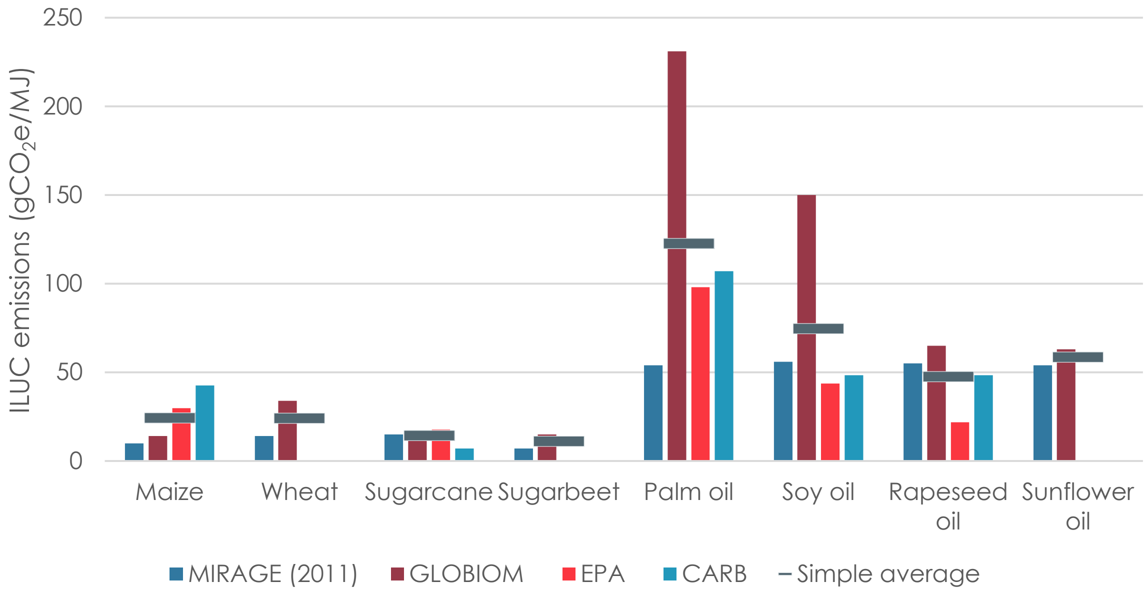


Figure 1. ILUC results from key regulatory ILUC studies*

**U.S. ILUC estimates adjusted to reflect the EU's convention of 20 year time accounting (multiplied by a factor of 1.5).*

Figure 1 expands the number of studies considered to four, by comparing results from the two most recent EU modelling studies (with MIRAGE and GLOBIOM) alongside the regulatory ILUC values adopted in the U.S., by the EPA within the Renewable Fuel Standard and by CARB within the Low Carbon Fuel Standard. Considering this broader evidence base, differences emerge between different feedstock within categories, in particular for vegetable oils. Taking a simple average[4] of the four results It is apparent that palm oil has generally been modelled with higher expected ILUC emissions than any other feedstocks (109 gCO_2e/MJ), with soy oil the second highest (75 gCO_2e/MJ) followed then by rapeseed and sunflower oil, then by starchy crops, then by sugary crops with consistently low ILUC estimates.

2.1. Differences between ILUC approaches

As has been noted in many earlier reviews of ILUC science (e.g. Malins, Searle, & Baral, 2014; RFA, 2008; Woltjer et al., 2017), several different approaches have been adopted over the last decade to consider likely ILUC emissions, with various advantages and disadvantages. We do not intend to revisit a full review of these methodologies here. It is, however, useful to briefly review some important differences that have emerged between the analytical approaches that have been used in the United States for regulatory ILUC values in the Renewable Fuel Standard and Low Carbon Fuel Standard, as against approaches used for analysis sponsored by the European Commission (the results shown in Figure 1).

One major difference between the models is the choice of partial as against general equilibrium approaches. As noted above, partial equilibrium modelling considers only the agricultural economy, which may therefore be covered with a greater level of detail, whereas general equilibrium approaches allow the entire economy to be simulated, but have less detail in their handling of the agricultural economy. In particular, general equilibrium approaches tend to be based on the use of relatively simple mathematical functions to simulate interactions between parts of the market, whereas partial models tend to deal more directly in physical and biological systems. In the EU context, for instance, the general equilibrium model MIRAGE handles the question of yield change due to higher demand through the use of parameters that characterise the amount the system is expected to respond without direct reference to any specific agricultural choices, while the partial equilibrium model GLOBIOM handles yield change through allowing agriculture to shift between specific management regimes as prices change.

From an EU perspective, it is also important to recognise that there are regional differences between models, reflecting differences in regional markets, agriculture and trade patterns. Consider, for instance, the partial economic modelling for increased maize ethanol demand in GLOBIOM and FAPRI-FASOM respectively. In the GLOBIOM modelling, an increase in EU maize ethanol demand equivalent to 1% of EU transport energy results in an increase in EU maize area of over 1 million hectares by 2020 (40% of global increase in planted maize area), while North American maize production expands by less than a twentieth of that, 60 thousand hectares. In the FAPRI-FASOM modelling, in contrast, a 10 billion litre increase in U.S. maize ethanol demand leads by 2022 to a 600 thousand hectare increase in U.S. maize area (35% of total global maize area increase), while EU maize area increases by only one hundredth that amount (7 thousand hectares). Clearly having significant parts of the predicted land use changes associated with a given feedstock occurring in different regions depending on where ethanol demand increases may lead to differences in land use change and ILUC emissions outcomes from models, which may reflect real differences in regional responses to changing demand.

4 A simple average may not always be the most appropriate way to weight results of different studies, but provides a first indication of how results compare across the literature considered.

There are also important differences in the different regional models regarding the linkages between markets. For soy oil, for instance, the EU modelling assumes a much stronger relationship between soy oil and palm oil markets than is assumed in the U.S. modelling. In the EU modelling, 40 % (GLOBIOM) to 50% (MIRAGE) of additional global vegetable oil production to meet increased soy oil demand is expected to come from palm oil (Malins, 2018). In the U.S. Modelling, by contrast, palm oil plays a much smaller role in the soy oil scenarios, meeting 20% of increase vegetable oil supply in FAPRI-FASOM (we do not have this data available for the GTAP modelling). This likely reflects that fact that the EU has historically been a stronger market for palm oil than the U.S. has, although some recent work suggests that U.S. analysis may have understated the connectivity to the palm oil market (Fabio Santeramo, 2017). Whatever the extent to which these different assumptions are supported by the available data, they certainly contribute to differences in ILUC emissions outcomes.

As well as potentially real differences between regional markets, there are differences between modelling structures that are not regional in origin but nevertheless contribute to differences in modelled outcomes. For example, an important difference between the general equilibrium models is that MIRAGE allows for expansion of total global managed land into unmanaged areas, whereas GTAP includes only transitions between different managed land uses. This means that all forest loss in GTAP is interpreted as the loss of a productive forest, creating a presumed reduction in timber supply that the model partly compensates elsewhere[5]. In MIRAGE, in contrast, some forest loss is interpreted as deforestation in unmanaged areas with no impact on productive forestry estates. Models also use different sets of land use change emission factors, which can drive different ILUC emissions outcome seven for comparable predicted land use changes.

To conclude on the modelling frameworks, each of the four discussed in this section is quite distinct from the others in various ways. Results for the same feedstock can vary significantly when increased demand is modelled in different markets, and the responses to increased demand even from the same market can be quite different depending on how the models are parameterised. There is no clear agreement among experts that one model is ‘better’ than another, nor that one result is likely to be closer to the truth than other results, and many experts hold strong opinions about the strengths and weaknesses of the individual frameworks. Confronted with this uncertainty not only in the results from individual models but in understanding which model results might be most pertinent to a given market (Plevin et al., 2010), it is important for policy analysis to recognise that there is no agreed ‘correct’ answer to the ILUC question, and therefore to seek transparently to consider the evidence at hand before drawing conclusions.

2.2. ILUC results reviewed by Woltjer et al. (2017)

While considering these four important studies clearly gives a more nuanced picture than is available from considering only the values written into the RED II, this still only scratches the surface of the total information resource available. A 2017 review for the European Commission of the state of ILUC modelling literature (Woltjer et al., 2017) provides a much

5 For example, it can be seen in land use change results for the soy biodiesel scenario characterised as ‘CARB average’ in the CCLUB module of the GREET model (Argonne National Laboratory, 2017) a large amount of afforestation is predicted in South America and China, compensating for forest lost in North America, Southeast Asia and Africa.

more extensive overview of available results, with numerical results identified from 105 studies, giving ILUC estimates across 28 different feedstocks and feedstock groups. Figure 2 shows simple averages of estimated ILUC emissions across studies, as well as showing the number of results detailed for each feedstock or feedstock group. Other than one outlier result for second generation ethanol[6], the highest reported ILUC estimates tend to be associated with biodiesel, with estimates for first generation ethanol being generally lower and estimates for second generation fuels typically lower than that. Within biodiesel, palm and sunflower come out highest on a simple average, with soy a little lower and rapeseed lower than that, although for all biodiesel feedstocks the average estimated ILUC emissions are well above 50 gCO_2e/MJ. Jatropha has a ILUC estimate of 93 gCO_2e/MJ but this is based on a single assessment in which it is assumed that jatropha plantation would compete for the same type of land as maize, and may therefore be misleading for the case of jatropha produced on more marginal land, which has been identified as a preferred model by many jatropha advocates.

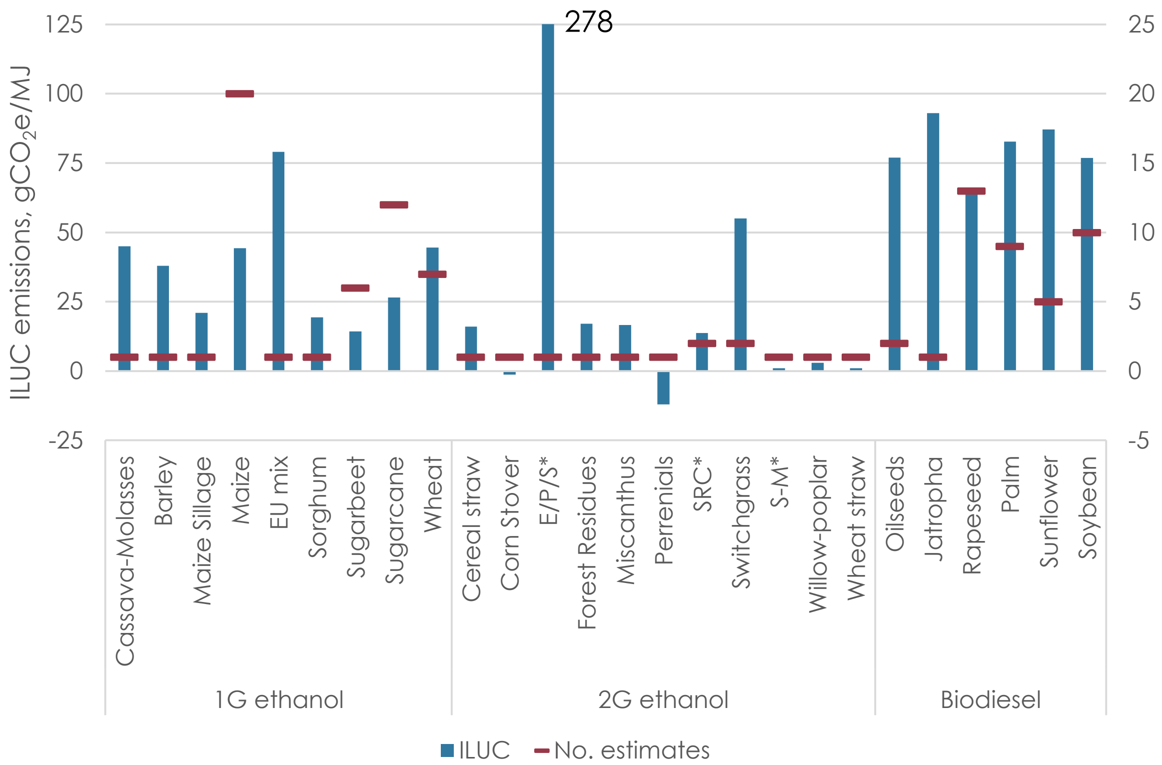


Figure 2. Simple average of ILUC factor by feedstock (left axis) and number of available estimates (right axis) based on data from Woltjer et al. (2017)

**E/P/S – Eucalyptus/poplar/switchgrass; SRC – short rotation coppice; S-M – switchgrass-miscanthus*

While this approach, taking arithmetic averages across studies, provides some indication of the general direction of research, it fails to recognise any difference in quality and relevance

6 A result from (Melillo et al., 2009) for 2G ethanol from eucalyptus, poplar and switchgrass, which likely reflects questionable land use change assumptions.

of the different results considered in the review report (Woltjer et al., 2017). A more subtle and representative sense of the current state of the evidence could be obtained by adding a more sophisticated weighting of study results - for instance by excluding outlier results that can be seen to be driven by implausible assumptions and by giving greater weight to results based on analysis of the EU case than to results from other markets. In the following section, we consider the results identified by Woltjer et al. (2017) for the primary first generation biofuel feedstocks used in the EU: maize, wheat, sugar beet, sugar cane, palm oil, soy oil, sunflower oil, rapeseed oil. In particular, we assess outlying results and whether they have any clear analytical deficiencies, and identify those studies that considered the EU market vs. other markets internationally. We then present revised weighted average ILUC results based on the following system of weightings:

- Studies for which clear and fundamental analytical deficiencies are noted are completely discounted;
- Results that reflect non-EU markets are given half weighting[7];
- The results from the two most important EU Commission studies (Laborde, 2011a; Valin et al., 2015) are given double weighting.

It should be explicitly understood that the precise weightings given here are arbitrary, and many alternative systems of weightings could be proposed and justified. It is not our goal here to present results that could or should be seen as some sort of 'best estimate' of ILUC effects based on the available literature – rather these results are used to identify feedstocks where the available data seems to suggest a higher ILUC risk with more sophistication than is possible through the simple arithmetic averages quoted in Woltjer et al. (2017).

2.3. Results in Woltjer et al. (2017) that can be discounted

In this section, qualitative assessment is made of some of the results for first generation feedstocks included in Woltjer et al. (2017) that we believe can be discounted when making an up to date assessment of the state of ILUC science. We do not claim to present a comprehensive review of the full set of results detailed by Woltjer et al. (2017), but rather seek to identify results that should be discounted when developing an understanding of the balance of the available literature, with a particular focus on results that are outliers compared to other results for the same feedstocks.

2.3.i) Wheat

One result for wheat stands out beyond the range of other results, a result of 155 gCO_2e/MJ obtained in GTAP analysis for Edwards, Mulligan, & Marelli (2010b). It is our understanding that this result is largely attributable to unrealistic model behaviours arising related to the trans-Atlantic trade in distillers' grains, which reflected the fact that the biofuel variant of GTAP was tuned specifically to U.S. corn ethanol production and that exogenous assumptions imposed in that context were inappropriate for the modelling of increased EU production of distillers' grains. We therefore discount this result.

7 It is generally expected that sugarcane ethanol used in the EU will primarily come from Brazil, and so results for Brazilian sugarcane are treated as representative for the EU market.

2.3.ii) Maize

Limitations and fundamental flaws in the analysis in Flugge et al. (2017) have been extensively documented by Malins (2017b). This result is therefore discounted.

One result for maize is significantly higher than the others (Searchinger et al., 2008). While some authors have critiqued elements of this work, and some of these criticisms may be well justified, these criticisms do not support a fundamental rejection of the approach used, and therefore we have not discounted this result here.

2.3.iii) Sugarbeet

The result from Al-Riffai, Dimaranan, & Laborde (2010) is significantly higher than other results, and was reduced in the follow up to that study (Laborde, 2011a). While a case could be made to discount the earlier result on that basis, we follow Woltjer et al. (2017) by not treating the existence of updated results within a given framework as reason to fully discount earlier results. The later result is given double weighting, however, as explained above.

2.3.iv) Sugarcane

One result for sugarcane is significantly higher than the others (Dunkelberg, 2014). We are not aware of any fundamental problem with the methodology, and therefore it was not discounted.

2.3.v) Palm

For palm oil, two results in particular are presented that are well below the average (Acquaye et al., 2012; Fritsche, Hennenberg, & Hünecke, 2010), at 9 gCO_2e/MJ and 27 gCO_2e/MJ respectively. The first point to note is that these are not properly two separate results – the 9 gCO_2e/MJ result given in Acquaye et al. (2012) is referenced to Fritsche et al. (2010). In the Oeko-Institut's "ILUC factor/Risk Adder"[8] approach detailed by Fritsche et al. (2010), an overall global average ILUC per hectare is calculated, and feedstock specific ILUC factor values are derived directly from this global average number by dividing by average yields. The relatively high yield of palm oil entirely accounts for it being allocated a lower ILUC factor value in this approach. The Oeko-Institut approach was an important early attempt to provide some numerical characterisation of ILUC risk, and predates the first economic modelling of ILUC by Searchinger et al. (2008). However, the absence form this approach of any consideration of the differentiated risk of land use change being driven by expansion of different feedstocks is a reason to discount it compared to more recent modelling approaches, and largely accounts for the fact that this approach has not been pursued as a regulatory or analytical tool. Indeed, the Oeko-Institut work explicitly recognises the very high land use change emissions associated with oil palm expansion, and certainly should not be quoted as evidence that oil palm is not linked to large LUC emissions. Beyond the structural issues that limit the value of the Oeko-Institut in understanding feedstock level ILUC risk, it is completely unclear, and unexplained in the paper, why Acquaye et al. (2012) use a number much lower than the range actually given in

8 The Oeko-Institut work represents one of (if not the) earliest uses of the term "ILUC factor", but the specific analytical meaning in the Oeko-Institut work is rather different to the more generic use of the term "ILUC factor" to refer to any ILUC estimate.

Fritsche et al. (2010). We conclude that it is reasonable to completely discount both of these studies in assessing the state of knowledge on ILUC – while the values given are outliers for palm oil in particular, we discount the results for all feedstocks.

The palm value reported from GTAP by Edwards, Mulligan, & Marelli (2010a) is based on emission factors that exclude peat oxidation. As peat oxidation is known to be a major source of oil palm related LUC emissions, this result is discounted.

Two results for palm are significantly higher than the others (Overmars, Edwards, Padella, Prins, & Marelli, 2015; Valin et al., 2015). These are not treated as outliers. This is because the sources are credible (both studies were published for the European Commission), because we are not aware of any fundamental shortcomings in the analysis, and because indirect land use change emissions of this magnitude are broadly consistent with a simplified estimation based on consideration of past land use change trends in Indonesia and Malaysia (Malins, 2017a). Note that the work presented in Overmars et al. (2015) uses a 'historical' approach, rather than an economic modelling approach. While historical approaches are subject to limitations, in particular relating to the difficulty of ascribing causality to land use transitions outside of modelling frameworks, the approach is considered legitimate and is therefore not discounted.

2.3.vi) Rapeseed

One result for rapeseed (Lywood, 2013) posits a significant negative ILUC factor. This result relies on a very specific set of assumptions favourable to rapeseed, in particular inappropriately strong assumptions relating to the role of rapeseed meal in substituting for soy meal (cf. Klasing, Hazzledine, Baral, & Malins, 2012), and assumptions on a strong relationship between soy expansion and deforestation. This study is funded by the rapeseed biodiesel industry and comes to much stronger conclusions than studies using comparable methodologies with more moderate assumptions (Baral & Malins, 2016; Bauen, Chudziak, Vad, & Watson, 2010) and is therefore discounted.

Two results for rapeseed are very high (Edwards et al., 2010a; Overmars et al., 2015), over 200 gCO_2e/MJ. The FAPRI-based result documented by Edwards et al. (2010a) may be inflated by poor representation of EU trade patterns by the U.S. developed FAPRI model, but in the absence of specific identified issues in the modelling we do not discount it. As noted for palm oil above, the Overmars et al. (2015) work published with the European Commission' is considered adequately credible not to be discounted.

2.3.vii) Soybean

One result (California Air Resources Board, 2014) is significantly lower than others. This likely partly reflects the difference between modelling of soybean expansion in the U.S. (anticipated as the dominant response to increased U.S. soy oil demand in the GTAP model) as opposed to modelling increased soybean production in Latin America where it is more strongly linked to deforestation (anticipated in most modelling of responses to increased EU soy oil demand). It may also reflect inadequate characterisation in GTAP of linkages between soy oil and palm oil markets. These issues are not considered adequately fundamental to warrant dismissing this result.

As in the case of palm oil, two results (Overmars et al., 2015; Valin et al., 2015) are higher than others reported but are considered credible.

2.3.viii) Sunflower

As for other vegetable oils, the Overmars et al. (2015) result is higher than others reported, but is not discounted.

2.4. Weighted average ILUC results

Figure 3 shows the result of applying a weighting and discounting to ILUC results for the primary first generation feedstocks. The basic picture emerging from the results is unchanged, but applying a weighting emphasises the hierarchy of biodiesel having higher expected ILUC emissions than ethanol. Within biodiesel, applying this qualitative weighting strengthens the conclusion that palm oil is likely to have the highest ILUC risk of feedstocks considered, and suggests that soy oil may have the second highest ILUC risk, with the risk for rapeseed and sunflower oils being similar.

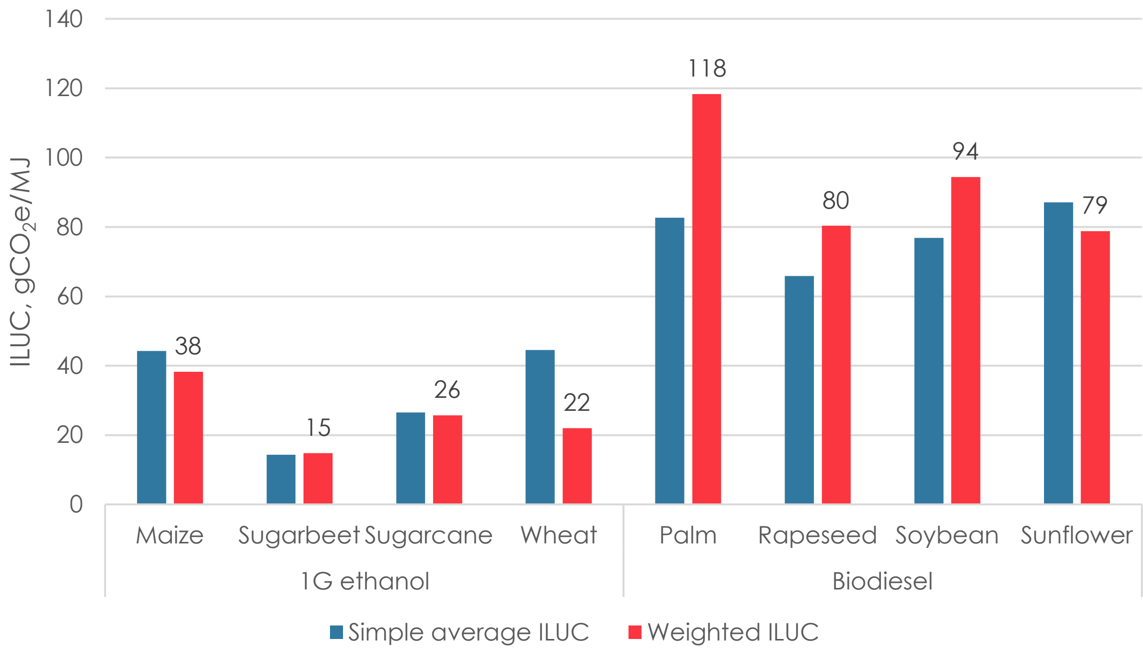


Figure 3. ILUC results from studies considered by Woltjer et al. (2017) calculated on a simple arithmetic average (left) and EU-relevance-weighted average (right, with labels)

Note: The weighting of results is as follows: results from the two most important European Commission studies are double weighted; results from studies considering non-EU demand shocks are half weighted; studies considered non-credible are not included; all other results are single weighted.

3. Identifying high ILUC-risk biofuel feedstock

In studies that identify high deforestation-risk commodities, two biofuel feedstock crops are consistently identified – oil palm and soybean. A review of FAOstat data confirms that the majority of expansion for these two crops and also for sugarcane occurs in countries where net deforestation is reported. Oil palm, soybean and sugarcane are therefore examined further as potentially high ILUC-risk feedstocks. There is no single study that provides a global assessment of the extent to which these crops expand onto land areas meeting the EU definition for high carbon stocks, but combining the results of studies that use satellite mapping tools reveals that oil palm expansion is strongly linked to both deforestation and peat loss, and that a weaker but still arguably significant link between soybean expansion and deforestation persists despite impressive reductions in soy-led deforestation in the Amazon in the past decade. In contrast, satellite observations show that sugarcane expansion in Brazil is not significantly associated with direct deforestation.

An illustrative assessment is undertaken to estimate the average carbon dioxide emissions from high carbon stock land conversion associated with oil palm and soy expansion – the results for both feedstocks exceed a threshold for significance set at 33 gCO_2e/MJ. Given the lack of a single comprehensive and consistent data source to identify crop expansion into high carbon stock land areas, it may be appropriate for the Commission to provide a clear specification of indicators it would consider, but make the final identification of high ILUC-feedstocks on a narrative basis informed by these indicators, rather than explicitly using a single threshold assessment. Based on the evidence reviewed here, we recommend that both palm oil and soy are identified as high ILUC-risk by the European Commission.

The RED II introduces into European Union law the concept of high ILUC-risk food or feed-crop based biofuels, the contribution of which to meeting renewable energy targets shall be limited, and reduced to zero by 2030. These fuels are defined as those **“for which a significant expansion of the production area into land with high carbon stock is observed”**. The European Commission is asked to “report on the status of production expansion of relevant food and feed crops worldwide” and to adopt a delegated act on the subject by 1 February 2019.

Land with high carbon stock is defined in the RED II in the context of the sustainability criteria for biofuels. The Directive defines high carbon stock land as land that had one of the following statuses in 2008:

1. wetlands, namely land that is covered with or saturated by water permanently or for a significant part of the year;
2. continuously forested areas, namely land spanning more than one hectare with trees higher than five metres and a canopy cover of more than 30 %, or trees able to reach those thresholds in situ;
3. land spanning more than one hectare with trees higher than five metres and a canopy

cover of between 10% and 30%, or trees able to reach those thresholds in situ, unless evidence is provided that the carbon stock of the area before and after conversion is such that, when the actual carbon stock change is calculated, the carbon saving threshold for biofuels produced on that land would be satisfied.

High carbon stock therefore not only covers areas that would be universally recognised as forests, but also some woody savannahs and shrubland, and any wetlands including peatland.

There is no single global dataset that would allow the exact identification of the fraction of expansion of each biofuel feedstock that has been directly associated with incursion onto high carbon-stock lands in any given time period. Rather, the available evidence consists of a combination of agricultural statistics, econometric analyses and remote sensing studies, with a wide variation in the level of detail available for different crops, different regions and different time periods. In this section, we first review evidence from agricultural statistics and global deforestation assessments with a view to identifying feedstocks that may potentially be associated with high ILUC-risk, and then look at region- and feedstock-specific evidence for those feedstocks. Finally, we discuss regulatory considerations confronting the European Commission in making firm determinations of which (if any) feedstocks should be counted as high ILUC-risk.

3.1. Identification of potentially high ILUC-risk feedstocks in FAO data

Data reported by national governments to the FAO and available on FAOstat[9] provide an overview of agricultural and land use trends at the national level, which can be used to provide an indication of which feedstocks may be most likely to be associated with a high ILUC-risk in the terms of the RED II. Two important caveats should be made when working with FAOstat data in this way. Firstly, in any land use change analysis one must be cautious about conflating correlation with causation. The fact that expansion of a given crop in a given country corresponds to reported deforestation does not imply that that crop has actually expanded into high carbon stock areas. It is therefore important that simple analysis of trends identified in FAOstat data should be supported (or refuted) by more detailed analysis of land use change patterns in relevant regions. Secondly, it cannot be assumed that FAOstat is uniformly accurate, as in some cases erroneous reporting, changes to the basis of reporting or inconsistent application of definitions may result in misleading data. As an example of FAOstat data that is likely misleading, FAOstat data for Malaysia indicate expansion of both overall forest area and primary forest area from 2000 to 2012. This contrasts markedly with the results of mapping analysis by 'Global Forest Watch'[10], which showed significant tree cover loss in Malaysia in that period, concluding that Malaysia had experienced the highest fractional forest loss in the world from 2000 to 2012. It also conflicts with the Malaysian REDD+ strategy, which reports an annual deforestation rate of 0.1% for 2000-2010. Such potential data inconsistencies further emphasise that analysis of FAOstat data must only be treated as an indicator of potentially high ILUC-risk, rather than as the sole determinant.

Using the FAO data for the period 2012-2015, we have developed indicators that could

9 http://www.fao.org/faostat/en/

10 https://news.mongabay.com/wildtech/2013/11/malaysia-has-the-worlds-highest-deforestation-rate-reveals-google-forest-map/

suggest that a given crop has a relatively high deforestation risk. We have cross-referenced data on area under each of the major biofuel crops against data on net reductions in forest land use, in order to identify what fraction of gross reported expansion in the period occurred in countries where cropland expansion may be a significant driver of deforestation.

On the left, Table 2 gives total gross[11] reported global increase in area harvested[12] for each of eight major biofuel crops. The columns on the right show how much of this area expansion occurred in countries where total forest area reduction was at least 20% of both total cropland expansion and of expansion of the specific crop in question. In general, there is unlikely to be a high deforestation risk from biofuel feedstock expansion in a given country unless forest area reduction in that country is significant compared to crop expansion, and therefore crops for which a low percentage is calculated on this metric are not likely to be high ILUC-risk.

Table 2. Harvested area expansion for key biofuel feedstocks, 2012-2015

	Global crop harvested area expansion, 2012-2015	Gross crop expansion in countries with forest land use reduction > 20% of cropland increase	
	ha	ha	%
Maize	10,402,704	2,839,435	27%
Oil palm fruit	2,410,361	2,179,434	90%
Rapeseed	1,482,829	29,632	2%
Soybeans	16,288,826	8,535,916	52%
Sugar beet	179,588	1,953	1%
Sugar cane	945,026	533,272	56%
Sunflower seed	1,765,087	42,574	2%
Wheat	11,517,053	1,276,625	11%

As indicated in Column 2 of the table, three feedstock crops have expanded primarily in countries reporting net forest area reduction –oil palm, soybeans and sugarcane. Maize shows 27% of expansion meeting this metric, wheat 11%, and the values for sunflowers, rapeseed and sugar beet are very low. For maize, it is worth noting that about half of the expansion that occurs in a country with significant reported deforestation is in Brazil. The context for maize in Brazil is complicated, however, by the rapid increase in double cropping of maize after soybeans. CONAB (2017) shows that during this period first crop maize area has consistently decreased in Brazil, even when harvested area has increased. It would be reasonable to assume therefore that maize expansion in Brazil is unlikely to have been a strong driver of

11 Gross increase calculated as the sum of net area increase in all countries reporting area increase, ignoring any countries reporting reduced harvested area for that crop.

12 Area harvested is distinct from area planted, as harvested area can be reduced compared to planted area by crop failures, and increased by multiple cropping.

deforestation in this period. This again emphasises the need to consider not only high level statistics but also local context when considering a high ILUC-risk categorisation.

3.1.i) Discrepancies between data reported to FAO and observed forest area changes

As noted above, forest data reported to FAO are not always consistent with information from other sources. This can reflect any combination of limitations in data collection methods, differences in definitions used (for instance, M. C. Hansen et al., 2013) note that FAO data is based on forest as a land ***use*** whereas satellite mapping is able to speak directly to the prevalence of forest as a land ***cover***) and data reporting or measurement errors.

Table 3. Comparison of FAOstat forest area reduction against Landsat tree cover loss for 2000-2012

	FAOstat forest land use change 2000-2012	Landsat forest cover change 2000-2012	Landsat/FAOstat
Brazil	-24,784,000	-28,441,100	1.15
Indonesia	-6,345,800	-8,814,900	1.39
Argentina	-3,857,600	-4,052,800	1.05
Colombia	-3,216,550	-1,967,700	0.61
Mexico	-1,541,200	-1,752,900	1.14
Canada	-593,200	-17,287,200	29.14
Finland	-227,000	-866,700	3.82
United States	-2,530	-12,586,200	4974.78
Denmark	11,640	-21,100	-1.81
Germany	59,000	-230,500	-3.91
United Kingdom	139,000	-57,800	-0.42
Malaysia	561,400	-2,148,000	-3.83
France	1,361,000	-260,200	-0.19
India	4,756,800	-642,200	-0.14
China	26,694,200	-3,874,300	-0.15

Landsat data include tree cover of 10% or higher, with trees defined as any vegetation 5 metres tall or higher.

Landsat mapping presented by M. C. Hansen et al. (2013) provides an alternative basis to identify rates of forest loss. This analysis reports relatively good agreement between government-reported forest area numbers for some example countries, including much of Latin America, but significant discrepancies in some other countries. Table 3 provides a comparison between reported reductions in forest land use in FAOstat data as against observed reductions in tree cover in (M. C. Hansen et al., 2013). The largest discrepancy is apparent in North America, where much more forest cover loss than reported is observed in both the United States and Canada. Much of this discrepancy is likely related to tree cover loss due to extensive mountain pine bark beetle infestation (Kurz et al., 2008), which affects physical forest cover without necessarily implying a land use change. It is also apparent that several EU countries and Malaysia have larger areas of observed tree cover loss than the reported change in forest land use for this period. This could reflect data reporting issues or simply arise from the different definitions applied for the two datasets.

3.2. Other evidence on forest risk commodities

Outside of the specific context of biofuel policy, several studies, including studies for the European Commission, have considered the question of the link between EU commodity demand and global deforestation. This body of work can provide further evidence relating to which biofuel feedstocks might be associated with expansion into high carbon stock areas.

There is no widely accepted method to estimate LUC emissions associated with expansion of a given crop, and a variety of analytical techniques are used in the literature. The methodological choices taken, in particular whether to consider only ‘direct’ land use changes (where a crop directly replaces a high carbon stock ecosystem) or to include indirect effects, can result in large differences in outcomes.

3.2.i) Feasibility study on options to step up EU action against deforestation (Ecofys, Milieu, & COWI, 2018)

A recent review of connections between EU commodity demand and deforestation s provided by Ecofys et al. (2018). This study looks specifically at EU demand for commodities “whose extraction or production contributes significantly to global tropical deforestation and degradation”, using a definition from Rautner, Leggett, & Davis (2013). Ecofys et al. (2018) review deforestation risk associated with a range of commodities including several biofuel feedstocks, and identify maize, soy, coffee, cocoa, palm oil, rubber, timber, wood pellets, beef and leather as the commodities of most interest – of those, maize, soy and palm oil are relevant to the biofuel discussion.

Ecofys et al. (2018) provide extensive references that provide an indication of which commodities have the highest associated deforestation risk:

- GEF Secretariat (2014) claim that soy, beef and palm oil are collectively responsible for more than 80% of tropical deforestation, but the basis for this conclusion is not clear.
- UNEP (2015) similarly identify soy, beef and palm oil as the commodities most associated with tropical deforestation. Following (Cuypers et al., 2013), they claim that livestock (mainly beef), soy and palm were associated with a third of deforestation globally from 1990 to 2008.

- The Amsterdam Declaration[13] identifies soy and palm oil as major deforestation risk commodities alongside beef, pulp and paper, leather, cocoa and rubber.
- Rautner et al. (2013) identify palm oil, soya, beef and timber, pulp and paper as the key forest risk commodities.
- Brack (2015) identifies palm, soy, maize, rice and sugarcane as the most deforestation linked commodities.
- Lammerant et al. (2014) find that "deforestation for actual timber production is far less important than deforestation for agricultural purposes (crops and cattle)", and note that soy, palm oil, beef, cotton, fish and shrimps, sugarcane and timber are 'consistently' identified in the literature as having a high biodiversity impact.
- Walker, Patel, & Davies (2013) identify beef and leather, palm oil, soy, timber and biofuels generically as the "major commodities implicated in driving deforestation".
- Henders, Persson, & Kastner (2015) assess deforestation associated with four commodities: palm oil, soy, beef and wood. Across seven case studies (Argentina, Bolivia, Brazil, Paraguay, Indonesia, Malaysia, and Papua New Guinea) they find 40% of deforestation associated with those commodities, with a growing role of export markets.

It is apparent that soy and oil palm are routinely identified as high deforestation risk. There is much less consensus relating to sugarcane and to maize, and other biofuel feedstocks are not identified.

3.2.ii) An assessment of deforestation and forest degradation drivers in developing countries (Hosonuma et al., 2012)

Hosonuma et al. (2012) provide a review of drivers of deforestation and forest degradation at the national level in non-Annex I countries[14], based on review and analysis of evidence including national REDD+ strategies, CIFOR country profiles and other UNFCCC and academic literature. The analysis focuses on 'direct' (proximate) causes of deforestation. Agricultural expansion is identified as the proximate cause of deforestation in over 70% of cases in Africa, over 90% in the Americas and just under 70% in Asia. In Africa and Asia this is split more or less evenly between commercial and subsistence agriculture, whereas in the Americas commercial agriculture dominates (about 70% of deforestation is assessed as proximately caused by expansion of commercial agriculture. Hosonuma et al. (2012) conclude that commercial cattle ranching, soybean and oil palm expansion play a dominant role driving deforestation in Southeast Asia and the Amazon region of Latin America.

13 https://www.euandgvc.nl/documents/publications/2015/december/7/declarations

14 The Annex I countries tha tare parties ot the Kyoto protocol are considered economically developed, and are expected to account for land use, land use change and forestry related CO_2 emissions.

3.2.iii) Trading forests: land-use change and carbon emissions embodied in production and exports of forest-risk commodities (Henders et al., 2015)

Henders et al. (2015) approach deforestation from the point of view of attributing forest loss to exports of four major commodities – beef, soy, palm oil and wood products. This paper couples data on national deforestation rates and academic research on proximate drivers of deforestation with agricultural statistics, in order to generate an attribution of deforestation to the four commodities considered. The analysis does not use mapping, and so the results do not necessarily reflect links between specific commodities and direct land use changes. The analysis covers the period 2000 to 2011. By 2011, soy exports are found to drive 0.4 million hectares per year of LUC, resulting in emissions of 0.1 $GtCO_2e$/year, while oil palm exports cause 0.3 million hectares of LUC, causing 0.2 $GtCO_2e$/year emissions. Normalised by total 2011 export market size (160 million tons of soy and 110 million tonnes of palm oil) this implies deforestation related emissions of about 1 tonne CO_2 per tonne of soy exports, and 2 tonnes of CO_2 per tonne of palm oil exports (not including peat emissions). Note that these emissions are spread across all exports, if attributed only across increases in production the values would be higher.

3.2.iv) Historical deforestation due to expansion of crop demand: implications for biofuels (Edwards, Padella, Vorkapic, & Marelli, 2014)

While many studies estimating the ILUC implications of biofuel use have taken modelling approaches, there have also been assessments that use allocative approaches to associate historical rates of deforestation with the expansion of various crop systems. Such an approach is presented by Edwards et al. (2014), building on research by Cuypers et al. (2013) that assessed the impact of EU commodity consumption on global deforestation. While this work generated quantified estimates of historical ILUC emissions associated with biofuel feedstocks, the intermediate analysis also provides useful insights into the historical relationship between feedstock expansion and encroachment onto high carbon stock areas.

Cuypers et al. (2013) undertook an analysis of association between crop production and deforestation using data from the FAO Forest Resource Assessment for 1990-2008, the same data for forest area that is reported via FAOstat (see section 3.1), and follows FAO by using the land use definition of forestry (in which managed forest land with temporarily reduced tree cover is still counted as forest land use). The FAO forest definition is consistent with the description of high carbon stock land in the RED and RED II – land that normally has at least 10% canopy cover with trees higher than 5 metres (or able to reach that height). It excludes agricultural plantation tree crops such as oil palm. Based on the FAO data, Cuypers et al. (2013) develop an attribution model to associate agricultural expansion with deforestation. This model intends to treat ‘direct’ and ‘indirect’ deforestation impact equally, attributing deforestation based on total cropping expansion without reference to evidence on direct deforestation drivers. The study takes as an assumption that agricultural expansion is a driver of deforestation, based on analysis by Boucher et al. (2011) and Houghton (2010), and deforestation is attributed to agriculture “up to the extents that agricultural land expansion can explain deforestation”, subject to the condition that a fraction of agricultural expansion is reallocated to roundwood logging to reflect the value of wood extraction from land converted to agriculture. It is assumed that pasture and cropping impact forest in proportion to calculated net increases in pasture and cropland area. Within the fraction of land expansion attributed to cropping, it is assumed that the relationship between expansion of certain perennials (including oil palm, rubber, banana & plantain, coffee, cocoa and tea) and deforestation is stronger for biophysical and agronomic reasons than the relationship between annual crops and deforestation, and thus proportionately more deforestation is attributed to those perennial crops. Finally, within the perennial and non-perennial groups, attributed deforestation is allocated in proportion to reported net expansion to give an estimate of the historical land use change 'directly' associated with expansion of each individual crop.

Table 4. Regional fractions of forest loss that are cropping-linked based on Cuypers et al. (2013)

Region	Fraction of gross forest loss linked to cropping
North America	0%
EU7	10%
Other Europe	2%
Oceania	3%
North Africa	25%
S-S Africa	33%
Central America	22%
South America	29%
South Asia	16%
East Asia	28%
Southeast Asia	34%

Table 4 shows the calculated fractional attribution of deforestation in each global region to crop expansion. The assessed link is strongest in sub-Saharan Africa and Southeast Asia, but weak in North America, Europe and Oceania. In North America and Oceania, it is concluded that deforestation is driven by 'natural hazards', consistent with the observation above that Canadian forest loss has been associated strongly with pine beetle infestation. Large absolute crop-specific deforestation impacts are attributed to soybean, maize, oil palm and sugarcane – 1.3 Mha; 7.5 Mha; 5.5 Mha and 3.3 Mha respectively.

The emphasis of Cuypers et al. (2013) is on identifying absolute deforestation linked to commodities exported to the EU, but from the point of view of identifying which commodities have high ILUC-risk as biofuel feedstocks it is important that these impacts should be normalised by reference to amount of crop expansion. Edwards et al. (2014) provide a form of normalisation by comparing reported increases in production of specific crops with the deforestation data and thereby estimating implied hectares of deforestation per tonne of additional production.

An alternative normalisation can be made by comparing gross[15] area expansion for relevant

15 Here, we have calculated gross area increase as the sum of increases in area for each crop

crops against the attributed area of deforestation. This can provide a simple indicator for the fraction of new hectares of each crop considered that might have been associated with deforestation. It is important to note that, as with the use of FAOstat data described above, there are limits to the analytical power available by looking at high level statistics. For instance, the Cuypers et al. (2013) analysis works by assessing correlations in land use changes and assuming that forest loss is caused equally by expansion of all comparable crops, which may not be true – below, we compare additional analysis of the links between soybeans and sugarcane respectively and deforestation in Brazil, and argue that the links to deforestation are not in fact directly proportional to rate of expansion. Nevertheless, as with the FAOstat analysis presented in Section 3, this analysis can provide an indication of which crops seem more likely to be associated with high ILUC-risk. As detailed in Table 5, this analysis suggests that of the biofuel feedstocks considered oil palm may have the strongest link to deforestation (about 60%) followed by sugarcane and soybean with a lower impact from maize and wheat. Groundnut is also included in the table as it has the highest identified deforestation association of the other oilseeds. Other oilseeds are grouped in Cuypers et al. (2013) and have a somewhat strong link attributed link to deforestation, but this appears to relate most strongly to groundnut and sesame seed, with a much weaker association to rapeseed and sunflower crops. Indeed, based on our analysis of FAOstat data, about 85% of expansion of sunflower and rapeseed crops in the period in question occurred in the region grouped by Cuypers et al. (2013) as 'rest of the world', in which only 2% of the deforestation attributed to 'other oilseeds' occurred.

Table 5. Implied fraction of gross crop expansion associated with deforestation, 1990-2008, based on Cuypers et al. (2013)

	Soybean	Maize	Oil palm	Rice	Sugar cane	Groundnut	Wheat
Fraction of new land from forest	30%	14%	59%	21%	36%	28%	2%

3.3. Feedstock-specific evidence of expansion of biofuel feedstocks on high carbon stock land

Above, evidence is presented suggesting that the biofuel feedstocks most likely to be associated with a high ILUC-risk are palm oil, soybean and sugarcane. As noted above, however, if considering a high ILUC-risk categorisation it is not enough simply to show that agricultural commodity expansion has occurred in countries that have experienced deforestation or wetland loss in the past decades, but to find additional evidence that such land use changes are indeed linked to expansion of feedstock production. In this section, we review additional local evidence on the potential link between these three feedstocks and high carbon stock land conversion, and also consider the case of palm fatty acid distillates as a palm oil by-product. Just as there may be data limitations and methodological issues in assessments of deforestation links based on global statistics, so there are important methodological differences and limitations in local assessments, with different studies often appearing to at least partly contradict each other. This can reflect differences including forest definitions, scope of coverage of assessments, identification errors and accuracy of any maps

recorded at the national level from 1990-2008 by FAOstat.

used as part of assessments. The question at hand is not to attempt to find precise 'best' or 'most accurate' characterisations of the historical land use change associated with expansion of each commodity, but to identify cases where the weight of complementary evidence on deforestation and wetland conversion are adequate to justify a high ILUC-risk designation under the RED II.

3.3.i) Soybean

One feedstock that emerges as potentially high ILUC-risk from analysis of modelling and high level statistical evidence is soy oil for biodiesel. It is associated with some of the highest ILUC estimates from models, most area expansion has occurred in countries with deforestation and it is uniformly included in lists of deforestation risk commodities. The major soy producing nations are Brazil, Argentina, and the United States, together accounting for over 80% of global production in 2016 based on FAOstat data. The direct deforestation associated with soy in the United States is expected to be low, but in 2016 47% of global soy production was by Brazil and Argentina.

Soybeans can be fed to livestock directly, or crushed to produce soy oil and soy meal. Soy is unusual among biofuel crops because (depending on prices at the time) more of the value of the crop is in the meal co-product than the oil that is used for biofuel feedstock. It has been argued that because the profitability of soybean farming is generally more sensitive to the price of the high-protein meal than the price of the oil, soybean area may not in fact be very as sensitive to vegetable oil demand as that of other crops like oil palm and rapeseed. This is reflected in ILUC modelling for the European Commission, where a large part of the demand for vegetable oil from increased soy biodiesel use is assumed to be met by an increased supply of palm oil rather than of soy oil (Laborde, 2011a; Valin et al., 2015). These market mediated effects can be considered in ILUC analysis, but are outside the scope of the analysis of direct impact on high carbon stock areas that is required for the RED II.

The location of soybean harvested area expansion[16] from 2012 to 2015 as reported by FAOstat is shown in Table 6. In this period, 44% of expansion occurred in Brazil, with 62% in Latin America as a whole. Outside Latin America, 14% of expansion occurred in the United States, and 5% in India.

In 2016, South America accounted for about three quarters of global soy oil exports and half of soybean exports, excluding re-export by nations with no soybean production.[17] South America and Southeast Asia are identified by Curtis, Slay, Harris, Tyukavina, & Hansen (2018) as the regions where there is by far the strongest link between expansion of commodity agriculture and deforestation. The strength of the association between forest loss and soy expansion in Latin America is therefore central in understanding whether soy should be considered high ILUC-risk.

16 Harvested area expansion may include increases in cropping intensity (making multiple harvests in the year) as well as increases in planted area, and harvested area is reduced by crop failures. There is no readily available dataset for planted area only, harvested area is considered an adequate proxy.

17 Own analysis of FAOstat data. Re-exports excluded by counting only exports from soy producing nations.

Table 6. Soybean harvested area expansion 2012-2015, FAOstat

	Soybeans
Brazil	44%
United States of America	14%
Argentina	11%
India	5%
Ukraine	4%
Russian Federation	4%
Paraguay	4%
Canada	3%
Uruguay	3%
RoW	7%

In the early 2000s, there was a particular concern relating to the role of soy expansion as a direct driver of Amazon deforestation in Brazil[18]. Amazon deforestation peaked in 2004, but there has been a significant reduction in overall rates more recently. It is generally understood that this reduction is associated with new policies and improved forest governance in Brazil following election of the Workers' Party in 2003, and with the voluntary soy and beef moratoria imposed in 2006 and 2009 respectively.[19]

Richards, Walker, & Arima (2014) conclude that a third of deforestation in the Amazon from 2002 to 2013 was associated either directly or indirectly with soy expansion, based on econometric analysis of relationship between soy price, land appreciation and deforestation rate, but do not present analysis of direct incursion of soy into the forest. Castro (2018) similarly identifies soy as a significant indirect driver of Amazon deforestation, but finds that for the example of Santarem County in Brazil the general dynamic has been for soy plantations to expand on areas previously deforested for pasture rather than directly into the forest. This pattern is also reported by Morton et al. (2006). Gibbs et al. (2015) report that whereas in the two years before the soy moratorium 30% of soy expansion in the Amazon biome was directly associated with deforestation (meaning that deforestation had occurred within three years prior to crop establishment), by 2014 this had reduced to 1%. Similarly, Macedo et al. (2012) assess changing deforestation dynamics in Mato Grosso, and conclude that in the period 2001 to 2005 26% of soy expansion occurred directly on forest, but that this reduced to 9% in the period 2005-2009.

Analysis of data that goes back to the start of the 2000s may therefore give an exaggerated sense of the current relationship between soy and deforestation, in the Amazon at least. While

18 See for instance https://www.greenpeace.org/usa/victories/amazon-rainforest-deforestation-soy-moratorium-success/

19 https://www.thesolutionsjournal.com/article/how-brazil-has-dramatically-reduced-tropical-deforestation/

it seems clear that the soy moratorium has been successful in reducing the role of soybean as a direct deforestation drive in the Amazon biome, it is possible that there has been significant deforestation leakage into other biomes and countries, and that some deforestation in the Amazon has evaded the terms of the moratorium. Gibbs et al. (2015) note that, "Smaller clearings accounted for 17% of Amazon deforestation in Mato Grosso from 2007 to 2014, yet these areas are … excluded from the [soy moratorium] monitoring system."

While the Amazon is arguably the most important biome to preserve in Brazil, it is not the only biome with forests, nor the dominant biome for soy production and expansion. Figure 4 shows area expansion of the soy crop into the five major Brazilian biomes for the period 2013 to 2018, based on planted area data from IBGE (2018) and allocated to biomes by federal unit ("unidades federativas"). This data shows that only about a fifth of expansion occurred in the Amazon in this period, and therefore only that part of expansion was subject to the soy moratorium. It is therefore important also to consider any deforestation link outside the Amazon, both in the rest of Brazil and in South America as a whole. This is consistent with data reported by Gibbs et al. (2015) showing that in the period 2006-10 about 1.3 million hectares of soy expansion occurred in the Amazon biome compared to an FAOstat reported harvested area increase in South America as a whole of 5.5 Mha.

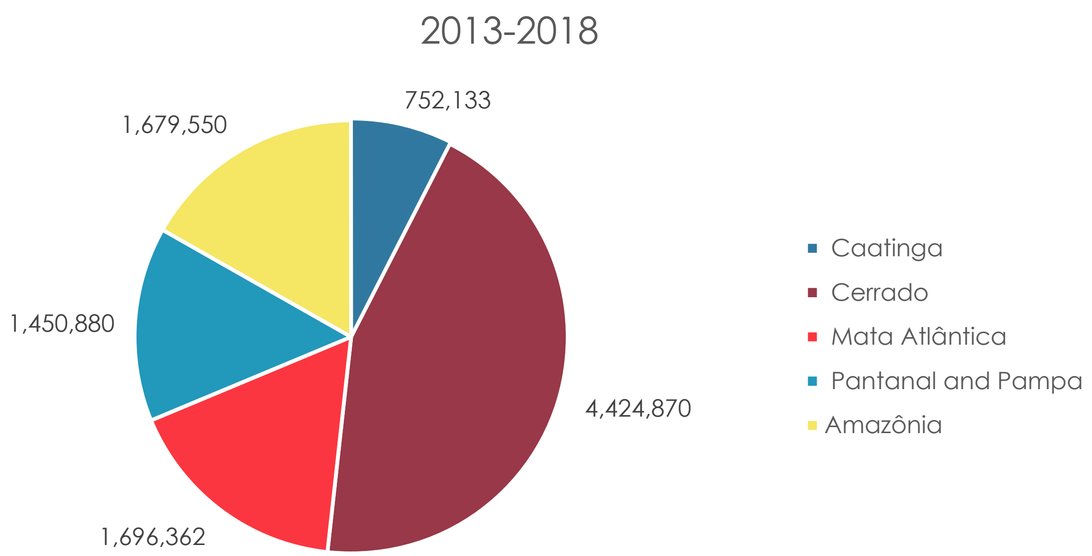


Figure 4. Biomes in which Brazilian soy area expanded (hectares), 2013-18

Source: Own analysis based on data from IBGE (2018). Expansion divided into biomes based on dominant biome in each Brazilian Federal Unit as documented by (Government of Brazil, 2017)*, except for Mato Grosso for which one third of expansion is categorised as Amazon and two thirds Cerrado based on* (Macedo et al., 2012) *and Maranha for which one third of expansion is categorised as Amazon and two thirds Cerrado based on relative area.*

Morton et al. (2006) provides satellite based documentation of large clearance[20] land

20 > 25 ha

transitions in Mato Grosso (straddling the Amazon and Cerrado biomes) from 2001 to 2004, and finds that about a sixth of deforestation was immediately followed by cropping, primarily soybeans. For cropland as a whole, 30% of new land came directly from forest, while another 34% came from non-forest Cerrado, some of which also potentially meets the high carbon stock definition within the RED.

More recent assessment by Picoli et al. (2018) identified 4.1 million hectares of deforestation in Mato Grosso from 2005 to 2016, in parallel with a 1.83 million hectare increase in total crop area, with crop expansion dominated by corn and soy, increasingly double cropped, but does not report direct conversion of forest to soy production. Gibbs et al. (2015) using satellite data from MODIS find that in the Cerrado 14% of soy expansion in 2013 was on land deforested in the previous three years, and that in the Mapitoba region ("Brazil's newest agricultural hotspot") up to 40% of new soy area was deforestation linked from 2007-13.

Fehlenberg et al. (2017) look at soy expansion in the Chaco region, which extends across 110 million hectares of Argentina, Bolivia and Paraguay. They find a correlation between soy expansion and deforestation, with 0.03-0.08 hectares of additional deforestation for every additional hectare of soybean area – this, however, is an econometric assessment rather than an assessment of proximate deforestation causes. Baumann, Piquer-Rodríguez, Fehlenberg, Gavier Pizarro, & Kuemmerle (2016) identifies soy expansion as the main driver of deforestation in the mainly Argentine dry Chaco, but identifies pasture expansion as the main deforestation drier in the wet Chaco (largely in Paraguay).

Graesser, Aide, Grau, & Ramankutty (2015) provide a satellite based assessment that covers the whole of Latin America, and that includes several years after the soy moratorium. This study assessed sources of all new cropland in Latin America for the period 2001-2013, and found that overall 17% of new cropland replaced forests. Soy is identified as the "main driver of cropland expansion in Argentina, Bolivia, Brazil, Paraguay, and Uruguay". Soy, maize and sugarcane are the main crops with area expansion in Latin America in the period. Given that sugarcane is understood to have a limited direct deforestation impact (see below), and that we are not aware of claims that other South American crops are more strongly deforestation linked than soy, this 17% might reasonably be treated as a lower limit estimate on the fraction of soy expanding on forest in that overall period. It is not, however, possible to decompose the fraction of soy expansion causing deforestation before and after the introduction of the soy moratorium.

Curtis et al. (2018) show that since 2004 the reduction in commodity-driven[21] Brazilian deforestation has been partly offset by increases in the rest of South America, as seen in Figure 5. Richards, Arima, VanWey, Cohn, & Bhattarai (2017) show that the introduction of enhanced disincentives against deforestation has resulted in an increase after 2008 in types of deforestation that are not detected by the data gathering systems used by Macedo et al. (2012), and therefore the reduction in deforestation impact may be overstated between these periods. Richards et al. (2017) also note that there is evidence that reductions in soy-related deforestation in the Amazon since 2008 correlate with increases in deforestation in other parts of Brazil (Morton et al., 2016) and in other South American nations (Graesser et al., 2015; le Polain de Waroux, Garrett, Heilmayr, & Lambin, 2016). At the time of writing, serious concerns have been expressed about the direction of forest protection in Brazil following the election

21 Commodity driven identification is identified in this study by analysis of satellite imagery, and includes any conversion to large plantations or pastures.

of a new President[22]. If there is a roll back of forest protections towards pre-2004 conditions, the recent period of reduced deforestation may no longer be representative of what can be expected in the near future.

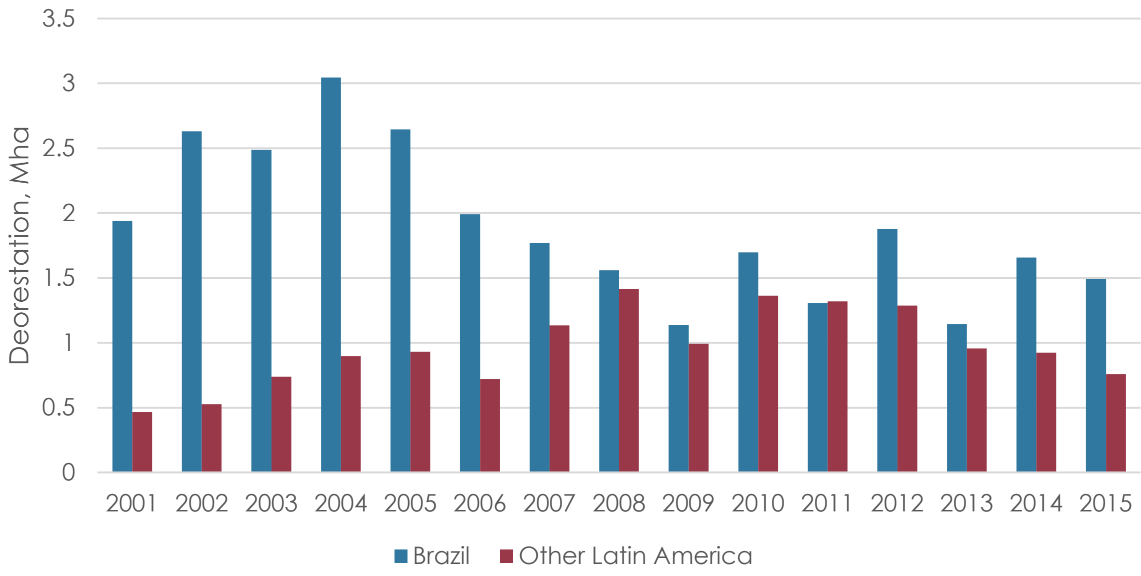


Figure 5. Commodity associated forest loss in Latin America

Source: (Curtis et al., 2018)

Conclusions on soybeans

Overall, there is a clear consensus in the literature that soybean expansion has historically been an important driver of deforestation in South America, both direct and indirect. Most soybean expansion occurs in South America. During the period 2000-06, prior to the soy moratorium, it seems reasonable to conclude based on the evidence available that between 20% and 30% of soy expansion in Latin America was directly linked to deforestation. More recently, the combination of improved deforestation prevention measures, particularly in Brazil, and of the Amazon soy moratorium appear to have significantly reduced direct Amazon deforestation, but likely contributed to increased soy-linked deforestation in other forest biomes, notably the Cerrado (most Latin American soy expansion occurs outside the Amazon biome). Without access to any single study that makes a broad regional assessment for the period since 2006, it is difficult to come to a precise estimate of the amount of soy expansion still associated with deforestation. Gibbs et al. (2015) identify about 14% of soy expansion driving deforestation in the Cerrado, based on relatively recent data, and there seems to be a broad consensus that Cerrado deforestation has not been reduced in the period since the soy moratorium. The Cerrado accounts for a bit under half of soy expansion in Brazil. If 5 to 10% of expansion in other

22 https://www.nationalgeographic.com/environment/2018/10/brazil-president-jair-bolsonaro-promises-exploit-amazon-rain-forest/

non-Amazon biomes is deforestation linked, then about 9% of soy expansion in Brazil may be deforestation linked at present.

According to FAOstat, Brazil accounted for 44% of global soy expansion. A further 11% occurred in Argentina, 4% in Paraguay and 3% in Uruguay. Using Graesser et al. (2015) values for fraction of cropland in general coming from deforestation in these three countries (9%, 57% and 1% respectively) gives 16% of soy expansion deforestation linked in the rest of Latin America, for an overall average of about 12% of Latin American soy expansion being deforestation linked (Table 7). With a bit over 60% of soy expansion occurring in Latin America these deforestation values taken together suggest that at least 7% of global soy expansion is directly linked to deforestation (assuming that there is only a weak link to deforestation in other areas where soy area has expanded in the period such as the U.S., Russia, India, Canada and Ukraine).

Table 7. Soy expansion and deforestation in Latin America

		Fraction of global soy expansion	Fraction of expansion associated with deforestation
Brazil	Caatinga	3%	8%
	Cerrado	19%	14%
	Mata Atlântica	7%	8%
	Pantanal and Pampa	6%	8%
	Amazônia	7%	1%
	Total Brazil	*44%*	*9%*
Argentina		11%	9%
Paraguay		4%	57%
Uruguay		3%	1%
Total Latin America		*62%*	*12%*

3.3.ii) Sugarcane

As discussed above, sugarcane is identified as a deforestation risk commodity in some studies, though not with the consistency of soy and palm, and sugarcane expansion is concentrated in countries where there is significant deforestation compared to cropland expansion. On the other hand, modelled ILUC estimates for sugarcane ethanol have generally been low, and it is often noted that in Brazil, the world's largest sugarcane producer, plantations tend to be well away from the Amazon rainforest, concentrated in the south of the country.

Locations for sugarcane area expansion between 2012 and 2015 are shown in Table 8. Brazil is the largest fraction in a single country (43%), and 61% was in Latin America as a whole.

Table 8. Sugarcane harvested area expansion 2012-2015, FAOstat

	Sugar cane
Brazil	43%
Thailand	13%
Cuba	8%
Pakistan	8%
Australia	4%
United Republic of Tanzania	3%
Mexico	2%
Cameroon	2%
Lao People's Democratic Republic	2%
Nigeria	2%
RoW	14%

Cuypers et al. (2013) suggests a large potential role of sugarcane in driving deforestation, up to 36% of sugarcane expansion, but this is based on analysis of national statistics, in particular for Brazil where 81% of deforestation attributed to sugarcane in their methodology occurs. Because the Cuypers et al. (2013) analysis is based on national statistics, it is insensitive to differences in the deforestation relationships to deforestation to different crops – e.g. it could not distinguish whether soybeans were more or less deforestation linked than sugarcane if both areas expand simultaneously.

Adami et al. (2012) provide a remote sensing assessment of the direct impact of sugarcane on forest in South-central Brazil in the period 2005-2010. During this period, sugarcane expanded by nearly 4 million hectares in the study area, out of a global reported sugarcane expansion of 4.3 million hectares in FAOstat, so it is reasonable to conclude that the results of this study ought to be fairly characteristic of sugarcane expansion globally. This study finds that in 2000 70% of areas converted to sugarcane in the period 2005-2010 were pastures, and a further 25% under annual crops. A further 3.4% were sugarcane fields in 2000 that had been under renovation at the start of the study period in 2005, and 1.3% were citrus plantations. Only 0.6% of the area was forested in 2000. This shows that the vast majority of deforestation linked to sugarcane by Cuypers et al. (2013) could not have been direct.

Of the other countries reporting significant sugarcane expansion, Thailand and Cuba both report growing forest area in FAOstat statistics. There could be a deforestation link in Pakistan, but sugarcane expansion does not seem to be identified as a major deforestation driver in the available literature, and Hosonuma et al. (2012) characterise Pakistan as a country likely to move from net deforestation to reforestation in the near future. It therefore seems reasonable to conclude that sugarcane should not be characterised as a high ILUC-risk crop in the sense of the RED II, although there may nevertheless be a stronger indirect link between sugarcane expansion and deforestation on the Amazonian agricultural frontier (cf. Lapola et al., 2010).

3.3.iii) Oil palm

Oil palm has often been identified by researchers and environmentalists as an environmentally problematic biofuel feedstock due to the reported link between oil palm expansion and both deforestation and peat drainage in Southeast Asia. As detailed above, palm oil not only has the highest ILUC emissions estimated in previous ILUC modelling, but is overwhelming produced in regions where FAOstat data suggest there may be a high risk of agricultural expansion driving land use change in high carbon stock areas, and is uniformly present on lists of deforestation risk commodities identified by other studies. Barthel et al. (2018) finds that, "there is a high degree of confidence that the expansion of oil palm cultivation has resulted in significant deforestation in Indonesia and Malaysia in particular." It is therefore of considerable interest as a potential high ILUC-risk feedstock.

As shown in Table 9, Indonesia and Malaysia continue to dominate oil palm expansion, accounting for 85% in the period 2012-15.

Table 9. Oil palm harvested area expansion 2012-2015, FAOstat*

	Oil palm fruit
Indonesia	68%
Malaysia	17%
Ecuador	3%
Colombia	3%
Thailand	2%
Guatemala	2%
Honduras	1%
Brazil	1%
Mexico	1%
Papua New Guinea	1%
RoW	2%

**FAOstat data for this period reports a 200 kha reduction in Malaysian palm oil area, which is inconsistent with local reporting by Malaysian Palm Oil Board (2017), which shows increasing area in this period. For Malaysia we have therefore used the planted area increase reported by Malaysian Palm Oil Board (2017) (using the period 2013-16 instead of 2012-15 as 2012 data was no longer available). A similar area increase is reported for both total area of oil palm and area of mature oil palm, so we believe this is a reasonable proxy for harvested area.*

Beyond the indication provided by models and global land use statistics, there is a wealth of research identifying a strong link between palm oil production and deforestation, in particular in Malaysia and Indonesia, including a number of studies using satellite imaging to identify links to deforestation and peat drainage. Indonesia and Malaysia are the source for the substantial majority of palm oil imported to Europe, for biodiesel or otherwise. According to FAOstat, excluding re-exports from countries with no palm oil production, Indonesia and

Malaysia account for 92% of global palm oil exports. The ILUC-risk of palm oil from Indonesia and Malaysia can therefore reasonably be treated as a proxy for the ILUC-risk of the average palm oil imported to Europe. Below we first review the evidence on links to deforestation and then to peat drainage.

For Indonesia, Abood, Lee, Burivalova, Garcia-Ulloa, & Koh (2015) examined oil palm expansion from 2000 to 2010, finding 1.5 Mha of deforestation within government registered oil palm concessions (1 Mha on mineral soils, and a further 0.5 Mha in peat swamp forest). That equates to just under 40% of new oil palm land being associated with deforestation, based on FAOstat data for harvested area expansion in the same period. Carlson et al. (2013) assesses the same period, considering only Kalimantan (Indonesian Borneo), identifying 1.7 Mha of forest loss, which equates to about 70% of new palm area in Kalimantan in that period (Malins, 2018). Vijay et al. (2016) finds 54% of new oil palm area from 1989 to 2013 associated with deforestation. Gunarso, Hartoyo, Agus, & Killeen (2013) undertakes satellite assessment for the RSPO of land converted to oil palm across Indonesia, Malaysia and Papua New Guinea in the period 1990 to 2010, finding that a third of Indonesian oil palm replaced forest in that period. Austin et al. (2017) undertakes an assessment by cross reference government held historical land use data against satellite identification of oil palm plantations, finding that 26% of oil palm expansion from 1995 to 2010 happened at the expense of forest. It should be noted that some of these estimates may use different forest definitions than those given for high carbon stock land in the RED II. For instance, Austin et al. (2017) defines forest as having at least 30% canopy cover, whereas under RED II some land that Austin et al. (2017) identifies as shrubland might meet the high carbon stock definition.

For Malaysia, Vijay et al. (2016) estimates that 40% of oil palm expansion in the period 1989-2013 was deforestation related. SARVision (2011) identifies 230 thousand hectares of oil palm linked deforestation in the Malaysian province of Sarawak from 2005-10, equivalent to more than half of oil palm expansion in the province in the period (Malins, 2018). Miyamoto, Mohd Parid, Noor Aini, & Michinaka (2014), referenced by the Malaysian REDD+ strategy (MNRE Malaysia, 2018), found based on regression analysis that palm oil was the "main proximate cause of deforestation" in Peninsular Malaysia from 1970 to 2010, although deforestation in Peninsular Malaysia has slowed since 1990 compared to the previous two decades.

In addition to the impact on forest, a significant fraction of palm oil expansion occurs in peat swamps, requiring drainage of the peat and resulting in very large emissions due to peat decomposition (Page, S.E., Morrison, R., Malins, C., Hooijer, A., Rieley, J.O. Jaujiainen, 2011). These peat emissions represent a significant element of estimated ILUC emissions associated with European biodiesel consumption (Laborde, 2011b; Valin et al., 2015).

Valin et al. (2015) reviewed available estimates of the fraction of oil palm expansion that resulted in peat drainage. For Indonesia, the mean estimate was 32%, while for Malaysia the mean estimate was 34%. These values are similar to estimates provided by Miettinen, Hooijer, Tollenaar, Page, & Malins (2012) (28% in Indonesia and 42% in Malaysia) and Edwards et al. (2010a). Searle & Giuntoli (2018) provide a more recent assessment based on data from Miettinen, Shi, & Liew (2016), concluding that 25% and 36% of palm expansion occurs on peat in Indonesia and Malaysia respectively. Austin et al. (2017) reports a lower rate of 20% of palm oil expansion on peatland in Indonesia. Gunarso et al. (2013) reports for 2005-10 that 24% of oil palm expansion in Indonesia was in swamp systems, presumably mostly on peat soil, but only 5.9% of expansion in Malaysia, which clearly is inconsistent with other studies, and which we therefore discount.

Outside of Southeast Asia there is generally less of an expectation of deforestation due to oil palm expansion, but the association is still significant. Furumo & Aide (2017) found that about 20% of oil palm expansion in Latin America since 2001 was deforestation linked. For West Africa, the rate of expansion into forest was only 6% according to Meijaard, E., Garcia-Ulloa, J., Sheil, D., Wich, S.A., Carlson, K.M., Juffe-Bignoli, D., and Brooks (2018). The impact of oil palm on peat landscapes outside Southeast Asia has not been addressed in as much detail, but is expected to be much more limited.

Overall, the link between palm oil and expansion into high carbon stock areas is by far the strongest for the biofuel feedstocks considered in this paper, and thus it would seem reasonable to characterise palm oil as a high ILUC-risk feedstock.

3.3.iv) Palm fatty acid distillates as co-products

Palm fatty acid distillates (PFADs) are an oil fraction removed during palm oil refining. PFADs are a marketable resource and have several existing applications in oleochemicals and livestock feed, but generally sell at slightly lower prices than palm oil, and refineries seek to minimise PFAD production (PFADs result from degradation of quality in the palm fresh fruit bunch). PFADs have been used as a feedstock for hydrotreated renewable diesel production. It is therefore important to consider whether a high ILUC-risk categorisation made for palm oil should also be applied to PFAD as a palm oil by-product.

While some biofuel industry actors have advocated to have PFAD identified as a residue under the RED and made eligible to be double counted towards compliance with RED targets[23], several countries have determined that given that the value per tonne of PFADs is comparable to other vegetable oils PFADS should be treated as a co-product, a determination supported by research showing that the use of PFADs for biofuel production is likely to cause significant displacement emissions (Malins, 2017c). As a co-product of palm oil production, it would be appropriate for PFADs to inherit a high ILUC-risk determination made for palm oil. It is therefore recommended that PFADs are designated high ILUC-risk, and that any co-products of high ILUC-risk feedstocks should similarly be considered high ILUC-risk.

3.4. Identifying high ILUC-risk feedstocks

The RED II defines high ILUC-risk feedstocks as, "food or feed crops for which a significant expansion of the production area into land with high carbon stock is observed". One of the main tasks facing the Commission in drafting the delegated act is to determine what constitutes 'significant' expansion into high carbon stock areas. The evidence for the strong connection of oil palm to conversion of high carbon stock land is very clear, and oil palm would be likely to be assessed as high ILUC-risk on any characterisation of significance, but for soy the deforestation link is somewhat weaker and thus the threshold set may well determine whether there will be a longer term market for soy biodiesel in the EU.

This question of significance could be understood in two ways, either solely as a question of quantity of converted land area, or else by reference to the expected carbon losses

23 E.g. https://www.neste.com/companies/products/renewable-fuels/renewable-raw-materials/waste-and-residues

associated with high carbon stock land area conversion and the impact of those carbon losses on lifecycle emissions from biofuel use.

The RED II provides some precedent for both approaches. The prohibition on using feedstock from recently converted high carbon stock land that was wetland, peatland or forest with at least 30% canopy cover is absolute, in that the Directive does not allow for any exceptions to these rules even if a net carbon benefit could be demonstrated. It could be argued that the status of land as high carbon stock is also a proxy for other aspects of ecological value, such as ecosystem services and biodiversity, which are not captured in a direct carbon stock comparison.

One comparison point for reduced deforestation in commodity supply chains comes from the Amsterdam Declaration on Deforestation (E. Hansen et al., 2015), which has been signed by several EU Member States. This declaration endorses a goal of zero net deforestation, and specifically of eliminating deforestation from commodity supply chains including palm oil and soy by 2020. A goal of entirely eliminating deforestation from commodity supply chains would be consistent with setting a fairly low threshold for 'significance' in the identification of high ILUC-risk fuels. This could for instance involve considering a maximum threshold for the fraction of expansion of a feedstock crop that was allowed to occur on high carbon stock land, perhaps between 2% and 5%.

On the other hand, the RED II also provides precedent for addressing these questions explicitly through a carbon emissions lens. For conversion of forest with 10-30% canopy cover the rule is not absolute – it is allowable to replace such a landscape with agricultural production provided there is no net carbon storage reduction. Similarly, the lifecycle analysis rules allow for direct land use changes on other land types providing the reportable carbon loss is not so great as to prevent a fuel production pathway from meeting threshold GHG reduction requirements.

Defining significance using these aspects of the Directive as precedents could involve assessing a carbon dioxide emission value per unit of energy associated with expansion of the feedstock in question, a value somewhat analogous to the lifecycle GHG intensity value calculated for fuels under the Directive, or to an ILUC factor expressed in gCO_2e/MJ. A carbon oriented approach has the advantage that the Directive provides some reference points to what level of emissions might be considered 'significant'. For example, the GHG reduction threshold for new facilities in the RED II is a 65% saving compared to a fossil fuel – that is equivalent to 33 gCO_2e/MJ given the defined fossil fuel comparator. If emissions above 33 gCO_2e/MJ are adequate to exclude a fuel from meeting the sustainability criteria, then this might be taken as a threshold for significance for emissions from high carbon stock land conversion.

Arguments could be made to set a threshold at either a lower or a higher level, and the decision must be somewhat subjective and political in the end. A higher threshold could be argued for on the basis that additional emissions at the level of 33 gCO_2e/MJ would not, on their own, be enough to eliminate all of the GHG benefit from a fuel. Counter to such an argument it could be noted that ILUC analysis shows that emissions from high carbon stock land conversion are not the only or necessarily the dominant source of land use change emissions across the system as a whole, depending on feedstock (Valin et al., 2015). It might therefore be argued that the standard for maximum allowable emissions from conversion of high carbon stock land should simply be that they would 'significantly' reduce the environmental performance of the fuel in question. On that basis, a lower threshold calculated value could be supported, for instance 20 gCO_2e/MJ. A further advantage of using a carbon framing is that it allows conversion of different types of land (such as peatland versus continuous canopy rainforest versus sporadic dry forest) to be weighted by carbon impact.

While there is a clear appeal to setting a numerical threshold for the significance assessment, it is potentially problematic to use an exact numerical threshold without any moderately precise global characterisation of high carbon stock land conversion. The analysis presented above provides what we think is a reasonable characterisation of expected high carbon stock land conversion from soy and palm, as the potential high ILUC-risk feedstocks, but by putting more weight on alternative sources one could justify higher or lower conclusions.

It may be that the most appropriate way to deal with the range of evidence available would be for the Commission to provide a clear specification of indicators it would consider, but make the final identification of high ILUC-feedstocks on a narrative basis informed by these indicators, rather than explicitly using a single threshold assessment.

3.4.i) Example threshold assessment

This paper does not make a firm recommendation for a specific approach to define significance in the high ILUC-risk assessment. There are many approaches that could be justified, and it is not a solely technical question. In this section we do, however, provide an example of how a carbon dioxide emissions based assessment might be constructed, and determine whether palm oil and soy oil would be identified as high ILUC-risk feedstocks given the example definition.

For the example, we use the sources detailed above to estimate recent historical rates of high carbon stock land conversion, then cross reference those numbers with land use carbon stock for forested areas from European Commission (2010), and the value for drained peatland carbon emissions from Valin et al. (2015).[24]

Table 10 details the resulting assumptions on fraction of expansion of palm and soy crops respectively that occurs at the expense of high carbon stock land types, identified by land type to allow cross-referencing with land carbon stocks. It is assumed that all forest conversion for palm occurs in the tropical wet land type. For soy, the converted forest type in Brazil is based on the biomes reported for soy expansion (see above), and for Argentina, Paraguay and Uruguay simple assumptions are made on the split of replaced forest type based on sources considered and location (e.g. Argentinian deforestation is assumed to be wholly in the subtropical dry land type, while in Paraguay it is split evenly across topical dry and moist and subtropical dry and humid types).

24 Carbon stock values from (European Commission, 2010) for wet/moist/dry forest are used based on a rough assessment of typical local biomes in each country. In the example, carbon stock values for forest with greater than 30% canopy cover are used, which is consistent with forest definitions in some but not all of the source studies. With further review of the source material, one could better estimate what fraction of reported deforestation might fall into the 10-30% canopy cover category (and whether land use changes identified as non-forest in the sources, such as scrubland, may partly fall into the 10-30% forest category and should therefore be added to the calculation). The carbon stock changes per hectare of expansion are then converted into GHG emissions intensity values in gCO_2e/MJ using yield data from Biograce and allocating emissions between co-products based on value.

Table 10. Fraction of crop expansion by biome and location

	Palm				Soy				
	Indonesia	Malaysia	Latin America	Africa	Brazil	Argentina	Paraguay	Uruguay	Other Latin America
Tropical dry forest	0.00%	0.00%	0.00%	0.00%	2.97%	0.00%	0.57%	0.00%	0.00%
Tropical moist forest	0.00%	0.00%	0.00%	0.00%	1.04%	0.00%	0.57%	0.00%	0.00%
Tropical wet forest	26.73%	3.60%	1.00%	0.30%	0.07%	0.00%	0.00%	0.00%	0.00%
Subtropical dry forest	0.00%	0.00%	0.00%	0.00%	0.00%	0.99%	0.57%	0.02%	0.00%
Subtropical humid forest	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.57%	0.02%	0.00%
Peat*	20.25%	3.15%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

**Peat conversion for oil palm will in some cases overlap with forest conversion. The emissions from peat drainage are added to the emissions from biomass loss.*

By multiplying the land conversion fractions with relevant carbon stocks, estimates are obtained of tonnes of carbon stock loss from high carbon stock land types for every hectare of land expansion. For oil palm, this gives an average of 150 tonnes carbon loss per hectare of expansion, while for soy there are 9 tonnes of carbon loss per hectare of expansion. Scaling these to respective typical yields and allocating the emissions across co-products by value gives GHG intensity values of 244 gCO_2e/MJ and 40 gCO_2e/MJ for palm and soy respectively. It is reasonably clear from this that oil palm should be characterised as high ILUC-risk. For soy oil, the conclusion would depend on the threshold value taken for comparison. If using 33 gCO_2e/MJ (the maximum direct GHG emissions intensity allowable for new facilities) or any lower value as a threshold, on this analysis soy oil would be identified as a high ILUC-risk feedstock.

3.5. Dealing with changing deforestation trends in the high ILUC-risk framework

In this paper, we have used historical data to assess the ILUC-risk of various biofuel feedstocks, aiming to focus on more recent data where it is available. The outcomes of this type of assessment will always be sensitive to the period chosen for analysis. Whichever biofuel feedstocks are identified as high ILUC-risk using the rules that the Commission presents in the February delegated act, there is therefore the possibility that deforestation links will change during the period of implementation of the RED II. How then should the European Institutions react to reductions (or increases) in reported deforestation rates for crops of interest?

Part of the answer to this question is already in place in the text of the RED II. While some limits will be placed on the use of high ILUC-risk feedstocks from 2021 onwards, it is only from 2023 that their use must be gradually reduced, and only by 2030 that they must be phased out. The Directive already provides for a review of the high ILUC-risk identification in 2023, and therefore it is already explicit that feedstocks identified as high ILUC-risk may have that identification revised in 2023, should available data justify a change. Similarly, any feedstock not identified as high ILUC-risk based on the rules in the February 2019 delegated act may still be added to the list of high ILUC-risk feedstocks in 2023.

When the time comes to undertake this review, it is suggested that the European Commission should have particular regard to emerging trends in the period from now until then, but that **it should never be casually assumed that reductions in deforestation observed over a short period will be permanently sustained**. For instance, if reported Indonesian deforestation continued at current rates until 2021, but was reduced dramatically in 2022, it would be naïve to base expectations for the coming decade only on the 2022 data. Ideally, assessment of changes in deforestation trends should be accompanied by analysis of underlying causes for those changes. For instance, if reduced deforestation is associated with credible long-term policies, this has quite different implications for the future than if deforestation is temporarily reduced due to an economic slowdown. It should also be noted that it will always be possible for individual project operators working with these feedstocks to seek low ILUC-risk certification.

4. Certification of low ILUC-risk biofuels – background

Low ILUC-risk feedstock certification has the potential to provide a basis for producers to show that they avoid ILUC emissions by preventing displacement of material from existing uses. This could be done by taking measures to improve agricultural productivity, or by farming areas that otherwise would not be productive. Since 2008, several methodologies have been suggested to identify low ILUC-risk feedstocks, and the RSB offers a low ILUC-risk certification. A central challenge in implementing low ILUC-risk certification involves the idea of additionality. Demonstrating that use of a feedstock for biofuel has not caused displacement of existing uses requires showing that the production of that feedstock is additional to what would have been achieved in a business as usual scenario. Additionality can be assessed directly, for instance using the principles of the "Tool for the demonstration and assessment of additionality" of the CDM, but some studies have felt that a direct assessment may be unduly burdensome and have instead proposed 'proxy' additionality tests. Such proxy tests involve identifying characteristics of a production system that could suggest that it is probably additional. The risk of such proxy tests is that they create the potential for free riders – projects that could be certified without actually avoiding displacement. It has been demonstrated that without some robust basis for assessing additionality, the potential number of free-riders could be very large for both productivity improvement and unused land projects. A second implementation challenge arises in the case of productivity improvement projects from the difficulty of distinguishing delivered yield gains from natural yield variation. It can be shown that normal yield variations tend to be large compared to the scale of yield improvement likely to be delivered by a project, and therefore measuring yields is not an adequate basis to determine whether projects have been successful.

Almost since the term ILUC was coined, the discussion of low ILUC-risk biofuel production systems has existed as a counter-point to the discussion about quantification of ILUC emissions. In 2008, for instance, the UK Government's Gallagher review (RFA, 2008) recommended that biofuels policy should prioritise the development of feedstock production systems that avoided ILUC emissions. More recently, the Roundtable on Sustainable Biomaterials has operationalised the low ILUC-risk concept through a certification option for 'low indirect impact biofuels' (Ecofys, 2013). Indirect land use change occurs when biofuel feedstock is taken from existing markets (for food, feed, fibre etc.) in order to be used in biofuel production, reducing availability of that material to existing users. ILUC models generate scenarios for the way that the market adjusts to this reduction in feedstock availability, and ILUC occurs if we expect farmers to increase agricultural area to compensate for those changes.

Throughout this report, only land-using (crop-based) biofuel production systems are considered for low ILUC-risk certification. It would also be possible to seek certification for low ILUC-risk status for the use of appropriate wastes and residues – this is already offered by the low ILUC-risk certification of the RSB, for instance. The certification of such materials is, however, not covered by the definition of low ILUC-risk feedstocks in the RED II, and therefore is considered out of scope for this study.

4.1. Additional production

The basic premise of low ILUC-risk biofuel certification is that it is possible to undertake actions to produce additional biomass feedstock for use in biofuel production without interfering with existing agricultural markets. This idea of low ILUC-risk feedstock production as 'additional' to existing production is very important. If and only if the existence of the biofuel mandate causes an additional amount of feedstock to be produced that completely covers demand from biofuel producers, then there need be no reduction in availability to existing users. This idea of being able to certify additional biofuel feedstock production has considerable overlap with the concept of 'additionality' in economic and environmental policy analysis as a framework to assess whether a given intervention has an impact beyond what would be expected in a reasonable baseline or reference case. Additionality goes beyond simply identifying that some change has had an effect, it involved assessing what the reason was that the change occurred (i.e. not assuming that all changes in the world can be automatically attributed to any given policy intervention). To quote the Wikipedia entry for additionality,

> *"Additionality becomes problematic when the parties claim that their behaviour is being changed due to recognized intervention (e.g., because of the economic incentive provided by earning carbon offset credits), when in fact the intervention is having no effect on their behaviour because other factors are dominant (e.g., earning a profit from an activity even without carbon credits)."*

An example of the application of the additionality concept can be found in the Clean Development Mechanism (CDM) under the Kyoto Protocol. Within the CDM, credits are awarded for projects that result in reductions of carbon dioxide emissions in the developing world. For instance, a CDM project could be developed around replacing fossil energy with hydroelectric renewable energy at an industrial facility. If this change results from the facility owner building a small hydroelectric plant on a local river, using the value of CDM credits to pay back the investment, then the project might be likely to be thought of as additional. If, on the other hand, the change in power generation occurs because a large national hydroelectric project has been opened and has replaced older coal power generation for much of the country, then we would generally conclude that the change is not additional (it would have happened regardless of the actions of the facility operator or the value of CDM credits). The CDM "Tool for the demonstration and assessment of additionality" (cf. section 4.6) could provide a template for a gold standard of additionality assessment within low ILUC-risk certification.

While a full additionality assessment similar to that required in the CDM may be the gold standard, some stakeholders and analysts have expressed concerns that setting such a high standard could be unduly costly, and become a barrier to project development. In the review below we therefore discuss several suggestions for 'proxy' additionality assessment measures, that are presented as ways to identify feedstock production that is *probably* additional without having to undertake a full additionality assessment. Finding a practical and proportional way to assess the additionality of low ILUC-risk biofuel projects is a key challenge for effectively incentivising projects that deliver real reductions in ILUC, rather than simply rewarding producers for actions that would have been taken anyway without delivering any ILUC reduction. Demonstrating additionality may be difficult for some types of projects, especially where an agricultural system produces a range of materials only some of which are destined for the biofuel market. However, if additionality cannot be demonstrated there is no clear basis to claim that ILUC-risk has been reduced.

4.2. Low ILUC-risk fuels in EU law

Introducing the low ILUC-risk concept into European law, the 2014 'ILUC Directive' added an outline definition of low ILUC-risk biofuels as "biofuels, the feedstocks of which were produced within schemes which reduce the displacement of production for purposes other than for making biofuels." Recital 27 of the 'ILUC Directive' identifies the potential to define and certify low ILUC biofuels through the use of certification schemes "which can reliably prove that a given amount of biofuel feedstock produced in a given project did not displace production for other purposes."

The definition has been strengthened in the RED II by introducing a firm requirement to avoid rather than simply reduce displacement: "low ILUC-risk biofuels and bioliquids' means biofuels and bioliquids, the feedstocks of which were produced within schemes which avoid displacement effects of food and feed crop based biofuels, bioliquids and biomass fuels through improved agricultural practices, as well as the cultivation of crops on areas which were previously not used for cultivation of crops." The RED II does not provide further specification of how this definition should be interpreted, such as the requirements for something to be considered a 'scheme', the timeframe against which previous use of land should be assessed or precisely how one can determine whether displacement effects have been avoided. It requires the European Commission to produce 'detailed implementing rules' to ensure compliance with the rules on both certifying low ILUC-risk biofuels and identifying high ILUC-risk biofuels.

It is important that a distinction should be made between biofuels that are produced from feedstocks generated by low ILUC-risk projects that avoid displacement, and biofuels that are estimated based on ILUC modelling or other assessment to have relatively low ILUC emissions. For feedstocks with low estimated ILUC emissions, displacement of existing uses may occur but the models conclude that this displacement will not result in large additional net GHG emissions, given expected land conversions and associated carbon stock changes. For low ILUC-risk feedstocks, we expect not that carbon stock losses from indirect land use change will be small, but that indirect land use changes will be avoided entirely (and that any direct land use change emissions for projects on land that was not previously farmed are measured and shown to be small). In the ILUC Directive and RED II it is clear that the term low ILUC-risk refers to this case of avoided emissions. The European Institutions have now three times turned down the opportunity to regulate using estimated ILUC factors directly, reflecting a caution about the uncertainty in estimated ILUC numbers (for both the low estimated values and the high). If the low ILUC-risk concept is well implemented, demonstrating that displacement of other feedstock uses is avoided at the project level escapes the inherent uncertainty of modelling approaches.

In the RED II, the primary role of low ILUC-risk certification at the project level is to demonstrate that a particular project using a feedstock considered high ILUC-risk avoids that high ILUC-risk by taking appropriate action to avoid displacement of existing agricultural demand. In this regulatory context, it is clear that additionality of the low ILUC-risk project is very important for the policy to deliver the intended outcome. The low ILUC-risk certification is not intended simply to reward relatively sustainable production practices, it is intended to manage a specific risk otherwise arising from using those feedstocks for biofuels.

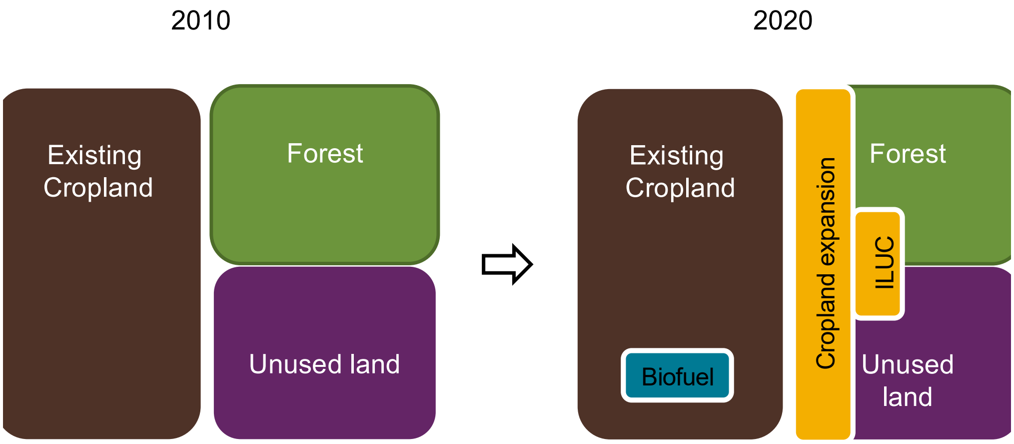
4.3. A background to low ILUC-risk biofuel approaches

As noted above, the dialogue on low ILUC-risk biofuels emerged as a response to the development of concerns about ILUC associated with biofuel production, and in particular as a response to early modelling work attempting to quantify ILUC emissions. Several different terminologies have been used for this concept over the last ten years, including 'responsible cultivation areas', 'ILUC mitigation', 'ILUC avoidance' and 'low indirect impact biofuels', but all of these terms refer to the same basic idea that by promoting production of additional biomass beyond business as usual it is possible to avoid displacing existing uses of feedstock and thereby avoid ILUC from biofuels. Here we provide a short review of the development of the low ILUC-risk concept – more detailed reviews can be found in Ecofys (2016) and El Takriti, Malins, & Searle (2016). While the Gallagher review suggested that avoiding ILUC should be a goal for all biofuel policy, at present the suggested role of low ILUC-risk certification is to provide a basis for marginally enhanced support for positive projects, or (in RED II) to provide a way for biofuels from the most problematic feedstocks to continue being used towards EU renewable energy targets.

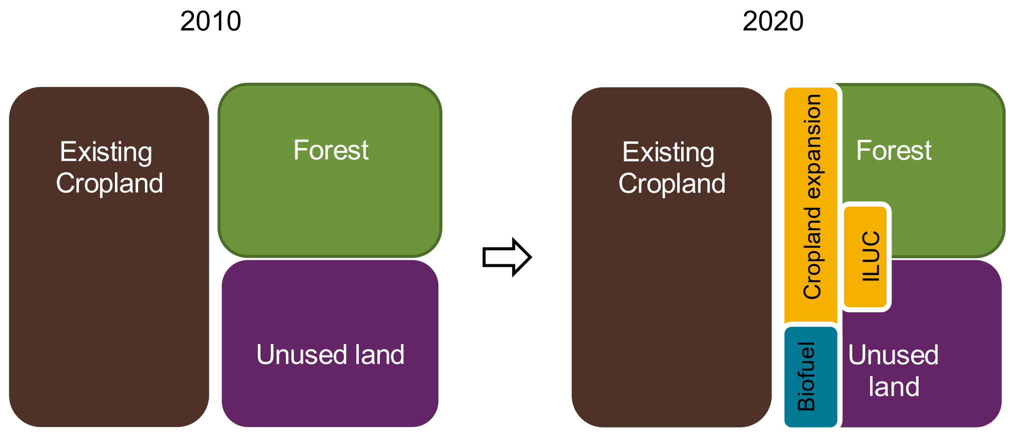
The first paper published on low ILUC-risk was written by Ecofys for the UK Renewable Fuels Agency, and presented an outline methodology accompanied by four case studies (Dehue, van de Staaij, & Chalmers, 2009). The methodology considered three approaches to deliver additional biomass production without displacing other provisioning services:

1. The use of land that would provide no provisioning services in the absence of a biofuel project.
2. Increasing the productivity of an existing system, for instance by increasing yield.
3. Increasing land productivity through integration of bioenergy and non-bioenergy production systems.

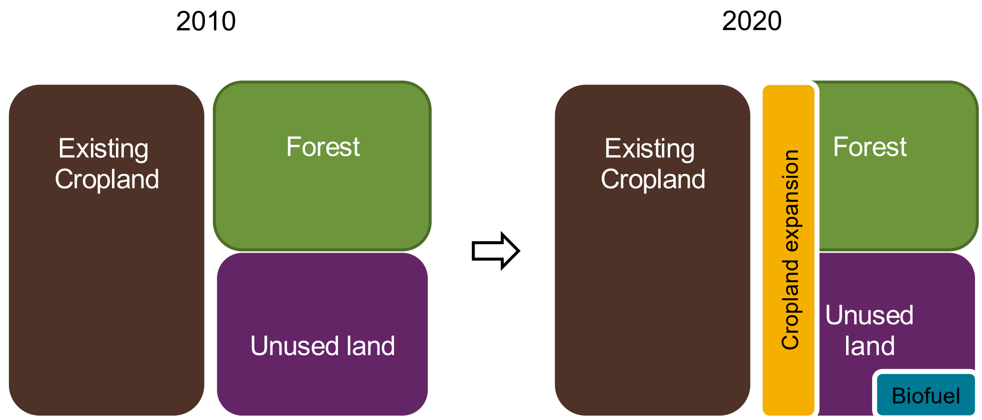
The importance of additionality, in the sense of demonstrating that biomass production is additional to a reference scenario, is stressed very clearly in this first study. The additionality requirement is described as follows: "in absence of the bioenergy feedstock demand the measure would not have been implemented during the crediting period." The framing of additionality against a hypothetical reference case scenario ("would not have been implemented") rather than simply against the immediate past is a crucial detail. Simply showing that a project represents a change from the previous status quo is not enough to show that displacement has been avoided.



a) ILUC from using feedstock from existing cropland



b) ILUC from using land that would have been converted in a business as usual scenario



c) There is no ILUC from bringing truly additional unused land into production

Figure 6. ILUC consequences of biofuel use in a business as usual case (a), under a weakly governed low ILUC-risk scheme (b), and under a robustly governed low ILUC-risk scheme (c)

Source: (El Takriti et al., 2016)

A simple example of this can be provided for the first type of project identified by Ecofys, the use of land that would otherwise provide no provisioning services. Figure 6 provides a graphical illustration of this in the case of an expanding agricultural frontier in which new land is regularly brought into agricultural use, taken from El Takriti et al. (2016). Without low ILUC-risk certification, biofuel feedstock is taken from the market and ILUC results as a consequence. If instead a rule is applied that biofuel can only come from new land brought into production, in the context of an already expanding agricultural frontier this still reduces the amount of feedstock placed on the market for other uses, and again ILUC is the consequence. If, instead, a robust low ILUC-risk certification is applied so that biofuel feedstock is produced on new land that otherwise would not have supplied feedstock to the market, ILUC is avoided. In short, if simple criteria for low ILUC-risk feedstock are applied that do not require additional production then there is a risk that some (or perhaps most) low ILUC-risk projects would in fact fail to reduce overall ILUC.

A subsequent study, also by Ecofys (Dehue, Meyer, & van de Staaij, 2010), provided additional discussion on the need for additionality to be robustly enforced, and directly addressed the question of whether additionality requirements proposed in the report could be relaxed. It is concluded that, "an ILUC policy that does require biofuels to come from land that was unused in 2010, but does not require additionality, could lead to just as much unwanted LUC in 2020 as a scenario without any ILUC policy". This conclusion is contextualised by the observation that the level of annual global cropland expansion (millions of hectares per year) would create a 'free-rider potential' that was large compared to potential EU demand for low ILUC-risk biofuels (i.e. it would be possible for all of EU demand for low ILUC-risk biofuel to be met from business as usual agricultural expansion onto land that would meet a badly framed low ILUC-risk criteria). As a corollary to this, a very large rate of 'free-rider' certification would also undoubtedly undermine any value signal for 'real' low ILUC-risk biofuels, thus effectively eliminating support for better projects. A low ILUC-risk programme with a significant free-rider problem could therefore be expected to fail both as an environmental protection and as a support for business.

The free-rider problem

A free rider problem occurs if a system of low ILUC-risk certification intended to drive actions that avoid ILUC is defined out in such a way that feedstock producers behaving in a business as usual fashion are able to be certified. As an analogy, consider a bus service that sells tickets with a cost depending on distance travelled, but with no ticket checks after boarding. Passengers with cheap tickets would be able to take long journeys – and as the bus fills up with passengers taking advantage of the lack of oversight to take cut-price trips, there may be no room left for passengers with long-trip tickets to get on board. In the same way, inadequate checks on low ILUC-risk projects would allow business as usual projects to take advantage of the scheme, paying only the certification cost rather than having to make any investment, and thereby destroy incentives for genuine projects.

Further development of the low ILUC-risk concept has more or less followed the project categories identified above. Assessing the role of a low ILUC-risk biofuel project in delivering productivity increases is complicated by the fact that agricultural yields generally show a long term trend of linear yield increase (Malins et al., 2014). Dehue et al. (2009) therefore discuss static and dynamic alternatives for setting a yield baseline. In the static case, the baseline would be set based on the average over some period, whereas in the dynamic case the baseline would follow a calculated yield trend. Use of a static baseline would tend to result in over-crediting the effectiveness of a specific project, but setting a dynamic baseline may require additional data collection, and if the trend is over- or under-estimated this would also result in a bias in crediting. For either case, setting a baseline is further complicated by the natural variation in agricultural yields – the calculated baseline could be skewed depending on whether growing conditions were unfavourable or favourable over the assessment period. A simple example of static and dynamic baselines is shown in Figure 7. In the example, ten years of randomised fictional yield data are generated, normally distributed about an underlying trend. Notice the differences between the static baseline, the calculated dynamic baseline, and the hypothetical 'real yield trend. In this case, the static baseline based on the average over the previous ten years is below the underlying trend, whereas the dynamic baseline calculated from the trend calculated from ten years of observations is above the underlying trendline.

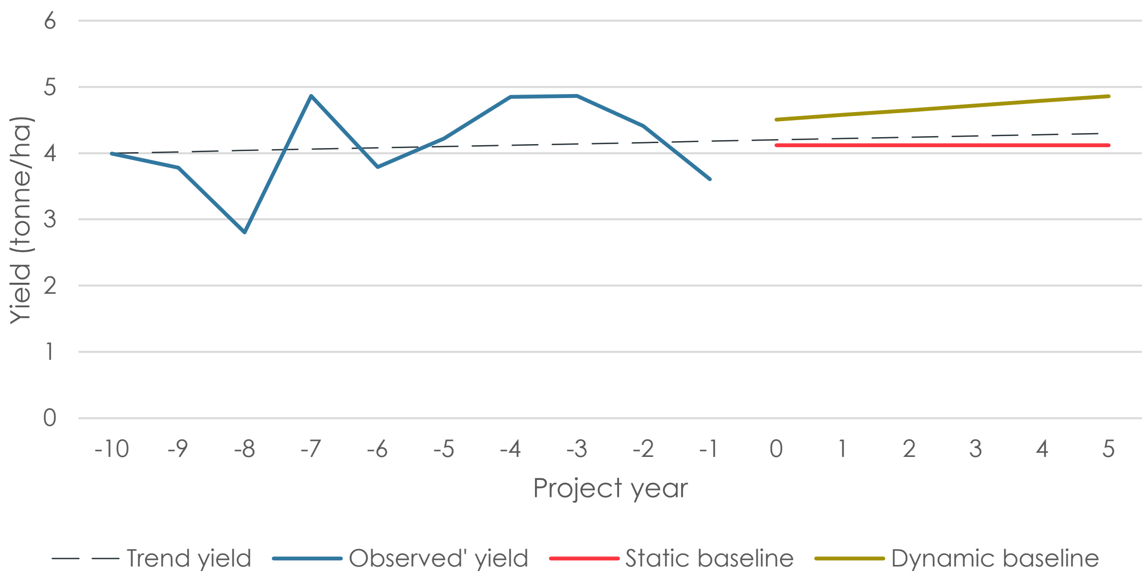


Figure 7. Example of static and dynamic baseline

Source: Randomly generated data with underlying trend yield increase of 0.02 tonnes per ha per year, and standard deviation of 0.5.

4.4. Certification by the Roundtable on Sustainable Biomaterials

Following on from the initial work by Ecofys laying out the low ILUC-risk concept (Dehue et al., 2010, 2009) the Roundtable on Sustainable Biomaterials (RSB) started a process to introduce the low ILUC-risk concept into the RSB standard as an optional certification module, to be used as an addition to certification to the general RSB standard (meaning that only a project able to achieve RSB certification on other sustainability criteria is eligible to attempt low ILUC-risk certification). This represented an important stage in the development of low ILUC-risk methodology, going from a set of principles on paper to an implementable system. The 'low indirect impact biofuel' (LIIB) module, since renamed to 'low ILUC-risk', is based on developing the earlier work by Ecofys into a system designed to be applied on the ground by auditors. The standard became live in 2015 (Roundtable on Sustainable Biomaterials, 2015), and the first certificates were issued in 2018[25]. It is important to recognise that the RSB low ILUC-risk principles and criteria are not a standalone document and are not intended to be used for standalone certification – implementation builds on the main RSB principles and criteria.

The RSB low ILUC-risk standard allows certification for three types of project:

1. Yield increase. The operator demonstrates that additional feedstock for biofuel was produced by increasing the yield on a given land area compared to a reference date.
2. Unused land. The operator demonstrates that feedstock for biofuel was produced on land not previously cultivated or that is not considered arable.
3. Waste and residues. The operator demonstrates that the feedstock for biofuel is produced in an existing supply chain and does not require dedicated land to produce.

The requirements for each project type are detailed briefly below.

4.4.i) Yield increase

For a yield increase project, a management plan must be developed describing the measures to be taken and the expected yield impact of those measures. Yield expectations must be supported with appropriate evidence. The management system in place in the year before project implementation (including fertiliser and pesticide use, rotations, seed varieties and land used) must be documented in detail, and elements of the existing management system cannot be considered for the certification of the yield measure. A baseline yield is to be set based on multiplying the average yield on that farm for the preceding five years by an annual yield growth factor derived for "similar producers" over the preceding ten year period. As we understand it, the baseline yield is static in this methodology – i.e. the yield growth factor is used once to set the baseline yield, but the baseline yield is not inflated year on year. If information for similar producers in the region is not available, the yield growth factor is set at 10% (almost certainly higher than observed annual growth rates). This is characterised as a 'conservative factor'.

The standard includes no explicit requirement that the implementation or success of the yield increase measure should be separately confirmed in order for crediting to continue for the full ten year period, only that recorded yields should exceed the calculated baseline. It is our understanding[26] that the RSB project auditor would be expected to assess compliance with the yield management plan as part of regular audits of the Environmental and Social Management Plan, but this would ideally be clarified in future versions of the documentation. In particular, the documentation does not specify the consequences for low ILUC-risk certificate award if an audit determined that implementation of the yield management plan was unsatisfactory but the recorded yield was still above the calculated baseline.

25 https://rsb.org/wp-content/uploads/2018/05/RSB_RPT_FullEvalReport_UPMUruguay_041918_PUBLIC.pdf

26 Email correspondence with the RSB.

4.4.ii) Unused land

For an unused land project, the land in question must first comply with the standards in the main RSB principles and criteria (for instance for managing conservation values). It must then be demonstrated that the land being farmed was not used for provisioning services for three years preceding the start of the project, and that the land was also not part of a system of 'shifting cultivation' (medium term fallowing). It is also acceptable to use land that had 'limited' provisioning services over the past three years, so long as the value (assessed on an economic, energy or protein basis[27]) of those limited provisioning services was less than a quarter of the value of the new crop, and that those limited provisioning services are either maintained or compensated. All production is then to be certified as low ILUC-risk. There is no reference to the likelihood that the land in question would have been farmed in the absence of the biofuel project, or to whether the agricultural frontier is generally expanding or contracting in the local region.

One of the risks that is often identified in discussions of the potential for biofuel production on 'unused' or 'marginal' land is that such land may already provide services to local populations in a way that may be overlooked (or even wilfully ignored) by project developers. The main RSB standard places obligations on feedstock producers to respect existing land rights and engage properly with affected communities. The rules for low ILUC-risk projects on unused land additionally specify that, "You shall demonstrate that the yield obtained through the limited provisioning services that existed prior to the reference date did not decrease due to the new operations." Given that production of some biofuel feedstocks has been strongly associated with land conflict in the past (e.g. palm oil, Malins, 2010) it would be highly undesirable for a renewed interest in the cultivation of 'unused' land to become a driver of unfair appropriation of local land rights for export oriented businesses. Such an outcome should be prevented by proper implementation of the RSB standard, which includes requirements on free prior and informed consent for local communities. The RED II includes no social requirements, and therefore outside of the RSB framework there would be no active protection of land rights.

4.4.iii) Waste and residues

For waste and residues the standard provides two options. The first requires that the material is identified as a waste or residue in the main RSB standard, and that in the source region the material is 'generally' discarded for landfilling or incineration (excluding energy recovery). Alternatively, it may be demonstrated that the use of the material does not result in indirect GHG emissions or land use increases. All such material may be counted as low ILUC-risk.

4.4.iv) Alternatives to an additionality assessment

While the RSB low ILUC-risk standard is built on the earlier Ecofys work described above, there is a significant shift in the way additionality is considered. Ecofys (2013) explains that, "The LIIB methodology has been developed to be user-friendly and cost-effective, avoiding the need for the operator to provide complex proofs of the 'additionality' of the implemented best practices." The RSB methodology therefore implicitly relies that consideration of other, more

27 The certifier should use the most appropriate comparison – it would not be acceptable for instance to select protein comparison and then replace a productive crop with a low protein fraction with a less productive crop that had a high protein fraction.

easily assessed, characteristics of a project can be treated as a proxy for an additionality assessment. While the desire to reduce certification costs is understandable, on face value the published low ILUC-risk standard has done away with enough additionality safeguards from earlier versions to **create potential free-rider problems in both the yield increase and unused land categories**. This includes removing all the explicit additionality safeguards for these measures that had been proposed in the version 0 draft of the standard (El Takriti et al., 2016). As demonstrated by Searle & Giuntoli (2018), applying a system of low ILUC-risk certification under EU policy that was consistent with the RSB criteria as written could in principle create free-rider opportunities in both the yield increase and unused land categories on the same scale as or larger than total EU demand for the relevant feedstocks. For yield projects this free-rider potential might be somewhat constrained by the fact that in order to be certified low ILUC-risk a farmer would at least be required to present a plausible management plan able to deliver a significant yield improvement – but as it stands the standard is unclear about whether demonstrating successful implementation of this plan should be required before any credits are awarded.

While the potential scale of the free-rider problem within the current RSB methodology appears to be large, it must be acknowledged that this problem has not yet been realised. Indeed, according to the RSB website only one project has been certified to date, a project that appears to be entirely credible. This slow uptake comes, however, in the context that RSB low ILUC-risk certification must be obtained as a supplement to the stringent RSB sustainability certification, and that there is currently no regulatory value in a low ILUC-risk certification. The RSB has few clients producing first generation biofuel feedstocks, and none using the biofuel feedstocks more likely to be characterised as high ILUC-risk (palm oil and soy oil).

Should a low ILUC-risk certification option be adopted by a standard with a larger market penetration (such as the ISCC scheme, which reports certificates for 2,600 supply chain actors working with oil palm derived feedstocks alone[28]), or if a low ILUC-risk certification be developed as a standalone scheme with no associated sustainability and monitoring requirements, the importance of robust additionality measures (and risk of free riders taking advantage of a weak system) would be much greater.

4.5. Proposed low ILUC-risk approach from Ecofys (2016)

In 2016, the European Commission published a report by Ecofys on methodologies for the identification and certification of low ILUC-risk biofuels (Ecofys, 2016), which presented a further development of the idea building on the initial 'Responsible Cultivation Areas' concept and following the operationalisation of the concept by the RSB.

Ecofys (2016) restores some of the emphasis on additionality that disappeared during the development of the RSB standard, asserting that a low ILUC-risk methodology must, "Include a credible calculation methodology of the reference situation and criteria to demonstrate additional production, including on a link between additionality and biofuel demand." While the concept of additionality is firmly embedded in the narrative of this report, the proposed implementation of additionality is very broad. Four options are proposed to allow a project to be classed as additional, only one of which must be demonstrated:

1. A binding biofuel mandate is in place in the region;

28 https://www.iscc-system.org/certificates/all-certificates/

2. More than 50% of target crop production in the region is used for biofuels;
3. A business case for a project only exists due to a biofuel related incentive;
4. Barrier analysis[29].

While the third and fourth of these are broadly consistent with additionality approaches in existing systems such as the CDM, the first two are rather more contentious and go well beyond previous proposals for identifying additionality in terms of breadth of coverage. In particular, under the first condition it seems that all projects in North America, Europe and most of South America and Southeast Asia would qualify as additional automatically due to existing biofuel mandates. This would in practice provide no assurance that projects in those countries truly went beyond a business as usual reference case.

Ecofys (2016) presents low ILUC-risk methodologies for yield increase and unused land, giving a specific sub-category for multi-cropping in addition to the general yield increase category.

4.5.i) Yield increase (general)

The yield increase methodology presented by Ecofys (2016) is similar to the RSB criteria, with a few important variations:

1. There is the explicit application of an additionality test, even if this test is potentially lax (see above).
2. The baseline yield trend is to be based only on the farm or farms being certified, not on a local trend (although group certification is proposed, partly to smooth out variability in yield data).
3. Consequently, the year zero yield baseline should reflect the trend yield on the farm or farms being certified in year zero, rather than the average yield over the past five years.
4. The annual yield increase is treated as following a linear rather than exponential trend, which better reflects historical patterns of yield improvement. The yield achieved by the project is to be compared to a dynamic rather than static baseline.
5. The verification process explicitly includes confirming that the yield increase measure has been implemented.
6. Group rather than individual certification is recommended.

The adjustments to the yield assessment are designed to give a more accurate picture of the amount of feedstock production that can fairly be considered. In this approach, the baseline yield in each year always reflects the 'best guess' based on assessed data for what the yield would have been without the yield project. This differs from the static baseline in the RSB approach.[30] The recommendation for group certification

29 A barrier analysis involves showing that there is some non-financial barrier that would normally be expected to prevent the project from going ahead. This is discussed further in section 4.6.

30 Specifically, by taking a five year average (giving the best estimate of the trend yield three years

4.5.ii) Yield increase through multicropping

The methodology for assessing yield increase through multi-cropping (i.e. harvesting the same land more than once in a given year) introduces the idea of crop-component yields, to allow comparison of systems that have different product portfolios. The requirement thus becomes not to increase yield of a specific crop product (e.g. wheat) but to increase yield of at least one crop component, while maintaining or increasing yields of other components. Components to be assessed are protein, oils and fats, starch and sugar, based on fractional content of those crop components in each of the crops being farmed. Because vegetable oils are considered to have a higher ILUC-risk than other crop components, it is allowable to compensate for a reduction in protein, starch or sugar production by excess oil production, but not the other way round. The low ILUC-risk feedstock quantity is the net increase in production across crop components after compensating for any production reductions.

The analysis of yield trends is analogous to the crop-level analysis, but undertaken at the level of the crop component.

4.5.iii) Unused land

The definition of unused land given by Ecofys (2016) is quite distinct from the RSB definition, specifying only land that has been abandoned from a previous agricultural use and has been unused for at least 5 years. This qualification would significantly curtail the potential size of the free-rider problem for unused land, as areas in regions with an expanding agricultural frontier that are still in a natural state or disturbed by earlier non-agricultural activity such as logging would not qualify. In particular, the large areas of shrubland and grassland (often previously deforested) that are converted to crop production every year in tropical countries would not qualify as unused land under this definition. It is suggested that remote sensing tools should be used to confirm an unused land designation.

Areas of land with limited existing use, as opposed to having had no productive use for at least five years, are excluded from the Ecofys proposal on the basis that, "underutilized land … bears the risk that low-intensity smallholder agriculture may in some cases be regarded as underutilized land, also leading to risks of land grabbing."

4.6. CDM CO_2 offset certification as a template for low ILUC-risk certification

Searle & Giuntoli (2018) discuss in detail the issue of additionality assessment and the risk of creating a large potential free-rider population, and propose developing a certification approach based on using tools developed for the CDM as a way to explicitly assess additionality at the project level, marking a return to the more stringent additionality requirements suggested in Dehue et al. (2009). The CDM Board provides a "Tool for the demonstration and assessment of additionality" (UNFCCC CDM EB, 2012), which was developed in order to allow additionality claims for emissions offset projects under CDM to be robustly assessed.

before a project starts) and adding one year of yield growth to that the RSB sets a baseline that is the best estimate of the trend yield two years before project commencement.

Under the CDM additionality tool, a project proponent is required to undertake the following steps, in order:

1. If appropriate, demonstrate that a project is 'first of its kind'. All first of their kind projects are treated as additional and need not undertake further assessment.

2. Develop several comparison cases involving realistic, regulation-complaint alternatives to the proposed project that would provide the same services or outputs.

3. Undertake investment analysis of the alternatives identified. If the proposed CDM project is less financially attractive than at least one other alternative, then it may be additional. If the proposed CDM project is the most financially attractive option assessed, then a barrier analysis would be necessary to show additionality.

4. If required, after the investment analysis, undertake a barrier analysis. If the project faces barriers would normally prevent implementation of the proposed project activity and would not apply to the alternative cases, and it can be shown that enrolment in the CDM enables the barrier to be overcome, then the project may be additional.

5. The final step is a common practice analysis, as a complement to the investment analysis (and where it has been undertaken the barrier analysis). If other projects of the type proposed are already in effect, then the proponent must document essential distinctions between the proposed project and the existing projects that would explain why the proposed project is less financially viable that existing projects. Unless such distinctions are demonstrated, the project cannot be additional. The common practice analysis is to be understood as a "credibility check to complement the investment analysis or barrier analysis".

The centrepiece of such an approach for low ILUC-risk biofuels certification would be the investment and/or barrier analysis. If a project would normally be expected to receive investment without a market for low ILUC-risk biofuels, and faced no other barriers, then it would not be treated as additional. Searle & Giuntoli (2018) suggest that barriers could include land continuation, if it made feedstock from that land inappropriate for food markets, or colonisation of land by difficult to remove invasive plants (such as *Imperata* grasses in Indonesia).

The advantage of using the CDM additionality assessment tool as the basis for an assessing the additionality of a low ILUC-risk biofuel project is that detailed guidelines are available and the system has been demonstrated in practice. The challenge of applying such a system is that the requirements would represent a larger administrative burden than the less robust requirements used by the RSB or proposed by some other authors. A very rough sense of whether the burden of the CDM approach would be bearable for low ILUC-risk biofuel producers can be found by considering the size of registered CDM projects. For agricultural projects registered between 2005 and 2012 (135 in total[31]) the average reported annual emission reduction according to the CDM database was 81 thousand tonnes of CO_2 per annum. The smallest projects generated about 5 thousand tonnes of CO_2 reductions per annum. Use of biodiesel meeting the RED II emission saving requirements and avoiding ILUC emissions generates roughly 2 tonnes of CO_2 reductions per tonne of biodiesel, so these smaller CDM agriculture projects might be considered to be of a comparable scale to a project producing 2,500 tonnes of certified

31 Cf. https://cdm.unfccc.int/Projects/projsearch.html

low ILUC-risk biofuel per annum. For palm oil, that would represent a 600 hectare plantation for an unused land project – a relatively small plantation. For a productivity increase project, where only a fraction of production can be certified as low ILUC-risk, the comparable project size would be rather larger though. For a project improving rapeseed yields by 5%, 40,000 hectares of production would be required to deliver 5,000 tonnes of biodiesel. This would require coordination across a large number of farms, but would be consistent with the size of the supply catchment for existing biofuel facilities. Ecofys (2016) proposes that yield increase projects should be applied at the level of a group of farmers, for instance coordinated through a commodity trader or biomass collector. A project able to deliver a larger incremental yield gain would not need to cover such a large area to achieve the same scale of low ILUC-risk feedstock production.

4.7. Proposals for regional low ILUC-risk certification

The larger part of previous work on low ILUC-risk biofuel production has been focused at the project level – identifying that feedstock production due to a specific innovation by a single operator or a small group of operators is additional. There has also however been some consideration of whether it would be possible to identify low ILUC-risk biofuel production at a regional level. Proposed regional low ILUC-risk assessments include:

- Dehue et al. (2009) considers whether EU wheat could be considered low ILUC-risk due to co-product generation, concluding that the evidence available was not adequate to draw that conclusion.
- Brinkman, Wicke, Gerssen-Gondelach, van der Laan, & Faaij (2015) presents a methodology intended for application at a regional level.
- At the European Commission's stakeholder workshop on low and high ILUC-risk biofuel definitions, a case was presented that palm oil from Colombia should be considered as low ILUC-risk due to having a different land use profile than Southeast Asian palm oil.

The first point to make regarding regional approaches to low ILUC-risk biofuels is a reminder that **there is a difference between biofuels that are expected to have a relatively low ILUC emission based on modelling or other similar analysis, and biofuel feedstock that can be certified as low ILUC-risk** due to the avoiding displacement of existing uses of material. It is clear that the RED II definition of low ILUC-risk material applies only to the second case. Low ILUC-risk certification is not available to fuels with low modelled ILUC emissions, and therefore certainly should not be available to fuels based on a narrative case that they might have low ILUC emissions if those emissions were modelled.

This would preclude, for instance, the certification of wheat ethanol as discussed in Dehue et al. (2009), as the argument for low ILUC-risk status is based on co-product generation, which is already assessed in ILUC modelling. Similarly, this would preclude providing low ILUC-risk status to biofuel feedstock from a given region simply because it has been modelled as having lower ILUC emissions than the global average; or indeed because it seems plausible that if modelled a lower ILUC factor would be calculated, as has been argued for oil palm in Colombia. The basis for the Colombian argument is that there is much less of a direct deforestation link for oil palm in Colombia than the global average, which appears to be true (Furumo & Aide, 2017; Meijaard, E., Garcia-Ulloa, J., Sheil, D., Wich, S.A., Carlson, K.M., Juffe-Bignoli, D., and Brooks, 2018). However, this argument fails to recognise the connectivity of the global market. If the EU preferentially imported all exported Colombian palm oil, then Colombia's current customers would need to look elsewhere. This would be likely to result in increased Malaysian and Indonesian exports to those other countries, and similar ILUC outcomes to those associated with importing palm oil from Malaysia and Indonesia directly. Actually avoiding ILUC would require not just cherry picking Colombian palm oil, but for EU biofuel demand to drive new oil palm projects in Colombia on appropriate unused land. Far better to assess these for additionality at the project level against the criteria detailed in this report, than to provide blanket regional exceptions that shuffle the palm oil trade without actually reducing ILUC.

The case studies presented by Brinkman et al. (2015) present a more interesting regional vision, as they provide detailed descriptions of a set of actions that could be taken at a regional level to allow low ILUC-risk characterisation. These include fairly high level governmental actions. For instance, the Polish case study includes:

- Evaluate options for land ownership reforms and provide financial support to facilitate it
- Provide alternatives for employment in the agricultural sector
- Stimulate sustainable intensification of the agricultural sector
- Increased food chain efficiency - improve insight in size and causes of food losses

The difficulty in the Brinkman et al. (2015) vision is highlighted by Malins (2015) which notes that, "intensification of agriculture is something that most governments would support – but if it isn't already happening, there are generally reasons why it isn't."

It is difficult in practice to imagine the European Union holding a national or regional government to account through biofuel policy for the implementation of the type of broad agricultural productivity actions detailed by the Brinkman et al. (2015) case studies. As concluded by Malins (2015), "To implement incentives for these types of government action through the RED, you would need a European framework that identifies the actions that could reduce ILUC, that requires implementation plans to be submitted by the appropriate regulatory authorities, that would ideally also require explicit buy-in from local stakeholders, that involves ongoing monitoring to ensure that productivity goals are being successfully delivered, and that has systems in place to deal with any failure to deliver on yield targets." While the possibility of should not be permanently ruled out, no framework for such an engagement is provided by the RED II, which envisions low ILUC-risk certification being handled through private schemes.

4.8. Yield increase and yield variability – illustrations

In existing approaches for certifying low ILUC-risk feedstock from yield increases, the basic process is to validate a project plan, and then certify biofuel production based on comparison of actual achieved yields against a baseline yield prediction. Such approaches suffer from various difficulties arising due to normal weather-influenced yield variation. Annual yield variations due to weather will often be larger than any annual marginal yield increase resulting from a given low ILUC-risk project activity. For a crediting system based on comparing reported yield to some yield baseline, this could result in over-crediting in years with good weather and under-crediting in years with poor weather.

It is hard to overstate how important the challenge of setting an appropriate yield baseline

based on variable observed data is. Given normal variability in agricultural yields, it is simply not possible to define an accurate baseline yield at the field level. Any comparison of observed yields after a project has been implemented to an inaccurate baseline will either over- or under-estimate benefits. **The difficulty of making a meaningful comparison between observed yields after a project has been implemented and a baseline calculated on limited historical data has often not been adequately recognized in previous literature on this subject**, but is fundamental to designing a practical system of certification.

In order to illustrate this point, Annex B provides two examples, one using real corn yield data from several U.S. counties, and a second using numerically generated example yields based on a probability distribution. Any reader not convinced of the importance of considering yield variability when designing a system to credit yield increase projects is strongly recommended to work through these examples!

4.9. Characteristics of a robust low ILUC-risk certification

It is, arguably, rather easier to point out difficulties in proposed schemes (see above from section 4.3 onwards) to identify low ILUC-risk biofuels than to propose a system that is immune to such criticisms. In the next chapter, an outline and set of assessment criteria for such a scheme are proposed. Before detailing this proposed scheme, however, it is useful briefly to lay out the characteristics that any low ILUC-risk certification scheme ought to meet in order to be robust.

These characteristics are presented below, in order of importance:

1. **The number of potential free-riders must be limited.** The cost of **c**ertification alone will always be less than the cost of certification coupled to real investments. Any system in which the free rider problem is large would allow environmentally problematic projects to escape regulatory restrictions, while destroying incentives for genuine projects. It would be preferable to have an over-stringent system that resulted in smaller numbers of genuine projects than to have an ineffective system that undermined environmental protection and supported no genuine projects at all.
2. **Using feedstock from certified projects must reduce the overall risk of displacement of commodity in the system**. In order to deliver environmental benefits, low ILUC-risk certification should certify projects that deliver genuine reductions in displacement impact. It must not only avoid free-riders, but also distinguish between investments that are effective at avoiding displacement by ensuring the additionality of production, and those that are not.
3. **Direct emissions associated with low ILUC-risk projects should be assessed.** Some low ILUC-risk projects may result in additional direct emissions, for instance from carbon stock change after unused land conversion or from increasing fertiliser application to improve yields. Where new practices are likely to materially affect direct GHG emissions, an actual GHG intensity calculation should be performed based on the LCA rules in the RED II.
4. **Any methodology for identifying ‘unused’ land should respect the rights and access of any existing low intensity land-users.** In many cases, in particular in the developing world, land that delivers apparently low economic value may still play an important

role in the livelihoods of local communities. Project planning should be based on free, prior and informed consent of affected communities and provide compensation for any lost access where appropriate.

5. **Any methodology for identifying and certifying delivered yield increases should recognise the role of normal annual yield variability.** Annual variation in yield due to weather and other external factors will often be larger than any variation from trend yield due to a yield increase measure. Ideally, a low ILUC-risk certification scheme would seek to avoid over- or under- crediting producers due to external factors beyond their control, such as local weather.

6. **Any methodology for identifying 'unused' land should aim to preserve existing ecosystem services.** Land that has no or limited economic value may often provide significant wildlife value and/or important ecosystem services. Any potential damage to wildlife or ecosystem services must be taken into account when determining eligibility, and weighed against potential benefits from the change in land use. This might involve the application of principles from existing sustainability standards such as RSB.

7. **Any methodology for identifying and certifying delivered yield increases should be appropriate to both annual and perennial crops.** In addition to the normal yield variation seen in annual crops, perennial crops will generally be subject to somewhat predictable changes in yields related to time since planting. Low ILUC-risk certification schemes ought to be sensitive to this difference if certification of yield projects is to be enabled for perennial crops.

Of these system characteristics, the first two are absolutely necessary (but may not be sufficient) for a functioning system able to meet its basic goals. Any system that is beset with free riders or that cannot provide an adequate demonstration that displacement effects are avoided will fail to meet its goals. A scheme that falls short on the other characteristics may be able to identify low ILUC-risk projects, but will suffer from limitations such as under- or over-crediting of feedstock production, being unfair to some project developers or resulting in unwanted externalities.

We believe that the scheme proposed below in Chapter 5 has these characteristics. It is assumed that in all cases in addition to any low ILUC-risk criteria, biofuels supplied in the EU will be expected to meet the mandatory sustainability requirements defined in the RED II.

5. A new outline approach for low ILUC-risk projects

A set of criteria for identifying low ILUC-risk projects is proposed in which crediting for yield improvement projects would be based partly on assessing the success of implementation, rather than only on observed yields. The CDM additionality tool is proposed as the preferred additionality approach, but project-type specific proxy additionality rules are suggested as lower-burden alternatives.

Based on the principles above, and on review of previous proposals for low ILUC-risk systems, we have developed the following outline proposal for criteria for low ILUC-risk certification that we believe could be an appropriate basis for the definition of low ILUC-risk certification criteria in a delegated act of the European Commission. While this paper is developed specifically with reference to the EU policy situation, it is our hope that the principles and criteria outlined would also be applicable to the identification of low ILUC-risk biofuels in other policy contexts.

The approach detailed below is intended to apply to projects for low ILUC-risk biofuels from crops. One might also design a system to certify residues and wastes as low ILUC-risk feedstock based on showing that utilizing them did not cause indirect impacts (cf. Malins, 2017c), but that is outside of the scope of the low ILUC-risk concept as defined in the RED II and therefore not considered here.

We have provided outline principles for three low ILUC-risk cases:

1. Increased yield for a single crop;
2. Increased overall productivity for a combination of crops and/or livestock;
3. Utilisation of land otherwise unlikely to be brought into (or back into) production.

Increasing productivity and bringing new land into production carries some degree of sustainability risk, as does any agricultural production. If a low ILUC-risk assessment is coupled to broader sustainability principles, as it is in the RSB, these risks can be directly managed. In the RED II, the mandatory sustainability criteria only deal with a few specific risks (prohibiting conversion of specific high carbon stock and highly biodiverse areas, and requiring assessment of land use change emissions). Implementation of low ILUC-risk certification through broader existing sustainability standards such as the RSB may allow additional assurance on the overall sustainability of credited low ILUC-risk projects.

As discussed above, demonstrating that displacement has been avoided by a low ILUC-risk feedstock project requires that the feedstock production in the project is additional. The most direct way to ensure additionality for any of the projects discussed would be to apply the type of assessment required by the "Tool for the demonstration and assessment of additionality" of the CDM (referred to below as the 'CDM Tool' for brevity), in which claims of additionality must be based on either being a first of a kind project, on an investment test or on a barrier analysis. In practice, this could be implemented within a scheme either by requiring certifiers to use the

CDM Tool directly[32] or by a scheme publishing comparable requirements specifically tailored to low ILUC-risk certification. This type of additionality assessment is proposed by Dehue et al. (2009) and Searle & Giuntoli (2018).

Such a direct additionality assessment **is the most robust way to ensure that displacement is indeed avoided**, but may in some cases be considered somewhat burdensome. In the sections below we therefore also discuss possible approaches for proxy assessment of additionality (criteria for a project that would imply that it *probably* resulted in additional production). Such proxy approaches could be allowed in order to reduce compliance costs, but on the understanding that any weakening of the additionality requirements must be done with caution, and would increase the risk of free-rider projects being certified.

5.1. Increased yield for a single crop

Increasing yield is one of the most often quote examples of a measure to reduce ILUC impacts from biofuel use, but demonstrating that a given set of actions actually improve yields is not a trivial task. As discussed above and demonstrated with examples in Annex B, **approaches for crediting yield increase projects that rely entirely on observed yields as a basis for issuing credits will inevitably result in over-crediting in years with favourable conditions (primarily weather) and under-crediting in years with unfavourable conditions**[33], and the amount of feedstock identified as low ILUC-risk will be sensitive to the method for baseline setting. These measurement issues will occur regardless of whether project implementation is successful. Such approaches also create a free-rider risk – if the success of projects is assessed only by recorded yields, it becomes possible for a project that has not been sustained, or that has failed, to still generate credits in years when favourable conditions lead to above-average yields. The dramatic differences in potential credit award demonstrated for different baseline setting approaches in Annex B demonstrate that it is not possible to implement a satisfactory crediting system where credit award is based solely on the difference between a measured yield and a baseline yield. As an alternative, we therefore propose a system in which crediting is based on a combination of expected project benefits (based on auditing whether the yield improvement plan is successfully implemented) and on delivered yield results.

5.1.i) Crediting project implementation

Providing credits on the basis of expected benefits puts additional importance on undertaking a thorough review of the viability of the yield improvements anticipated in the yield management plan. The RSB standard provides several suggestion for demonstrating that a yield management plan has reasonable expectations,

> *"The expected yield increase of the intended measures can for instance be demonstrated by reference to scientific literature, experience from field trials, information from breeders or simple calculations (e.g. reduced number of tram lines*

32 With some leeway allowed to accommodate the differences between the CO_2 offset projects it is designed for and low ILUC-risk feedstock projects.

33 This statement should be taken with the caveat that it may in future be possible to use project specific yield modelling based on local agronomic conditions and known weather to calculate a much more sophisticated yield baseline – such approaches are not considered viable for implementation within a certification scheme at this time and are therefore not considered further.

due to increased operation width of field sprayer leads to higher yields in the same field).”

If satisfactory evidence is not available to validate the expected yield increase, then a project could not be certified.

Following validation of the expected benefits, this approach **requires ongoing auditing to show that a project has been implemented and sustained**. For instance, if the yield increase plan required switching to a new seed variety, use of that variety would need to be documented. If the yield increase plan involved a revised fertilisation regime, documentation of fertiliser purchases would be required to show that the new regime was being applied. It is suggested that implementation should be audited after the first year, and again every three years. In the case of group certification with a number of producers, it might be appropriate to use a sampling approach to reduce the overall administrative burden. This would need to be accompanied by dissuasive penalties and loss of certification in cases where sampling showed non-implementation.

The advantage of crediting based on project implementation rather than reported yields is that it avoids the variability problem. The potential disadvantage of such an approach is that it could result in persistent crediting of projects that were ill conceived, and does not create an ongoing incentive to yield maximisation. It is therefore suggested that **part of credit issue should continue to be tied to observed yield performance**. There is no ‘correct’ answer as to how the balance should be set between crediting implementation of the yield improvement plan and crediting of observed yields, except that the award of credits for each element should be enough to provide a meaningful incentive. We would therefore suggest that at a minimum 30% of crediting should be based on each of the two assessments – enough credit given for yield plan implementation to provide a return even in years with disappointing yields, but enough credit for observed yields that the incentive to maximise yield improvements remains intact.

For the proposal here we suggest that the fraction issued based on implementation could be set at 50% of the expected low ILUC-risk feedstock generation identified in the project plan. The remainder of credit issue would then be tied to observed yield.

Providing 50% of crediting each year without reference to realised yields would make credit issue more predictable and provide several benefits to project participants. Predictability will make it more viable to base investment decisions on future crediting, and should allow more ambitious projects to be developed. It would also reduce the correlation between annual crop sale income and credit income, so that credit income would not be cut off in years when farmers were already suffering from poor financial performance.

The imposition of an additional audit requirement (to demonstrate that the actions described in the project plan had been effectively implemented and had been sustained) is central to this approach. If robustly implemented, this audit check should eliminate the free-rider potential for this type of project, as only farms where real yield improvement measures are taken would pass the audit. Regular oversight should also help reduce fraud risk. Should it be determined that implementation of the yield increase project had ceased or failed, crediting should be cancelled, either pending resubmission of a new project plan or else pending demonstration of successful project implementation and above trend yield performance.

5.1.ii) Crediting project outcomes

Beyond the automatic annual credit award, additional credits would be rewardable based on comparing reported yields to a calculated yield trend (similar to the process under the RSB or Ecofys, 2016, methodologies). This additional crediting would be limited to be consistent with the expected yield increase from the management plan, thereby avoiding the case that a project only realistically able to deliver 0.5 tonnes per hectare of yield improvement could be awarded low ILUC-risk status for 1.5 tonnes per hectare of feedstock production (possible under the RSB rules). Additional credit would be given for 50% of the yield realised over the trend yield. In order to allow for over-performance and to balance years in which yields were poor, the maximum awardable low ILUC-risk feedstock production could be set slightly above the projected benefit from the yield management plan (for instance up to 120% of the intended level).

As an additional control, a project review could be undertaken at the end of the fourth year (the second implementation audit) to compare overall yield performance across the four years to a calculated yield trend. For projects systematically failing to realise yield improvement against the trend and unable to explain this poor performance, it might be appropriate to reduce the minimum annual credit level for the remainder of the project period, for instance to 20% of expected low ILUC-risk feedstock production.

5.1.iii) Example using new methodology on fictional project data

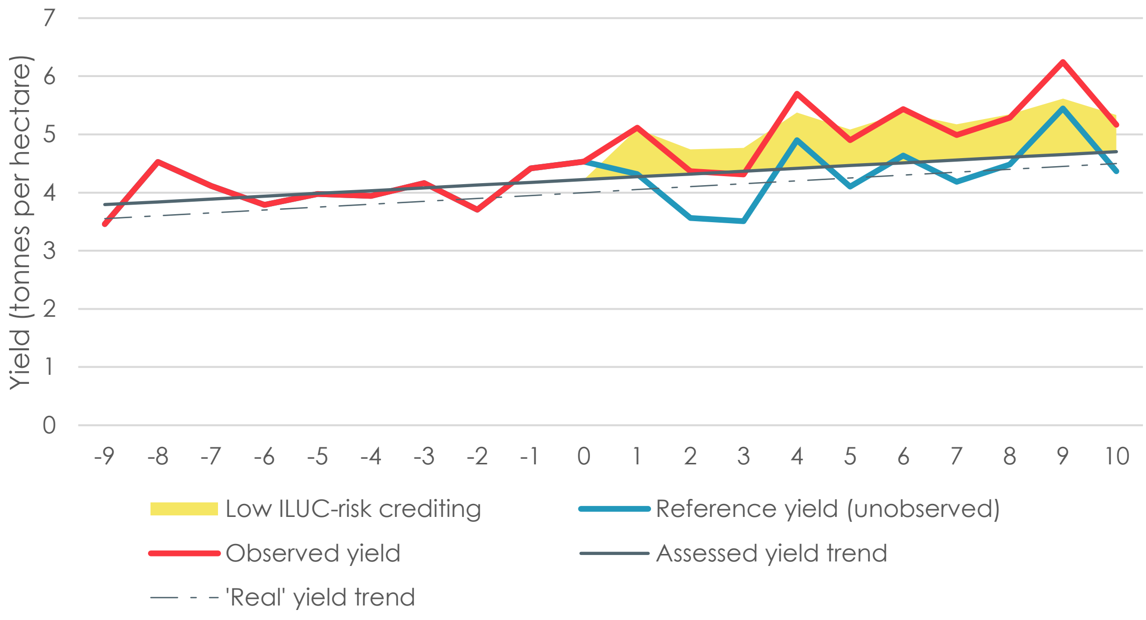


Figure 8. Low ILUC-risk crediting under alternative methodology

The result of applying this system for the first fictional example project described in Annex B.2 is shown in Figure 8. When assessed against the Ecofys (2016) methodology, the project (which we know by hypothesis delivers a 0.8 tonne per hectare yield improvement) resulted in only 0.67 tonnes per hectare per year of low ILUC-risk feedstock production being credited – but with annual credit award ranging from 0 to 1.6 tonnes per hectare. Using the alternative methodology would result in an average of 0.7 tonnes per hectare of feedstock being certified (slightly closer to the 'real' performance of the project), with annual credit awards varying between 0.4 and 0.96 tonnes per hectare, thus providing a more reliable revenue stream for the project operator.

The new methodology shows a greater advantage for the second and third cases discussed in that section of the Annex (in the second case the project delivers the same real yield benefit of 0.8 tonnes per hectare per year but due to favourable variability receives 1.3 tonnes per hectare per year of low ILUC-risk certification under the Ecofys methodology, while in the third case the project delivers the same real yield benefit of 0.8 tonnes per hectare per year but due to unfavourable variability is credited for only 0.2 tonnes per hectare per year). The revised methodology delivers 0.9 tonnes of credits per hectare per year to the project in the second case, and 0.5 tonnes of credits per hectare per year in the third case. In all three cases, the proposed methodology delivers crediting that is closer to the 'real' yield improvement than crediting based on the Ecofys methodology would, with less annual variation in credit award.

5.1.iv) Yield baseline

For the yield baseline assessment, we propose a calculation using elements of both the RSB and Ecofys (2016) methodologies. To set the baseline yield in year zero on the farm or farms to be certified, we would suggest following the Ecofys approach – identifying a trend based on least squares analysis of the most recent ten years of production data, and setting the 'year zero' baseline yield consistent with that trend. The project certifier should be allowed a certain amount of leeway in this exercise – for instance, if there is evidence in the data of a discontinuous yield increase during the previous ten years, it might not be appropriate to draw a trend line through the full period. There should also be an accommodation for farmers without ten years of data.

As well as determining the year zero baseline yield, a yield trend should be assessed. As illustrated above, setting a realistic yield trend may be undermined by variable yields and the choice of period. It is suggested that the trend should be set based on regional or national data, rather than based on data for the local farm or group of farms. Steps could be taken to reduce the influence of variability in the calculated yield trend, such as by discarding the lowest and highest yields reported in the dataset from the calculation, and by setting limits on minimum and maximum yield growth in the trend calculation. The minimum rate could be set at zero (so yield decay would never be assumed in the baseline). It might also be appropriate to set a maximum trend yield increase based on analysis of longer term trends, for instance at no more than three times the thirty year rate of yield growth reported for a given crop at the national level.

The baseline yield Y for year N of project implementation should then be set as:

$$\mathrm{Y}_{\mathrm{baseline,t=x}} = \mathrm{Y}_{\mathrm{baseline,t=0}} + \mathrm{N} \times \Delta\mathrm{Y},$$

where $\Delta\mathrm{Y}$ is the annual trend yield increase.

For the case of a yield improvement project for a perennial crop, the task of baseline setting is complicated by yield evolution through the life of the plantation. For oil palm, for instance, the first crop will be taken several years after planting, yields will then reach a peak some years later, which will be maintained for about a decade before yields start to decline significantly, as illustrated in Figure 9. Clearly in this case it would not be appropriate to compare yield in a given year of plantation development to an industry average (regional or otherwise). For perennial crops, it will therefore be necessary to develop a yield baseline that includes a fair characterisation of the normal rate of yield development by plantation age, scaled to be locally appropriate.

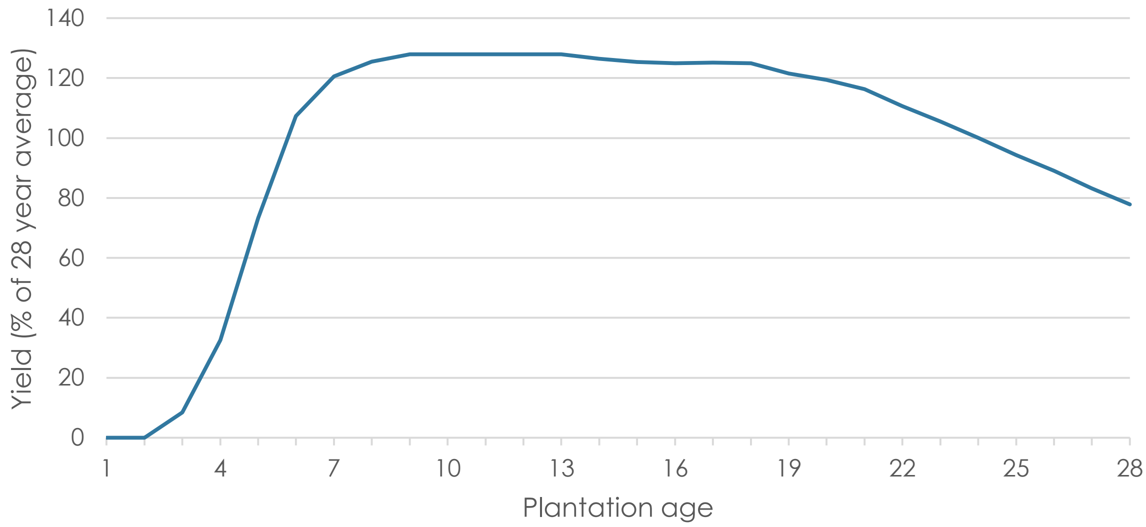


Figure 9. Illustration of yield development for an oil palm plantation

Source: (Ling, 2012)

5.1.v) An alternative additionality approach for yield increase projects

The approach detailed above ought to limit the free-rider potential for yield increase projects by ensuring that all certified projects have taken some kind of yield improvement actions, but this alone does not guarantee true additionality. Farms all over the world regularly undertake yield improvement actions, and simply certifying such business as usual investments would not be enough to reduce ILUC. The most direct way to ensure additionality for yield projects would be to apply the type of investment test/barrier analysis used in the CDM system and proposed by Dehue et al. (2009) and Searle & Giuntoli (2018). This would be a robust approach, but of course comes with an administrative overhead, and as noted above (section 4.6) would potentially require coordination across a number of farms to deliver an appropriate project scale to support certification.

As noted above, Ecofys (2016) suggests a relaxed system of proxy additionality assessment, relying on the existence of a local biofuel mandate or of largescale biofuel demand for a given feedstock to claim that biofuel demand is the driver of investments. Neither of these measures is adequately robust or restrictive to provide confidence, as between them they would automatically qualify a large fraction of global agriculture. This said, there may be some merit in the underlying premise that yield increase is most likely to be additional when there is a clear link between production and biofuel demand. An analogous but much stronger requirement might therefore be proposed, which would show that there was a direct connection between a low ILUC-risk project and a specific biofuel producers. Demonstrating such a connection would make it much more reasonable to believe that yield improvements actions are taken in response to biofuel demand, and with a view to low ILUC-risk biofuel production.

Such a connection could be demonstrated by requiring documentation as part of the project plan showing a commitment in principle by the specific biofuel facility to take delivery of any produced low ILUC-risk feedstock from the project. With such documentation, it would be clear that there was a direct link from the biofuel market to the decision to implement the yield improvement measure. The requirement for such documentation could be complemented by requiring a segregated physical supply chain from the project (farm or group of farms) to a known biofuel facility. This combination of a statement of intent at the planning stage and physical delivery of the produced material to a specified biofuel facility would require the creation of a direct relationship between farm and biofuel producer, increasing the potential for positive engagement by the biofuel producer to support yield improvement, and would reduce the potential for business-as-usual yield increase to be certified over a very wide area resulting in large volumes of free-rider certified fuel. The use of segregated supply chains can result in increased supply chain costs when imposed over long distances, but may not impose any significant additional costs for farms and biofuel facilities collaborating locally.

As a third element of this alternative approach to additionality, we suggest that a common practice analysis should be required (based on the requirement of the CDM Tool). This would involve demonstrating that the yield improvement measure proposed was either not common practice in the local region, or that there were particular characteristics of the project being certified that made the yield improvement measure less appealing than on other farms locally. This would prevent yield improvement measures that had already been widely adopted from being certifiable as low ILUC-risk, further limiting the free-rider potential.

The main free-rider risk that could not be dealt with under this alternative additionality approach would be that farmers already geographically close to or already supplying biofuel facilities could register business as usual yield improvements as low ILUC-risk projects.

5.2. Increased overall productivity by adding an additional crop to an existing crops and/or livestock system

Displacement of existing feedstock use can also be avoided by the implementation of systems that increase productivity by adding an additional crop to an existing production system (i.e. growing two or more crops or combining a crop and a livestock system). These projects can be divided into two groups: those where feedstock production for the added crop is strictly additional to pre-existing production; and those where production of the new crop results in a marginal reduction in productivity of the existing system which must be offset.

5.2.i) Feedstock production strictly additional to an existing system

In the simplest case, the project would aim to produce a new supply of biofuel feedstock strictly in addition to production of any other materials already being produced. An example of this type of project is provided for cattle-sugarcane integration by Dehue et al. (2009). Another example would be growing an additional cover crop between main crops without interfering with the existing planting and harvest cycle. In such a case, all biofuel feedstock production should be certifiable providing that the production of the previous materials is shown to be maintained. Audit should be undertaken after one year of project implementation and every three years thereafter to confirm that the productivity of the existing system is not negatively affected. It would be appropriate to allow some leeway on this, allowing for a normal level of variability in delivered productivity for the system in question. Should productivity of the existing system be seen to have been systematically reduced, crediting for the project should be cancelled.

5.2.ii) An alternative additionality approach for adding an additional crop without affecting productivity of the existing system

As with yield increase projects, the most direct way to approach additionality would be through the use of the CDM Tool. For projects that involve introducing an additional crop, a less burdensome (but less robust) alternative could be considered based on rewarding early adopters of new multicropping options by reducing the full additionality test to only a common practice analysis. A project could pass this test if the agricultural practice being implemented was not yet widely used in that region.

It seems reasonable to believe that where a new practice not common in the region is introduced by an operator aiming for low ILUC-risk certification then that project may not have occurred without the possibility of certification, and is likely to be additional.

The main free-rider risk that could not be dealt with under this alternative additionality approach is that a new practice that would have been adopted even without the low ILUC-risk biofuel market would be certified. The risk of certifying projects that would have occurred anyway would be somewhat offset by the potential to spur adoption of a sustainable productivity improvement by other local farmers. Also, beyond a certain level of deployment in a region, a given project type could no longer pass the common practice assessment, and so this approach would naturally limit the free-rider potential for any given project type.

5.2.iii) Feedstock production involving trade-offs with existing system

The second case of integrated production would involve a more fundamental change in outputs from the existing system. This would be the case, for instance, if multicropping was expected to lead to an absolute reduction in yield for a main crop, but more than compensate for this through the yield of the second crop. In such cases, Ecofys (2016) suggests assessing production on a crop-component basis (oils and fats, protein, sugars, starch) and allowing increase in absolute production of one crop **component** to be certified as low ILUC-risk provided production of the other components is either maintained or increased). For instance, if adding a second crop to a corn production system resulted in an increase in overall annual starch production, then the net increase in produced starch could be eligible to be treated as low ILUC-risk feedstock for ethanol production.

When considering increases on a crop-component basis, attention should be paid to the hierarchy of nutritional/financial value of crop components. The value hierarchy among the components considered (from highest to lowest) is: oils and fats; protein; sugars; starch. Production of higher value components earlier in the list should be allowed to compensate production of lower value components later in the list on a mass basis, but not the other way round (so for example an increase in oil production at the expense of starch production would be permitted, but an increase in sugar production at the expense of protein production would not). This methodology should not be applied at all to cases where production of a fruit or vegetable crop is reduced due to the addition of a biofuel feedstock crop.

Crediting for such a system should be analogous to crediting for a yield increase project as described above. A management plan should be developed detailing and justifying the expected overall productivity gain. Some fraction (for instance a half) of the expected productivity improvement should be credited based on demonstrating that the project action has been taken and sustained (with audits after one year and then every three years). The remainder of the credits should be subject to demonstrating both that there is an above baseline actual yield improvement for the feedstock crop component in question and that the yield of other crop components has been maintained or increased.

5.2.iv) An alternative additionality approach for adding an additional crop in a way that affects the yield of the existing system

For this type of system, it is suggested that the same alternative additionality assessment could be appropriate as detailed for single-crop yield increase projects. That would mean a statement of intent from a biofuel producer to take delivery of produced certified low ILUC-risk feedstock, a segregated supply chain from farm to facility once production commences, and a common practice analysis based on the CDM Tool.

Similarly to the case for proxy additionality for single-crop yield increase projects, the main free-rider risk under this alternative assessment would be that projects that would have happened anyway would be certified.

5.3. Utilisation of unused land otherwise unlikely to be brought into production

For the case of unused land, it is vital that the definition of 'unused' should reflect not only the status in the year immediately before project implementation, but a broader consideration of whether the land would be likely to remain unused in the reference case. Without such a mechanism the low ILUC-risk certification scheme could create a very large free-rider potential, as discussed by Dehue et al. (2010) and Searle & Giuntoli (2018). Ecofys (2016) deals with this by limiting the definition of unused land to include only land previously abandoned from agricultural use. While this falls short of a formal additionality analysis, it certainly significantly reduces the potential free-rider opportunity by excluding projects on any land with no history of cultivation, and therefore excluding new land on the agricultural frontier in the developing world. While the Ecofys (2016) approach has merit in this regard, it may be unduly limiting. For instance, this definition would largely rule out the *Imperata* grassland projects suggested by Dehue et al. (2009).

For the case of a region where the dominant trend is agricultural shrinkage, the definitions for unused land from Ecofys (2016) provide a good starting point – a "plot of land which is **not under cultivation because of biophysical or socioeconomic limitations and not used for other provisioning services currently and during the past 5 years**, with low carbon stocks and limited biodiversity value." To this should be added the criterion from the RSB standard that shifting cultivation is not being practiced on the site with a fallow period of over five years. As in the Ecofys and RSB methodologies, we suggest that it could be appropriate to allow certification of areas where low level provisioning services have previously been supplied, on the condition that such provisioning services are either maintained or replaced by appropriate alternatives. Certifiers should be conservative on this point in order to protect the rights and access of local communities (the RSB low ILUC-risk criteria provide an example for implementation of this principle[34], and the general RSB standard provides an example of requirements for free, prior and informed consent from local communities).

For regions where the overall agricultural trend is one of expansion onto new land, a slightly expanded unused land definition would be appropriate, including also a requirement to document that there is a 'large' (compared to annual rates of agricultural expansion) supply of potentially available land in the region in question that would normally be considered more suitable for agricultural expansion.

For such unused land projects, 100% of the feedstock produced would be eligible to be certified as low ILUC-risk (providing any pre-existing provisioning services had been compensated). For both project types, additionality could then be demonstrated using the principles of the CDM Tool.

5.3.i) An alternative additionality approach for unused land projects

While the CDM additionality approach again represents the most direct and robust option, for projects on formerly abandoned land a streamlined alternative might be considered. For projects in regions that are experiencing agricultural shrinkage and that are sited on previously abandoned land[35] the proxy additionality criteria would be that a regulatory surplus analysis should be undertaken (i.e. require it to be confirmed that there is no regulatory requirement to farm the land) coupled to a demonstration either that the local region includes relatively large areas of available land in more favourable conditions. In this case, it can reasonably concluded that use of this parcel of land would not be likely to happen in a business as usual scenario.

For regions where the overall agricultural trend is one of expansion onto new land, the risk of free-rider projects would be very great if any proxy additionality requirement was implemented, so it is recommended that a full CDM Tool assessment should always be required. The application of the tool could potentially be streamlined for operators by approving unused land project types by region at the level of the certification scheme, rather than by undertaking

34 "You shall obtain available data on land use during the three years preceding the reference date. In the EU, information should be available from the plot growing cadastre for farmers' cross-compliance applications. In addition to this data gathering it is important to perform interviews with the (previous) land owner or tenant and other local people/ local authorities. Such interviews are crucial when limited or no data are available. Supporting evidence could come from satellite images from the three previous growing seasons."

35 Defined as land for which there is evidence available of former cultivation within the last 40 years."

the full analysis for every project. Where the scheme operator had identified that a certain project type faced a barrier in a region and therefore was likely to be additional, the project auditor would have only to determine whether a proposed project was a good example of that approved project type. This would also allow the certifier to be given guidance by a scheme operator appropriate to the project type being considered, and more sensitive to local considerations than is possible in generalised guidance.

5.4. Proposed high level criteria for certifying low ILUC-risk biofuel projects

In this section, we briefly set out proposed criteria for three types of low ILUC-risk project, intended to be comparable to the criteria used in the RSB low ILUC-risk standard. Implementation of these criteria, as with criteria in any sustainability assessment, would require the definition of specific indicators and the development of guidance for verifiers. In the following sections (5.1 - 5.3) a more detailed discussion and explanation of these criteria is provided for each project type. Section 5.4 and Annex C then suggest a form of language that might be used to introduce these criteria into the RED II legal framework through a delegated act.

The criteria suggested below include the alternative additionality assessments detailed above as options for additionality demonstration, identified as optional by italicisation. Offering such streamlined additionality options may reduce the implementation burden for some project operators, but would increase the risk of certifying ‘false positives’ (free-rider projects).

5.4.i) General criteria

1. Any scheme to certify low ILUC-risk fuels must enforce a rigorous set of criteria and indicators that provide adequate assurance that displacement effects associated with biofuel use are avoided by certified projects.
2. The scheme requirements should include requirements for appropriately qualified validators of the project plan and verifiers of delivered low ILUC-risk feedstock quantities.
3. Any scheme to certify low ILUC-risk fuels must have clearly defined procedures to be applied in the case that a low ILUC-risk biofuel project is found in verification to be in any way non-compliant with the requirements of the scheme, including dissuasive penalties to be applied where appropriate.
4. Displacement effects are avoided when a project delivers additional feedstock production against a business as usual baseline, without reducing other provisioning or ecosystem services from the land in question.
5. Any low ILUC-risk project must be detailed in a management plan prepared by the project operator.
6. Low ILUC-risk certification should be given for at most ten years.

5.4.ii) Increased yield for a single crop

1. In the project plan, the project operator shall provide an evidenced assessment of

the increase in feedstock production that can be expected due to implementing the project.

2. After the first year of project implementation, and every three years thereafter, the project shall be audited to confirm correct implementation of the intended productivity increase measure. Only projects where the intended measure has been correctly implemented may generate certified feedstock.

3. Additionality shall be demonstrated either:

    - By application of the principles of the 'Tool for the demonstration and assessment of additionality' of the United Nations Clean Development Mechanism by a qualified auditor; *[or*

    - *By both:*

        - *demonstrating that the yield improvement measure being implemented is not common practice in the region in question based on application of the relevant principles of the 'Tool for the demonstration and assessment of additionality'; and*

        - *documenting in the project plan a statement of intent from a specific biofuel operator to take delivery of the low ILUC-risk biofuel produced by the project, and demonstrating that the produced low ILUC-risk material is then supplied to biofuel producers using a segregated supply chain.]*

4. A yield baseline shall be assessed as follows:

    - The baseline yield in the year before project implementation, Y_0 is defined as the greater out of the expected yield in that year based on least squares regression on the last ten years of yield data; or the average yield in the last ten years.

    - An annual baseline yield increment ΔY shall be calculated as whichever is greater out of zero and the annual yield increase calculated by least squares regression of yield data at the national or regional level for the last ten years for the crop being cultivated.

    - The baseline yield in year *N* of project implementation shall be set as

    - Where the crop is a perennial, the yield baseline should be appropriately adjusted to reflect age of plantation.

5. The amount of feedstock to be certified as low ILUC-risk shall be set as half[36] of the expected yield increase, plus half of any above-baseline yield delivered each year. The maximum amount of feedstock certified in any year shall by 1.2 times the total expected yield benefit from the project.

36 As noted above, the choice of 50:50 crediting is somewhat arbitrary, and therefore different crediting splits could reasonably be considered.

5.4.iii) Increased overall productivity by adding an additional crop to an existing crop and/or livestock system

1. In the project plan, the project operator shall provide an evidenced assessment of the increase in feedstock production that can be expected due to implementing the project.
2. After the first year of project implementation, and every three years thereafter, the project shall be audited to confirm correct implementation of the intended productivity increase measure. Only projects where the intended measure has been correctly implemented may generate certified feedstock.
3. After the first year of project implementation, and every three years thereafter, the project shall be audited to confirm that there has been no decrease in production of other materials from the system due to project implementation.
4. Additionality shall be demonstrated either:
    - by application of the principles of the 'Tool for the demonstration and assessment of additionality' of the United Nations Clean Development Mechanism by a qualified auditor; *[or*
    - *by:*
        - *demonstrating that the project type being implemented is not common practice in the region in question based on application of the relevant principles of the 'Tool for the demonstration and assessment of additionality'; and*
        - *documenting in the project plan a statement of intent from a specific biofuel operator to take delivery of the low ILUC-risk biofuel produced by the project, and demonstrating that the produced low ILUC-risk material is then supplied to biofuel producers using a segregated supply chain.]*
5. Where the project is not expected to result in reduction in production of any existing crops or livestock systems, the whole amount of feedstock produced from the new crop may be certified as low ILUC-risk.
6. Where the project is expected to deliver a net increase in material production at the expense of reductions in yields of some existing crops, a yield baseline shall be calculated for each crop component in the existing system using the baseline assessment methodology for yield increases. The amount of feedstock to be certified as low ILUC-risk shall be set as half of the expected net productivity increase, plus half of any above-baseline productivity delivered each year. The maximum amount of feedstock certified shall by 1.2 times the total expected productivity benefit from the project.
    - The crop components to be assessed shall be: oils and fats; protein; sugars; starch. Production of components earlier in the list may compensate production of components later in the list, but not the other way round (so for example an increase in oil production at the expense of starch production may be counted

as a net gain, but increase in sugar production at the expense of protein may not).

- A project may not be certified as low ILUC-risk if it involves substituting production of fruits or vegetables with a crop that has lower human nutritional value.

5.4.iv) Utilisation of unused land otherwise unlikely to be brought into production

1. In the project plan, the project operator shall provide an evidenced use history for the area of land in question for at least ten years.

2. Additionality shall be demonstrated either:

   - by application of the principles of the 'Tool for the demonstration and assessment of additionality' of the United Nations Clean Development Mechanism by a qualified auditor; *[or*

   - *In the case of land that is shown to have been abandoned from previous agricultural use, by demonstrating either: that total cultivated area in the local region reduced in each of the five previous years; that large areas of land with more favourable production characteristics are available in the local region; or, by demonstrating that the land was abandoned due to degradation and that it is not common practice in the local region to cultivate land in that degraded state by application of the relevant principles of the 'Tool for the demonstration and assessment of additionality'.*

   - *in the case of land not cultivated within the last 30 years but in a degraded or contaminated state, by demonstrating that there are regulatory barriers preventing supply of feedstock from that land for non-energy uses, or demonstrating that it is not common practice in the local region to cultivate land in that state by application of the relevant principles of the 'Tool for the demonstration and assessment of additionality'.]*

3. The amount of feedstock to be certified as low ILUC-risk shall be set as the full amount of feedstock produced.

5.5. Example language on criteria for low ILUC-risk certification

Above, a set of principles and a narrative outline are presented for a low ILUC-risk feedstock certification system. This outline does not yet have the level of detail necessary for a ready-to-implement low ILUC-risk certification scheme, but may nevertheless provide more detail and discussion than the European Commission would be likely to include in a delegated act. In Annex C, we suggest language that may be more appropriate for formally framing requirements on low ILUC-risk certification.

6. Potential impacts of the high ILUC-risk/low ILUC-risk framework

Under the RED II, feedstocks categorised as high ILUC-risk may not be counted towards 2030 targets, and must have their support progressively reduced from 2023. Without support under national RED II implementations, the supply of biodiesel and renewable diesel is unlikely to be competitive with fossil diesel supply, and therefore it is expected that should palm oil and soy oil be identified as high ILUC-risk feedstocks their use as biofuel feedstock will be eliminated from the EU market by 2030. Based on the rates of expansion onto high carbon stock land identified in Chapter 3, eliminating direct EU demand for palm oil as a biofuel feedstock could avoid 130-210 thousand hectares a year of deforestation and 100-150 thousand hectares a year of peat destruction in 2030 (the saved peat area would partly overlap the avoided deforestation). Eliminating direct EU demand for soy oil as a biofuel feedstock could avoid 10-20 thousand hectares a year of deforestation in 2030. These estimates account for the expected indirect implications of increasing demand for other vegetable oils as alternatives, but should be treated as illustrative only. Indirect land use change modelling should remain the preferred analytical tool for policy analysis of land use changes from biofuel demand.

Based on the analysis of potential high ILUC-risk feedstocks presented in section 3, we would anticipate that the European Commission will certainly identify palm oil as a high ILUC-risk feedstock, and may also identify soy oil as high ILUC-risk (subject to where the threshold is placed for assessing whether deforestation links are 'significant'). If palm oil and soy oil are classified as high ILUC-risk feedstocks, the support for the use of those feedstocks will be capped at 2019 levels until 2023, and must then be gradually reduced to zero. The estimated production costs of palm and soy oil based alternative fuels are generally higher than the price of fossil diesel. This is illustrated in Figure 10 (see below) for eighteen months from January 2017. The estimated biodiesel production costs are broadly consistent with reported price of biodiesel imports taken from the 'EU Trade Helpdesk'[37] of 840 Euro per tonne for 2017 and 900 Euro per tonne for 2016.

The pre-tax price of diesel fuel in Europe is generally below the price of palm oil on an energy equivalent basis, although since June 2018 based on the data used the price of palm oil has fallen lower than that of diesel. However, the additional estimated costs of production for palm based biodiesel and renewable diesel, the production cost of those fuels has been consistently higher on an energy equivalent basis than the fossil diesel price. For biodiesel, the 'blend wall'[38] could be an additional limit on the supply of fuels considered to be high ILUC-risk, as they would compete directly for market share with biodiesel from other feedstocks. Given this price hierarchy and the additional limits on biodiesel supply, it can be expected

37 http://trade.ec.europa.eu/tradehelp/statistics

38 The maximum blend of biodiesel allowed in retail diesel fuel, generally 5, 7 or 10% in Europe.

that categorisation of feedstocks as high ILUC-risk would more or less eliminate the supply of biodiesel or renewable diesel from those feedstocks in the EU[39].

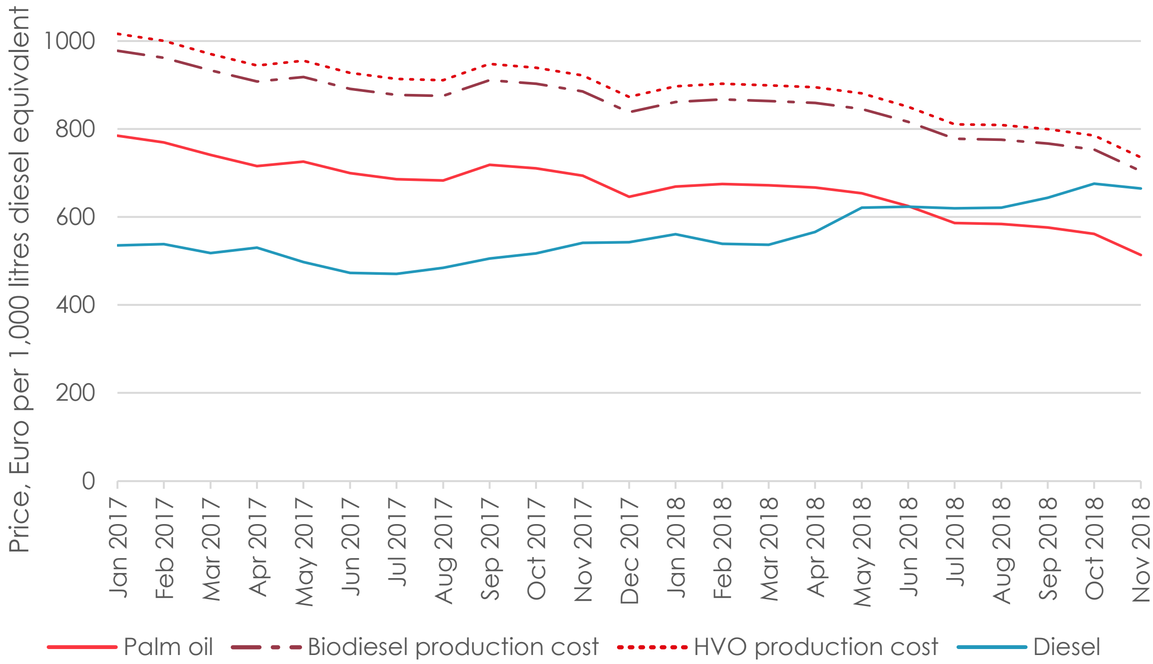


Figure 10. Comparison of prices for palm oil and diesel, and estimated production cost for biodiesel and renewable diesel

Notes: *Palm oil price from World Bank pink sheet[40], converted to Euros at $1.15 to the Euro; diesel price taken as EU average from EU weekly oil bulletin; conversion efficiency of palm oil to FAME and HVO from Biograce; non-feedstock production cost of FAME assumed to be 16 Eurocent per litre, non-feedstock production cost of HVO assumed to be 20 Eurocent per litre (production cost assumptions based on Hofstrand, 2014; Malins, 2019).*

If not classified as high ILUC-risk feedstocks, then the use of these feedstocks could be continued or could grow within the 7% (or lower) caps on support for food based biofuels. As detailed above in sections 1.1 and 3, these feedstocks are associated both with higher direct conversion of high carbon stock land than other first generation biofuels and with higher estimated ILUC emissions (which include assessment of carbon losses from low and medium carbon stock landscapes). Reducing the use of these feedstocks through the high ILUC-risk mechanism should therefore reduce net deforestation and ILUC emissions associated with EU biofuel policy.

In order to provide an indication of the potential environmental benefit of reducing demand for

39 This could in principle change if there was a significant persistent increase in oil prices without a corresponding increase in vegetable oil prices, but in practice the use of vegetable oil as biodiesel feedstock and the fungibility of the vegetable oil market make it unlikely for such a change in the price hierarchy to occur even if oil prices rise significantly.

40 http://pubdocs.worldbank.org/en/561011486076393416/CMO-Historical-Data-Monthly.xlsx

palm oil and soy oil, we have constructed three scenarios for biodiesel-related palm oil and soy oil demand under RED II from 2021 to 2030. The 2021 demand for palm and soy oil respectively are based on 2017 numbers for feedstocks for EU biodiesel production documented by Buffet (2018) and 2017 biodiesel imports reported by the 'EU Trade Helpdesk'[41,42]. In the business as usual scenario in which neither palm oil nor soy oil is defined as high ILUC-risk, we assume that use of palm and soy oil for biodiesel remain flat at 2017 levels to 2030. In the event that they are categorised as high ILUC-risk, we assume that EU demand reduces linearly to zero between 2024 and 2030. This results in a cumulative reduction in palm oil demand by 14 million tonnes, and of soy oil demand by 4 million tonnes. These scenarios are shown in Table 11.

Table 11. Scenarios for palm and soy oil demand from the biodiesel market (million tonnes)

		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Palm	BAU	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
	Defined as high ILUC-risk	4.2	4.2	4.2	4.2	4.2	4.2	3.6	3.0	2.4	1.8	1.2	0.6	0.0
Soy	BAU	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
	Defined as high ILUC-risk	1.1	1.1	1.1	1.1	1.1	1.1	0.9	0.8	0.6	0.5	0.3	0.2	0.0

The BAU case given in Table 11 does not consider the possibility that Member States might take regulatory action to reduce biodiesel consumption outside of the high ILUC-risk framework, for instance by giving ethanol preferential incentives over biodiesel. In this regard, this analysis could be considered a high-end estimate of the impact of a high ILUC-risk categorisation for palm and soy oil.

The values in Table 11 reflect a direct reduction in demand for palm and soy oil for conversion to biofuels for the EU market, but the real reduction in global demand for those oils would likely be less than this. This is because of indirect effects, whereby shifting EU biodiesel production from palm oil and soy oil to rapeseed oil and sunflower oil could indirectly increase palm oil imports for other sectors (cf. Malins, 2013). Also, given that rapeseed oil and sunflower oil generally have a higher price than palm and soy oils, eliminating the lower cost feedstock options would likely lead to marginal reduction in total EU biodiesel use under RED II, as alternative renewable fuels would become more competitive with biodiesel.

Assessing those market mediated changes would require an economic model such as are used for ILUC modelling. Results from previous European Commission modelling (Laborde, 2011a; Valin et al., 2015) suggest that the rebound effect back into the palm and soy oil markets could be between 10 and 40% (cf. page 36 of Malins, 2018). There is also an indirect connection from the soy oil to palm oil market – based on the same studies, 40 to 50% of any

41 http://trade.ec.europa.eu/tradehelp/statistics

42 Imports from Indonesia and Malaysia are assumed to be palm oil biodiesel, imports from Argentina assumed to be soy oil biodiesel. These account for two thirds of EU biodiesel imports, the largest other sources being China, Taiwan and Norway. It is likely that part of the biodiesel imported from these three countries (and elsewhere) is palm or soy oil based, and so the total figure given is conservative, although this conservatism may be partly offset by the possibility that some fraction of imports from Indonesia, Malaysia and Argentina could be waste based.

reduction in direct soy oil demand may be indirectly transferred to the palm oil market. When including these indirect effects based on those previous ILUC modelling results, categorising palm and soy oils as high ILUC-risk might therefore be expected to deliver a **net global palm oil demand reduction in 2030 of 2.7 to 4.2 million tonnes, and a net global soy oil demand reduction of 0.3 to 0.7 million tonnes.**

While these demand reductions would be significant, they are modest compared to expected growth in demand for vegetable oils for the food and oleochemicals sector. Analysis by OECD & FAO (2017) anticipates over 1.5 million tonnes additional vegetable oil demand per year from 2017 to 2026. Figure 11 illustrates this for palm oil, showing that even a total global elimination of biodiesel related palm oil demand would not reverse the current trend of market expansion. The potential 4.2 million tonne reduction in 2030 palm oil demand from the high ILUC-risk framework represents only a fifth of expected demand from food markets in the same period. Adjustments to EU biofuel policy should be understood as reducing the rate of growth of the palm and soy oil markets, rather than creating a situation of market contraction.

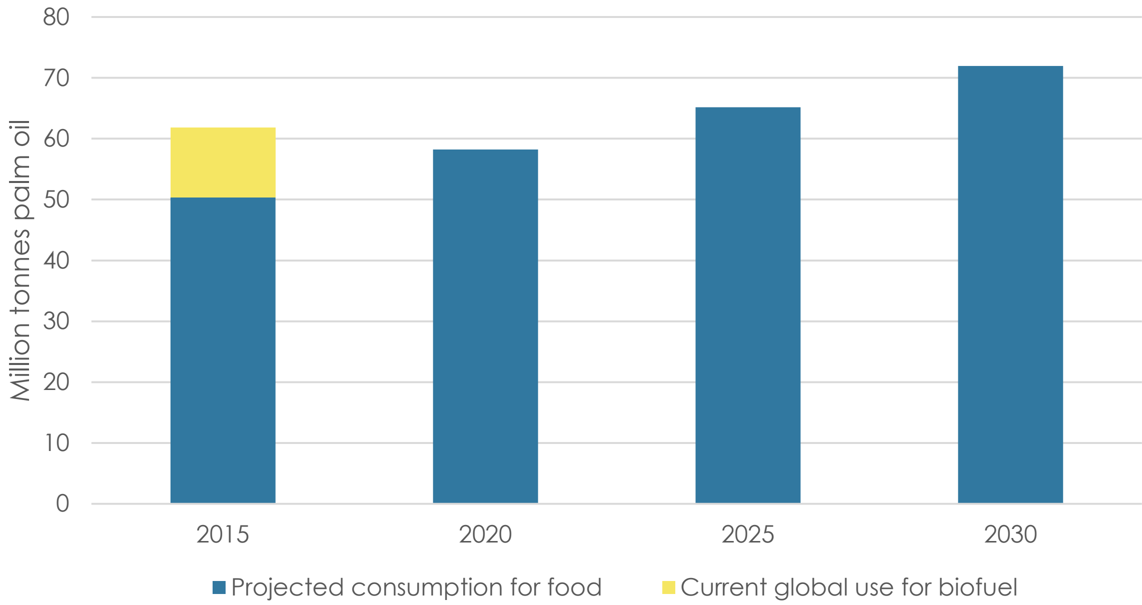


Figure 11. Projected demand for palm oil for food, and estimated current total global palm oil demand from biofuel production

Source: (Malins, 2018; OECD & FAO, 2017)

6.1. Potential land conversion and carbon stock losses avoided by high ILUC-risk designations

Given the estimated demand reductions given above, the deforestation links identified in section 3.4.i), and allocating by value across main co-products, it is possible to provide some indication of the amount of deforestation and peat drainage that might be avoided by categorising palm oil and soy oil as high ILUC-risk feedstocks.

It is important to recognise that not all demand changes for agricultural commodities are met by changes in rates of agricultural expansion. ILUC modelling shows that demand increases should be expected to be met by a combination of area increase, yield increase and demand reduction in other sectors. By the same logic, a demand reduction for palm and soy oil for biodiesel may be expected to result partly in reductions in the rate of area expansion[43] partly by reduced yield growth and partly by increased consumption in other sectors. Here, we assume for illustrative purposes that half of the demand change is accommodated by reduced area expansion, and the other half by some combination of lower rates of yield improvement and by a demand adjustment for food and oleochemicals.

Table 12. Potential avoided high carbon stock land conversion

	Net demand change		Avoided LUC (ha/ tonne feedstock)		Avoided forest loss (kha)		Avoided peat loss (kha)	
	High	Low	Forest	Peat	High	Low	High	Low
Palm oil	4.2	2.7	0.099	0.073	206	134	153	99
Soy oil	0.7	0.3	0.067	0.000	22	10	0	0

Based on these illustrative assumptions[44], by 2030 identifying palm oil as high ILUC-risk could avoid 130 to 210 thousand hectares of annual deforestation by 2030, and 100 to 150 thousand hectares of peat drainage (see Table 12, in cases where there is forest on peat soils these areas would overlap). A high ILUC-risk categorisation of soy oil could avoid 10 to 20 thousand hectares of annual deforestation by 2030.[45] These illustrative values are informed by previous ILUC modelling, but are based on numerous assumptions. Comprehensive ILUC modelling should remain the preferred analytical tool for policy analysis of questions of this sort relating to biofuel policy.

6.2. Relation of the high and low ILUC-risk framework to other renewable fuel regulation

Introducing a framework of high and low ILUC-risk designations could in some respects bring EU renewable fuel policy closer to that in other regions, notably the United States, but is in other respects different and novel. Currently, the U.S. Renewable Fuel Standard and California Low Carbon Fuel Standard effectively block the use of palm oil biodiesel (or renewable diesel) because of palm's high ILUC emissions. Categorising palm oil as high ILUC-risk would therefore make EU policy similar in effect to U.S. policy. Soy based biofuels in contrast are not limited in

43 Overall demand for both crops is set to continue to rise, so we talk about reduced expansion rather than area shrinkage.

44 And adjusted for co-product value, which is important for soybeans where the meal has the larger value share.

45 Note that the high estimates are not additive, as the high value for net palm demand change assumes a larger transfer of soy oil demand into the palm oil market than is assumed for the high value for net soy oil demand change.

the U.S., and thus identifying soy oil as high ILUC-risk would make the EU the first region to take such decisive regulatory action to recognise the deforestation risk from soy biodiesel.

The use of a metric based on risk to high carbon-stock land rather than on ILUC modelling would also represent a departure for the EU from precedents in North American biofuel policy. Arguably, the EU approach has the potential to achieve buy-in from countries that have been cautious of ILUC modelling in the past, and thus might provide a useful template to improve the sustainability of biofuel policy more widely. The counter-point to such an argument is that by adopting a novel framework, the EU may move the always illusory goal of international harmonisation of biofuel sustainability regulation even further from realisation. Alongside the high ILUC-risk element of the RED II, the low ILUC-risk element has the potential to be genuinely innovative. A rule that creates a robust, rigorous and practical definition for low ILUC-risk projects could provide a template for global efforts to promote more sustainable land use practices in the biofuel industry.

7. References

Abood, S. A., Lee, J. S. H., Burivalova, Z., Garcia-Ulloa, J., & Koh, L. P. (2015). Relative Contributions of the Logging, Fiber, Oil Palm, and Mining Industries to Forest Loss in Indonesia. *Conservation Letters*, *8*(1), 58–67. http://doi.org/10.1111/conl.12103

Acquaye, A. A., Sherwen, T., Genovese, A., Kuylenstierna, J., Lenny Koh, S. C., & McQueen-Mason, S. (2012). Biofuels and their potential to aid the UK towards achieving emissions reduction policy targets. *Renewable and Sustainable Energy Reviews*, *16*, 5414–5422. Retrieved from http://www.sciencedirect.com/science/article/pii/S1364032112003218

Adami, M., Rudorff, B. F. T., Freitas, R. M., Aguiar, D. A., Sugawara, L. M., & Mello, M. P. (2012). Remote Sensing Time Series to Evaluate Direct Land Use Change of Recent Expanded Sugarcane Crop in Brazil. *Sustainability*, *4*, 574–585. http://doi.org/10.3390/su4040574

Al-Riffai, P., Dimaranan, B., & Laborde, D. (2010). Global trade and environmental impact study of the EU biofuels mandate. *Energy*, (March), 1–125. Retrieved from http://trade.ec.europa.eu/doclib/html/145954.htm%5Cnhttp://environmentportal.in/files/biofuelsreportec.pdf

Argonne National Laboratory. (2017). The Greenhouse gases, Regulated Emissions, and Energy use in Transportation Model. Retrieved August 2, 2018, from https://greet.es.anl.gov/

Austin, K. G., Mosnier, A., Pirker, J., McCallum, I., Fritz, S., & Kasibhatla, P. S. (2017). Shifting patterns of oil palm driven deforestation in Indonesia and implications for zero-deforestation commitments. *Land Use Policy*, *69*(August), 41–48. http://doi.org/10.1016/j.landusepol.2017.08.036

Baral, A., & Malins, C. (2016). Additional supporting evidence for significant iLUC emissions of oilseed rape biodiesel production in the EU based on causal descriptive modeling approach. *GCB Bioenergy*, *8*(2), 382–391. http://doi.org/10.1111/gcbb.12254

Barthel, M., Jennings, S., Schreiber, W., Sheane, R., Royston, S., Fry, J., … McGill, J. (2018). *Study on the environmental impact of palm oil consumption and on existing sustainability standards*.

Bauen, A., Chudziak, C., Vad, K., & Watson, P. (2010). *A causal descriptive approach to modelling the GHG emissions associated with the indirect land use impacts of biofuels*. *E4Tech*. London: E4tech. Retrieved from http://www.e4tech.com/reports/a-causal-descriptive-approach-to-modelling-the-ghg-emissions-associated-with-the-indirect-land-use-impacts-of-biofuels/

Baumann, M., Piquer-Rodríguez, M., Fehlenberg, V., Gavier Pizarro, G., & Kuemmerle, T. (2016). Land-Use Competition in the South American Chaco. In *Land Use Competition* (pp. 215–229). Cham: Springer International Publishing. http://doi.org/10.1007/978-3-319-33628-2_13

Biggs, C., Oliver, E., Valin, H., Peters, D., & Matthias Spöttle. (2016). *Decomposing biofuel feedstock crops and estimating their ILUC effects*. Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/Report.pdf

Blanco Fonseca, M., Burrell, A., Gay, S. H., Henseler, M., Kavallari, A., M'Barek, R., … Tonini, A. (2010). *Impacts of the EU biofuel target on agricultural markets and land use: a comparative modelling assessment*. *Reproduction* (Vol. Canadian-J). http://doi.org/10.2791/45105

Boucher, D., Elias, P., Lininger, K., May-Tobin, C., Roquemore, S., & Saxon, E. (2011). *The Root of the Problem - What's driving tropical deforestation today?* Cambridge, MA: Tropical Forest and Climate Initiative, Union of Concerned Scientists. Retrieved from http://www.ucsusa.org/assets/documents/global_warming/UCS_RootoftheProblem_DriversofDeforestation_FullReport.pdf

Brack, D. (2015). Reducing Deforestation in Agricultural Commodity Supply Chains Using Public Procurement Policy Reducing Deforestation in Agricultural Commodity Supply Chains: Using Public Procurement Policy, (September). Retrieved from https://www.chathamhouse.org/sites/files/chathamhouse/field/field_document/20150902AgriculturalCommoditiesDeforestationBrack.pdf

Brinkman, M., Wicke, B., Gerssen-Gondelach, S., van der Laan, C., & Faaij, A. (2015). Methodology for assessing and quantifying ILUC prevention options, 28. Retrieved from https://www.uu.nl/en/research/copernicus-institute-of-sustainable-development/research/research-groups/energy-and-resources/potential-indirect-land-use-change-iluc

Buffet, L. (2018). *Up in smoke: Europe's cars driving deforestation in South East Asia*. Brussels.

California Air Resources Board. (2014). *Appendix I - Detailed analysis for indirect land use change*. Sacramento, CA. Retrieved from https://www.arb.ca.gov/regact/2015/lcfs2015/lcfs15appi.pdf

Carlson, K. M., Curran, L. M., Asner, G. P., Pittman, A. M., Trigg, S. N., & Marion Adeney, J. (2013). Carbon emissions from forest conversion by Kalimantan oil palm plantations. *Nature Clim. Change*, *advance on*. Retrieved from https://www.nature.com/nclimate/journal/v3/n3/pdf/nclimate1702.pdf

Castro, W. M. (2018). Soybean's footprint in Amazonia: past and current trends, 4–27.

CONAB. (2017). A Cultura do Café: análise dos custos de produção e da rentabilidade nos anos-safra 2008 a 2017. *Campanha Nacional de Abastecimento*, *12*, 54. Retrieved from http://www.conab.gov.br/OlalaCMS/uploads/arquivos/17_06_06_11_19_13_8_compendio_de_estudos_conab_algodao_-_volume_8_2017.pdf

Curtis, P. G., Slay, C. M., Harris, N. L., Tyukavina, A., & Hansen, M. C. (2018). Classifying drivers of global forest loss. *Science*, *361*(6407), 1108–1111. http://doi.org/10.1126/science.aau3445

Cuypers, D., Geerken, T., Gorissen, L., Peters, G., Karstensen, J., Prieler, S., … vVn Velthuizen, H. (2013). *The impact of EU consumption on deforestation : Comprehensive analysis of the impact of EU consumption on deforestation*. European Commission. http://doi.org/10.2779/822269

Dehue, B., Meyer, S., & van de Staaij, J. (2010). *Responsible Cultivation Areas: Identification and certification of feedstock production areas with a low risk of indirect effects*. Ecofys.

Dehue, B., van de Staaij, J., & Chalmers, J. (2009). Mitigating indirect effects of biofuel production. Case studies and Methodology. Retrieved from http://www.renewablefuelsagency.gov.uk/sites/renewablefuelsagency.gov.uk/files/_documents/Avoiding_indirect_land-use_change_-_Ecofys_for_RFA.pdf

Dunkelberg, E. (2014). *A case-study approach to quantifying indirect land-use change due to expanding biofuels feedstock cultivation*. Retrieved from https://depositonce.tu-berlin.de/bitstream/11303/4279/1/dunkelberg_elisa.pdf

Ecofys. (2013). The Low Indirect Impact Biofuels (LIIB) Methodology, 5. Retrieved from http://www.ecofys.com/files/files/ecofys-epfl-wwf-2013-credible-robust-certification-of-low-iluc-biofuels.pdf

Ecofys. (2016). Methodologies for the identification and certification of Low ILUC risk biofuels, 1–64.

Ecofys, Milieu, & COWI. (2018). *Feasibility study on options to step up EU Action against Deforestation*. Luxembourg. Retrieved from http://ec.europa.eu/environment/forests/pdf/feasibility_study_deforestation_kh0418199enn_main_report.pdf

Edwards, R., Mulligan, D., & Marelli, L. (2010a). *Indirect Land Use Change from increased biofuels demand: Comparison of models and results for marginal biofuels production from different feedstocks*. Ispra: EC Joint Research Centre - Institute for Energy. Retrieved from http://publications.jrc.ec.europa.eu/repository/handle/JRC59771

Edwards, R., Mulligan, D., & Marelli, L. (2010b). *Indirect Land Use Change from increased biofuels demand*. *Contract*. http://doi.org/10.2788/54137

Edwards, R., Padella, M., Vorkapic, V., & Marelli, L. (2014). *Historical deforestation due to expansion of crop demand : implications for biofuels*. http://doi.org/10.2790/02220

El Takriti, S., Malins, C., & Searle, S. Y. (2016). Understanding options for ILUC mitigation. *The ICCT Working Paper*, (23).

European Commission. COMMISSION DECISION of 10 June 2010 on guidelines for the calculation of land carbon stocks for the purpose of Annex V to Directive 2009/28/EC (2010). Brussels: European Commission.

Fabio Santeramo. (2017). *Cross-price elasticities for oils and fats in the U.S. and the EU | International Council on Clean Transportation*. Retrieved from https://www.theicct.org/publications/cross-price-elasticities-oils-and-fats-us-and-eu

Fehlenberg, V., Baumann, M., Gasparri, N. I., Piquer-Rodriguez, M., Gavier-Pizarro, G., & Kuemmerle, T. (2017). The role of soybean production as an underlying driver of deforestation in the South American Chaco. *Global Environmental Change*, *45*(April), 24–34. http://doi.org/10.1016/j.gloenvcha.2017.05.001

Flugge, M., Lewandrowski, J., Rosenfeld, J., Boland, C., Hendrickson, T., Jaglo, K., … Pape, D. (2017). *A Life-Cycle Analysis of the Greenhouse Gas Emissions of Corn-Based Ethanol*.

Fritsche, U., Hennenberg, K., & Hünecke, K. (2010). *The "iLUC Factor" as a Means to Hedge Risks of GHG Emissions from Indirect Land Use Change. Working Paper*

(Vol. 49). Darmstadt, Germany: Oko-Institut. Retrieved from http://www.oeko.de/oekodoc/1030/2010-082-en.pdf

Furumo, P. R., & Aide, T. M. (2017). Characterizing commercial oil palm expansion in Latin America: land use change and trade. *Environmental Research Letters*, *12*(2), 024008. http://doi.org/10.1088/1748-9326/aa5892

GEF Secretariat. (2014). Taking Tropical Deforestation out of Commodity Supply Chains | Global Environment Facility. Global Environment Facility. Retrieved from https://www.thegef.org/publications/taking-tropical-deforestation-out-commodity-supply-chains

Gibbs, H. K., Rausch, L., Munger, J., Schelly, I., Morton, D. C., Noojipady, P., … Walker, N. F. (2015). Brazil's Soy Moratorium: Supply-chain governance is needed to avoid deforestation. *Science*, *347*(6220), 377–378. http://doi.org/10.1126/science.aaa0181

Government of Brazil. (2017). Conheça os biomas brasileiros. Retrieved November 24, 2018, from http://www.brasil.gov.br/noticias/meio-ambiente/2009/10/biomas-brasileiros

Graesser, J., Aide, T. M., Grau, H. R., & Ramankutty, N. (2015). Cropland/pastureland dynamics and the slowdown of deforestation in Latin America. *Environmental Research Letters*, *10*(3), 034017. http://doi.org/10.1088/1748-9326/10/3/034017

Gunarso, P., Hartoyo, M. E., Agus, F., & Killeen, T. J. (2013). *Oil Palm and Land Use Change in Indonesia, Malaysia and Papua New Guinea*. *RSPO*. http://doi.org/papers2://publication/uuid/76FA59A7-334A-499C-B12D-3E24B6929AAE

Hansen, E., Royal, S., Pompili, B., Müller, G., Schmidt, C., Ploumen, L., … Greening, J. (2015). Amsterdam Declaration "Towards Eliminating Deforestation from Agricultural Commodity Chains with European Countries," (December).

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., … Townshend, J. R. G. (2013). High-resolution global maps of 21st-century forest cover change. *Science*, *342*(6160), 850–853. http://doi.org/10.1126/science.1244693

Hélaine, S., M'barek, R., & Gay, H. (2013). Impacts of the EU biofuel policy on agricultural markets and land use - Modelling assessment with AGLINK-COSIMO (2012 version). *JRC Scientific and Policy Reports*, 25. http://doi.org/10.2791/20985

Henders, S., Persson, U. M., & Kastner, T. (2015). Trading forests: Land-use change and carbon emissions embodied in production and exports of forest-risk commodities. *Environmental Research Letters*, *10*(12), 125012. http://doi.org/10.1088/1748-9326/10/12/125012

Hofstrand, D. (2014). Tracking Biodiesel Profitability. Retrieved from https://www.extension.iastate.edu/agdm/energy/html/d1-15.html

Hosonuma, N., Herold, M., De Sy, V., De Fries, R. S., Brockhaus, M., Verchot, L., … Romijn, E. (2012). An assessment of deforestation and forest degradation drivers in developing countries. *Environmental Research Letters*, *7*(4). http://doi.org/10.1088/1748-9326/7/4/044009

Houghton, R. A. (2010). How well do we know the flux of CO_2 from land-use change? *Tellus, Series B: Chemical and Physical Meteorology*, *62*(5), 337–351. http://doi.org/10.1111/j.1600-0889.2010.00473.x

IBGE. (2018). Sistema IBGE de Recuperação Automática - SIDRA. Retrieved May 2, 2017, from https://sidra.ibge.gov.br/pesquisa/pam/tabelas

Klasing, K., Hazzledine, M., Baral, A., & Malins, C. (2012). Improving estimates of displacement ratios of co-products for calculating GHG credits in life cycle analysis of biofuels.

Kurz, W. A., Dymond, C. C., Stinson, G., Rampley, G. J., Neilson, E. T., Carroll, A. L., … Safranyik, L. (2008). Mountain pine beetle and forest carbon feedback to climate change. *Nature*, *452*(7190), 987–990. http://doi.org/10.1038/nature06777

Laborde, D. (2011a). Assessing the land use change consequences of European biofuel policies. *International Food Policy Institute (* …, (October), 1–111. http://doi.org/Specific Contract No SI2. 580403

Laborde, D. (2011b). *Assessing the land use change consequences of European biofuel policies*. Brussels: European Commission.

Laborde, D., Padella, M., Edwards, R., & Marelli, L. (2014). *Progress in estimates of ILUC with MIRAGE model*. http://doi.org/10.2790/92998

Lammerant, J., Vertriest, L., Peters, R., Lawlor, N., Hernandez, G., Markowska, A., … Moran, D. (2014). *Identification and mitigation of the negative impacts of EU demand for certain commodities on biodiversity in third countries*. DG Environment. http://doi.org/10.2779/188061

Lapola, D. M., Schaldach, R., Alcamo, J., Bondeau, A., Koch, J., Koelking, C., & Priess, J. a. (2010). Indirect land-use changes can overcome carbon savings from biofuels in Brazil. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(8), 3388–3393. http://doi.org/10.1073/pnas.0907318107

le Polain de Waroux, Y., Garrett, R. D., Heilmayr, R., & Lambin, E. F. (2016). Land-use policies and corporate investments in agriculture in the Gran Chaco and Chiquitano. *Proceedings of the National Academy of Sciences*, *113*(15), 4021–4026. http://doi.org/10.1073/pnas.1602646113

Ling, A. H. (2012). Weather effects on palm oil production: supply outlook 2012/13. Kuala Lumpur. Retrieved from http://www.mpoc.org.my/upload/P5_LingAhHong_POTSKL2012.pdf

Lywood, W. (2013). *Estimate of ILUC impact of EU rapeseed biodiesel based on historic data*.

Macedo, M. N., DeFries, R. S., Morton, D. C., Stickler, C. M., Galford, G. L., & Shimabukuro, Y. E. (2012). Decoupling of deforestation and soy production in the southern Amazon during the late 2000s. *Proceedings of the National Academy of Sciences of the United States of America*, *109*(4), 1341–6. http://doi.org/10.1073/pnas.1111374109

Malaysian Palm Oil Board. (2017). Palm oil area statistics. Retrieved December 7, 2018, from http://bepi.mpob.gov.my/index.php/en/statistics/area.html

Malins, C. (2010). *Palm Oil Cultivation in Malaysia Case study*. St Leonards on Sea.

Malins, C. (2013). *Vegetable oil markets and the EU biofuel mandate*. Washington, D.C.: International Council on Clean Transportation.

Malins, C. (2015). Low ILUC-risk; high loophole risk? Retrieved from https://www.theicct.org/blogs/staff/low-iluc-risk-high-loophole-risk

Malins, C. (2017a). *For peat's sake - Understanding the climate implications of palm oil biodiesel*. London: Cerulogy and Rainforest Foundation Norway. Retrieved from http://www.cerulogy.com/uncategorized/for-peats-sake/

Malins, C. (2017b). *Navigating the maize*. London. Retrieved from http://www.cerulogy.com/corn-ethanol/navigating-the-maize/

Malins, C. (2017c). *Waste Not, Want Not: Understanding the greenhouse gas implications of diverting waste and residual materials to biofuel production*. London: Cerulogy. Retrieved from http://www.cerulogy.com/wastes-and-residues/waste-not-want-not/

Malins, C. (2018). *Driving deforestation: the impact of expanding palm oil demand through biofuel policy*. London. Retrieved from http://www.cerulogy.com/palm-oil/driving-deforestation/

Malins, C. (2019). *Washington's Clean Fuel Future*. London. Retrieved from http://www.cerulogy.com/supply-assessments/washingtons-clean-fuel-future/

Malins, C., Searle, S. Y., & Baral, A. (2014). *A Guide for the Perplexed to the Indirect Effects of Biofuels Production*. International Council on Clean Transportation. Retrieved from http://www.theicct.org/guide-perplexed-indirect-effects-biofuels-production

Meijaard, E., Garcia-Ulloa, J., Sheil, D., Wich, S.A., Carlson, K.M., Juffe-Bignoli, D., and Brooks, T. . (2018). *Oil palm and biodiversity*. http://doi.org/https://doi.org/10.2305/IUCN.CH.2018.11.en

Melillo, J. M., Reilly, J. M., Kicklighter, D. W., Gurgel, A. C., Cronin, T. W., Paltsev, S. V, … Schlosser, C. A. (2009). Indirect emissions from biofuels: how important? *Science (New York, N.Y.)*, *326*(October), 1397–1399. http://doi.org/10.1126/science.1180251

Miettinen, J., Hooijer, A., Tollenaar, D., Page, S. E., & Malins, C. (2012). *Historical Analysis and Projection of Oil Palm Plantation Expansion on Peatland in Southeast Asia*. Washington, D.C.: International Council on Clean Transportation.

Miettinen, J., Shi, C., & Liew, S. C. (2016). Land cover distribution in the peatlands of Peninsular Malaysia, Sumatra and Borneo in 2015 with changes since 1990. *Global Ecology and Conservation*, *6*, 67–78. http://doi.org/10.1016/j.gecco.2016.02.004

Miyamoto, M., Mohd Parid, M., Noor Aini, Z., & Michinaka, T. (2014). Proximate and underlying causes of forest cover change in Peninsular Malaysia. *Forest Policy and Economics*, *44*, 18–25. http://doi.org/10.1016/J.FORPOL.2014.05.007

MNRE Malaysia. (2018). *National REDD Plus Strategy*.

Morton, D. C., DeFries, R. S., Shimabukuro, Y. E., Anderson, L. O., Arai, E., del Bon Espirito-Santo, F., … Morisette, J. (2006). Cropland expansion changes deforestation dynamics in the southern Brazilian Amazon. *Proceedings of the National Academy of Sciences of the United States of America*, *103*(39), 14637–14641. http://doi.org/10.1073/pnas.0606377103

Morton, D. C., Noojipady, P., Macedo, M. M., Gibbs, H., Victoria, D. C., & Bolfe, E. L. (2016). Reevaluating suitability estimates based on dynamics of cropland expansion in the Brazilian Amazon. *Global Environmental Change*, *37*, 92–101. http://doi.org/10.1016/J.GLOENVCHA.2016.02.001

OECD, & FAO. (2017). *OECD-FAO Agricultural Outlook 2017-2026*. OECD Publishing. Retrieved from http://www.oecd-ilibrary.org/agriculture-and-food/oecd-fao-agricultural-outlook-2017-2026_agr_outlook-2017-en

Overmars, K., Edwards, R., Padella, M., Prins, A. G., & Marelli, L. (2015). *Estimates of indirect land use change from biofuels based on historical data*. *JRC Scientific and Policy Reports*. http://doi.org/10.2790/3647

Page, S.E., Morrison, R., Malins, C., Hooijer, A., Rieley, J.O. Jaujiainen, J. (2011). Review of Peat Surface Greenhouse Gas Emissions from Oil Palm Plantations in Southeast Asia. *Indirect Effects of Biofuel Production*, (15), 1–77.

Picoli, M. C. A., Camara, G., Sanches, I., Simões, R., Carvalho, A., Maciel, A., … Almeida, C. (2018). Big earth observation time series analysis for monitoring Brazilian agriculture. *ISPRS Journal of Photogrammetry and Remote Sensing*, (August), 1–12. http://doi.org/10.1016/j.isprsjprs.2018.08.007

Plevin, R. J., Jones, A. D., Torn, M. S., Group, R., Division, E. S., Berkeley, L., … Gibbs, H. K. (2010). The greenhouse gas emissions from indirect land use change are uncertain, but potentially much greater than previously estimated. *Environmental Science & Technology.*, *44*(21), 8015–8021. http://doi.org/10.1021/es101946t

Rautner, M., Leggett, M., & Davis, F. (2013). The little book of big deforestation drivers. *Global Canopy Programme: Oxford*.

RFA. (2008). *The Gallagher review of the indirect effects of biofuels production*. St Leonards on Sea. Retrieved from http://webarchive.nationalarchives.gov.uk/20110407094724tf_/http://www.renewablefuelsagency.gov.uk/reportsandpublications/reviewoftheindirecteffectsofbiofuels

Richards, P. D., Arima, E., VanWey, L., Cohn, A., & Bhattarai, N. (2017). Are Brazil's Deforesters Avoiding Detection? *Conservation Letters*, *10*(4), 469–475. http://doi.org/10.1111/conl.12310

Richards, P. D., Walker, R. T., & Arima, E. Y. (2014). Spatially complex land change : The Indirect effect of Brazil ' s agricultural sector on land use in Amazonia. *Global Environmental Change*, *29*, 1–9. http://doi.org/10.1016/j.gloenvcha.2014.06.011

Roundtable on Sustainable Biomaterials. (2015). *RSB Low iLUC Risk Biomass Criteria and Compliance Indicators*.

SARVision. (2011). Impact of oil palm plantations on peatland conversion in Sarawak 2005-2010, (January 2011), 1–14.

Searchinger, T. D., Heimlich, R., Houghton, R. A., Dong, F., Elobeid, A., Fabiosa, J. F., … Yu, T.-H. T.-H. (2008). Use of U.S. croplands for biofuels increases greenhouse gases through emissions from land-use change. *Science*, *319*(February), 1238–1240. http://doi.org/10.1126/science.1151861

Searle, A. S., & Giuntoli, J. (2018). Analysis of high and low indirect land-use change definitions in European Union renewable fuel policy.

UNEP. (2015). Bank and investor risk policies on soft commodities. Summary, 19.

UNFCCC CDM EB. (2012). Methodological Tool: "Tool for the demonstration and assessment of additionality" (Version 07.0.0), 1–16. Retrieved from https://cdm.unfccc.int/methodologies/PAmethodologies/tools/

Valin, H., Peters, D., van den Berg, M., Frank, S., Havlík, P., Forsell, N., & Hamelinck, C. N. (2015). The land use change impact of biofuels consumed in the EU - Quantification of area and greenhouse gas impacts, (2015), 261.

Vijay, V., Pimm, S. L., Jenkins, C. N., Smith, S. J., Walker, W., Soto, C., … Rodrigues, H. (2016). The Impacts of Oil Palm on Recent Deforestation and Biodiversity Loss. *PLOS ONE*, *11*(7), e0159668. http://doi.org/10.1371/journal.pone.0159668

Walker, N., Patel, S., & Davies, F. (2013). Demand-side interventions to reduce deforestation and forest degradation. *Demand-Side Interventions to Reduce Deforestation and Forest Degradation*, 27. http://doi.org/10.13140/2.1.3844.3528

Woltjer, G., Daioglou, V., Elbersen, B., Ibañez, G. B., Smeets, E., Sánchez González, D., & Barnó, J. G. (2017). *Study Report on Reporting Requirements on Biofuels and Bioliquids*. Wageningen: European Commission. Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/20170816_iluc_finalstudyreport.pdf

Annex A. References to high and low ILUC-risk in RED II

A.1. RED II recitals

{62bis} … it is appropriate to limit food and feed crop-based biofuels, bioliquids and biomass fuels promoted under this Directive in general and in addition to require Member States to set a specific and gradually decreasing limit for biofuels, bioliquids and biomass fuels produced from food and feed crops for which a significant expansion of the production area into land with high carbon stock is observed whereas low indirect land-use change-risk biofuels, bioliquids and biomass fuels should be exempted from the specific and gradually decreasing limit.

{62ter} Yield increases in agricultural sectors through improved agricultural practises, investments into better machinery and knowledge transfer [beyond levels which would have prevailed in the absence of productivity-promoting schemes for food and feed crop-based biofuels, bioliquids and biomass fuels], as well as the cultivation of crops on areas which were previously not used for cultivation of crops, can mitigate indirect land-use change. In case there is evidence that such measures have led to an increase of the production going beyond the expected increase in productivity, biofuels, bioliquids and biomass fuels produced from such additional feedstock should be considered as low indirect land-use change-risk biofuels. Annual yield fluctuations, should be accounted for in the process.

{99} the power to adopt acts in accordance with Article 290 of the Treaty on the Functioning of the European Union should be delegated to the Commission in respect of … the adoption of criteria, and if appropriate their revision, for certification of low indirect land-use change-risk biofuels, bioliquids and biomass fuels and for determining the high indirect land-use change risk feedstocks for which significant expansion of the production are into land with high carbon stock is observed and the gradual decrease in their contribution to the targets set out in articles 3(1) and 25 (1),

A.2. Articles

2(u) 'low indirect land-use change-risk biofuels and bioliquids' means biofuels and bioliquids, the feedstocks of which were produced within schemes which avoid displacement effects of food and feed crop based biofuels, bioliquids and biomass fuels through improved agricultural practices, as well as the cultivation of crops on areas which were previously not used for cultivation of crops and which were produced in accordance with the sustainability criteria for biofuels and bioliquids set out in Article 26.

25.1 The contribution to the targets set out in Article 3(1) and for the calculation of the numerator (1) from high indirect land-use change risk food or feed crop-based biofuels, bioliquids and biomass fuels produced from food or feed crops for which a significant expansion of the production area into land with high carbon stock is observed, shall not exceed the level of consumption in 2019 in the Member State, unless they are certified as low indirect land-use change-risk biofuels, bioliquids and biomass fuels pursuant to the following two subparagraphs:

As of 31 December 2023, this limit shall decrease gradually to 0% by 31 December 2030 at the latest.

The Commission shall submit, by 1 February 2019, to the European Parliament and the Council a report on the status of production expansion of relevant food and feed crops worldwide and shall adopt, by 1 February 2019, a delegated act setting out the criteria for certification of low indirect land-use change-risk biofuels, bioliquids and biomass fuels and for determining the high indirect land-use change risk feedstocks for which a significant expansion of the production area into land with high carbon stock is observed. The report and the accompanying delegated act shall be based on the best available scientific data.

By 1 September 2023 the Commission shall review the criteria set out by the delegated act referred to in the previous subparagraph based on the best available scientific data and adopt a delegated act amending, where appropriate, such criteria and including the trajectory to gradually decrease the contribution to the targets set out in in Article 3(1) and Article 25(1) of high indirect land-use change risk biofuels, bioliquids and biomass fuels produced from feedstocks for which a significant expansion of the production into land with high carbon stock is observed.

27.4 The Commission may decide that [voluntary national or international schemes setting standards for the production of biofuels, bioliquids, biomass fuels and/or other fuels] contain accurate information on measures taken for soil, water and air protection, the restoration of degraded land, the avoidance of excessive water consumption in areas where water is scarce, and for certification of biofuels and bioliquids with low indirect land-use change-risk.

27.5 In order to ensure that compliance with the sustainability and greenhouse gas emissions saving criteria as well as with the provisions on low or high direct and indirect land-use change-risk biofuels and bioliquids is verified in an efficient and harmonised manner and in particular to prevent fraud, the Commission shall specify detailed implementing rules, including adequate standards of reliability, transparency and independent auditing and require all voluntary schemes to apply those standards. When specifying these standards, the Commission shall pay special attention to the need to minimize administrative burden.

Annex B. Examples of the impact of yield variability on low ILUC-risk certification

B.1. Illustration with U.S. maize data

This underlying variability in the agricultural system can be illustrated using examples of reported agricultural statistics, using data for U.S. maize yields from the USDA. U.S. maize is chosen for the illustration due to the availability of reported data down to the county level, following Searle & Giuntoli (2018).

Figure 12 shows U.S. average maize yields from 1946 to 2018, along with a linear least squares trendline. It is clear from visual inspection that linear yield increase is a reasonable model for this period – yields increased on average by 0.06 tonnes per hectare per year. There are of course some years that depart from the trend, notably recent poor yields due to a drought year in 2012. The more recent part of the trend (2002-2018) is shown on its own in Figure 13, and for this period the calculated yield trend is somewhat stronger, 0.12 tonnes per hectare per year. It will not be clear for some years hence whether this represents a real departure from the long term trend, or simply reflects a poor 2002 and good period from 2014 to 2018.

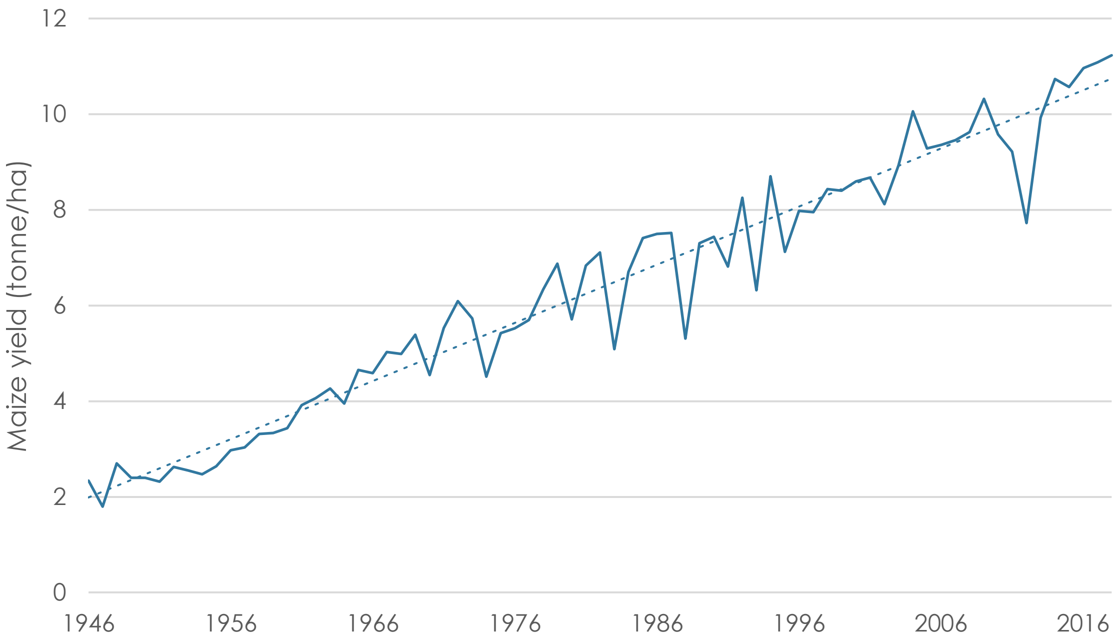


Figure 12. U.S average maize yields since 1946, with trend line

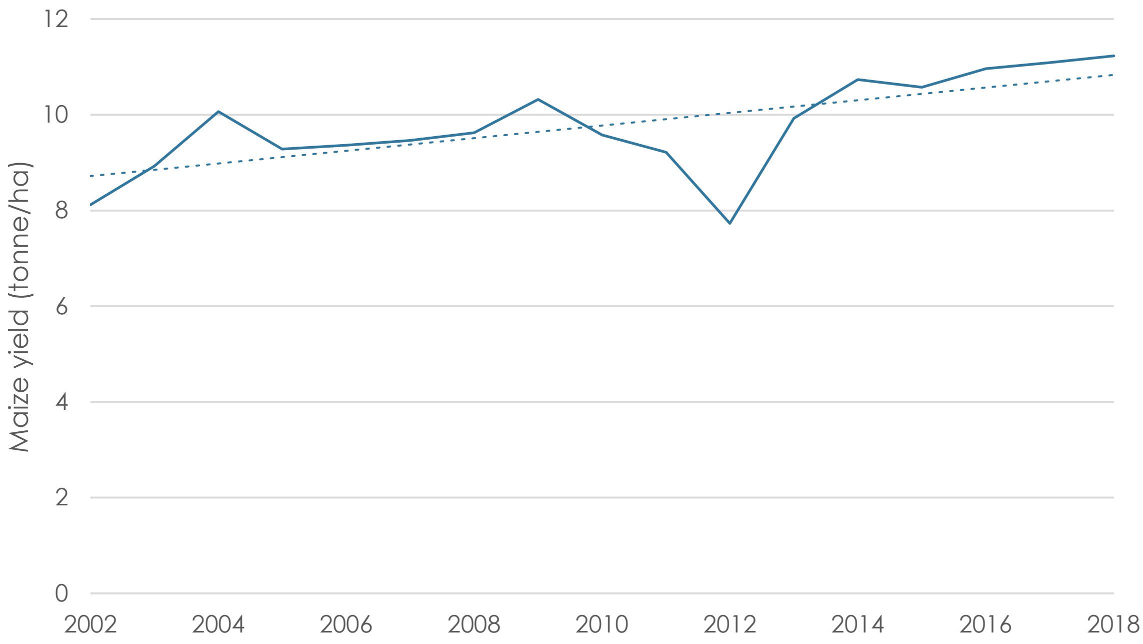


Figure 13. U.S. average maize yield 2002-2017

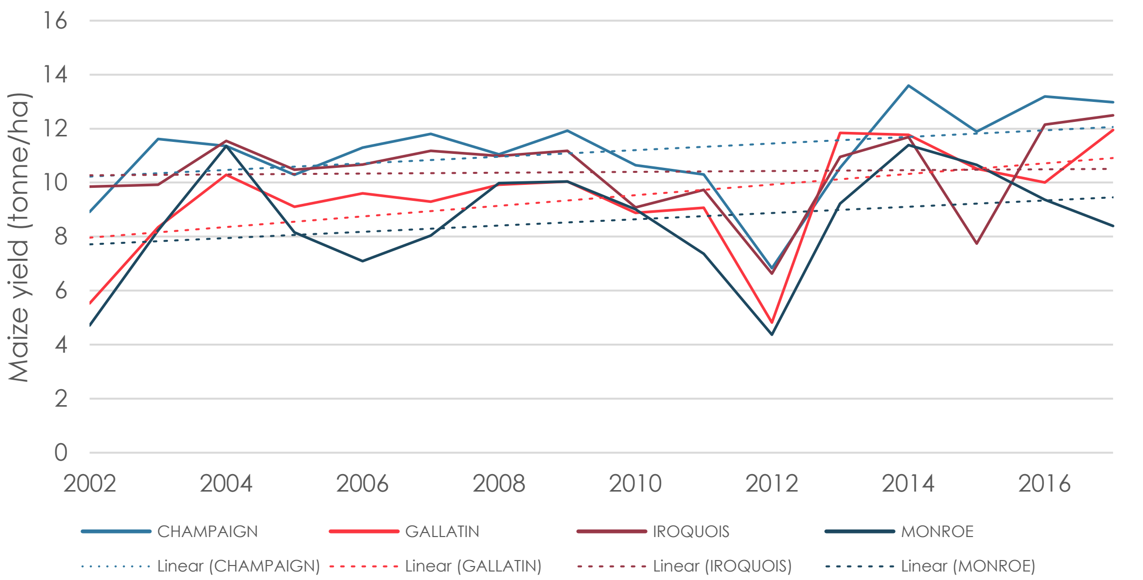


Figure 14. Average maize yield in four counties in Illinois, 2002-2017

As one might expect, if we look at local data for the same period, a similar pattern emerges, but the overall trends show a degree of variation, as can be seen in Figure 14 which shows yields reported in four arbitrarily chosen Illinois counties (Champaign, Gallatin, Iroquois and

Monroe). The calculated trend yield increase over the period ranges from 0.02 tonnes per hectare per year to 0.20 tonnes per hectare per year. The arithmetic average yield in the period ranges from 8.6 tonnes per hectare to 11.1 tonnes per hectare.

Consider now a low ILUC-risk certification project starting in one of these counties, Monroe, in 2013, treating the county as a single project for the purpose of the illustration. If a ten year baseline yield trend is calculated for Monroe level for the ten preceding years, the combination of the drought in 2012 and a productive 2004 give a rather skewed impression of the long-term trend, as shown in Figure 15. On this particular period, the calculated yield trend is firmly down, -0.29 tonnes per hectare per year – even though the trend calculated on the longer time period for the same county was upwards at 0.12 tonnes per hectare per year.

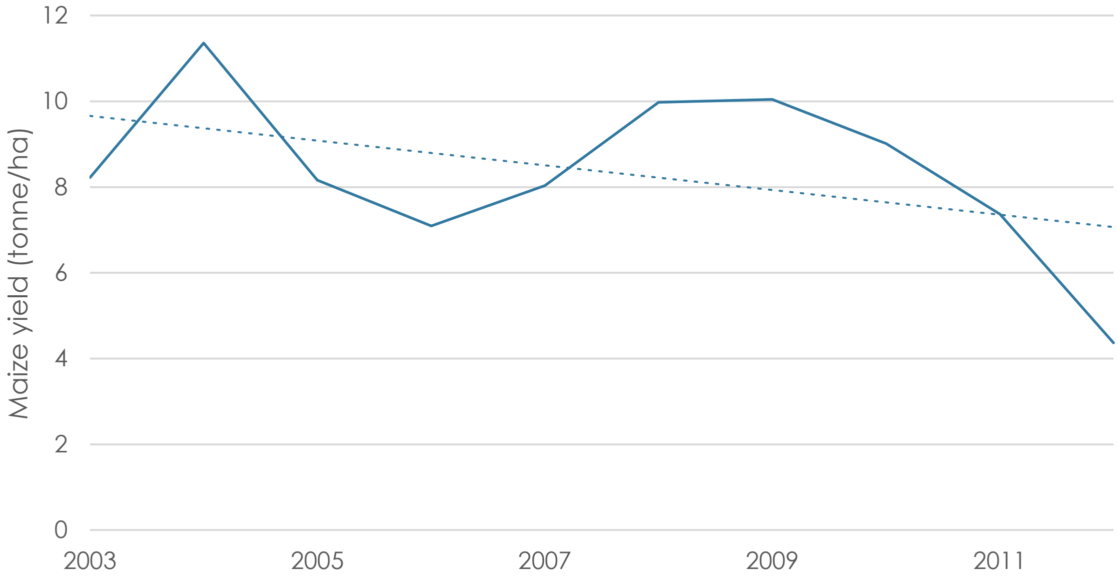


Figure 15. Ten year maize yield trend for Monroe county, Illinois, 2003-2012

What would this mean for crediting low ILUC-risk feedstock production over the next five years (2013-2017) for the imaginary project in Monroe? Figure 16 illustrates four different cases of how many credits could be awarded **for the exact same farm outcomes** given different ways of setting the baseline. First (top left) is the case in which the baseline is set based directly on the calculated local trend for the previous ten years. In this case, because of the strong negative trend, a large amount of credits are calculated – 18 tonnes of low ILUC-risk feedstock per hectare over five years, almost 40% of total corn produced. The top right case illustrates the use of the U.S. yield trend to extend the baseline out, instead of the local Monroe trend – by using national data, the variability at the county level is reduced, and while the calculated yield trend remains negative, it is less so. On this system, instead of crediting 18 tonnes of corn over the five years, we would credit 10 tonnes per hectare.

The bottom left considers the case that in order to be conservative negative yield trends are ignored, and the baseline is set based on a simple arithmetic average over the previous ten years. On this system, only 7 tonnes of corn per hectare would be creditable as low ILUC-risk.

Finally, the bottom right graph illustrates the case of using the long-term U.S. maize yield trend calculated from 1946-2012. Because this longer term trend is positive, the creditable amount of feedstock is further reduced, to 5 tonnes of corn per hectare over five years.

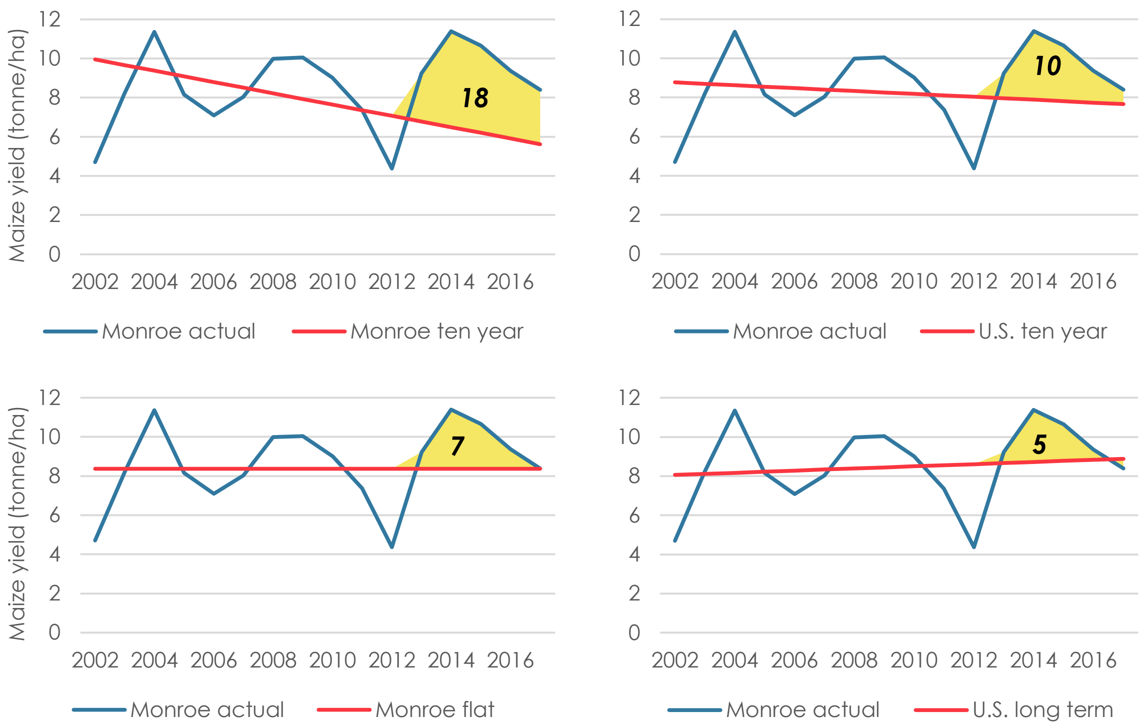


Figure 16. Creditable 'low ILUC-risk' feedstock production in Monroe County calculated based on four different yield trends (red lines), labelled with total tonnes per hectare of production that would be counted as low ILUC-risk feedstock

This example is intended to illustrate two points. Firstly, it illustrates the challenges of setting an appropriate yield baseline, and the sensitivity of a yield baseline calculated over ten years to natural yield variability. Different ways of setting the baseline resulted in a more than threefold increase in the creditable quantity of low ILUC-risk feedstock produced in Monroe County in this period. It is not clear that any one of these baseline approaches is more arithmetically valid than the others.

Secondly, and most importantly, ***there was no low ILUC-risk feedstock production project implemented in Monroe County in this period!*** All of the above-trend yield delivered in the period 2013-2017 in this example was a result of business as usual variation and improvement in agricultural yields, not of novel yield improvement projects. **In the most extreme case, using a low ILUC-risk feedstock production assessment based only on reported yields and with no reference to weather conditions or whether any action had actually been taken resulted in 40% of feedstock production being identified as eligible for certification.** This powerfully illustrates the downside of a low ILUC-risk certification system in which credits generated are based solely on reported yield data. Below, in section 5.1, a novel approach is suggested in which the role of reported yield results in determining credit award is purposefully muted.

B.2. Illustration using synthesised project data

To further illustrate the importance of yield variability in assessing low ILUC-risk biofuel credits, we have created a simple example using a spreadsheet with a random number generator to simulate annual yield data for a hypothetical biofuel project. The advantage of using a hypothetical project is that, based on a set of assumptions, it is possible to 'know' what yields would be achieved with and without the implementation of a fictional yield increase project.

B.2.i) Yield trend and historical 'observed' yields

For the illustration, we consider an idealised farm that would deliver a yield of 4 tonnes per hectare in year zero given 'average' weather, and that experiences an underlying trend yield increase of exactly 0.05 tonnes per hectare per year. This yield trend is illustrated in Figure 17. This is the 'true' yield trend in this example, but in real life the trend must be estimated from actual observed yields. As observed yields are always subject to significant variability, when we estimate a trend based on a limited number of observations (for instance ten years), we cannot guarantee that the estimated value will be close to the 'real' value.

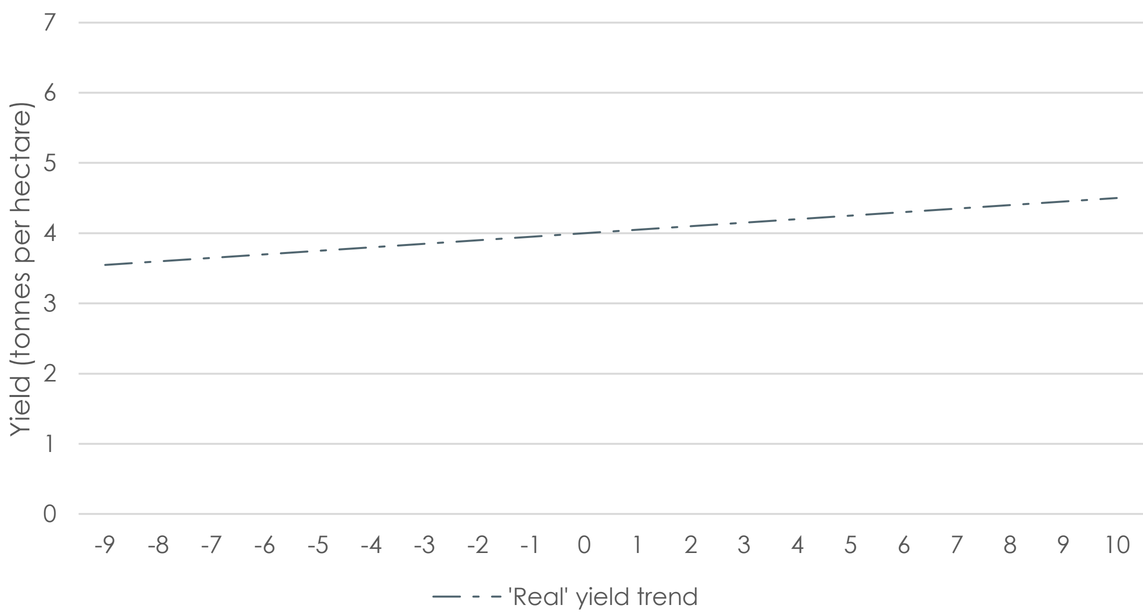


Figure 17. 'Real' yield trend in illustrative example

Building on this assumed underlying yield trend, a simple random number generation scheme has been used to produce an illustrative set of observed yields (i.e. in each year an observed yield is calculated as the sum of the trend yield and a normally distributed random number[46]). This is done from the year -9 through to the year 0 to provide a ten year observed yield trend for the farm, as shown in Figure 18. In the Ecofys (2016) methodology, these observed yield from the farm (or ideally from a group of farms) seeking certification would be used to estimate a trend yield – and this derived trend will generally not exactly match the 'real' underlying trend. This is illustrated in Figure 19. In this case, the yield increase line calculated from the observed data is slightly above the 'real' trend yield.

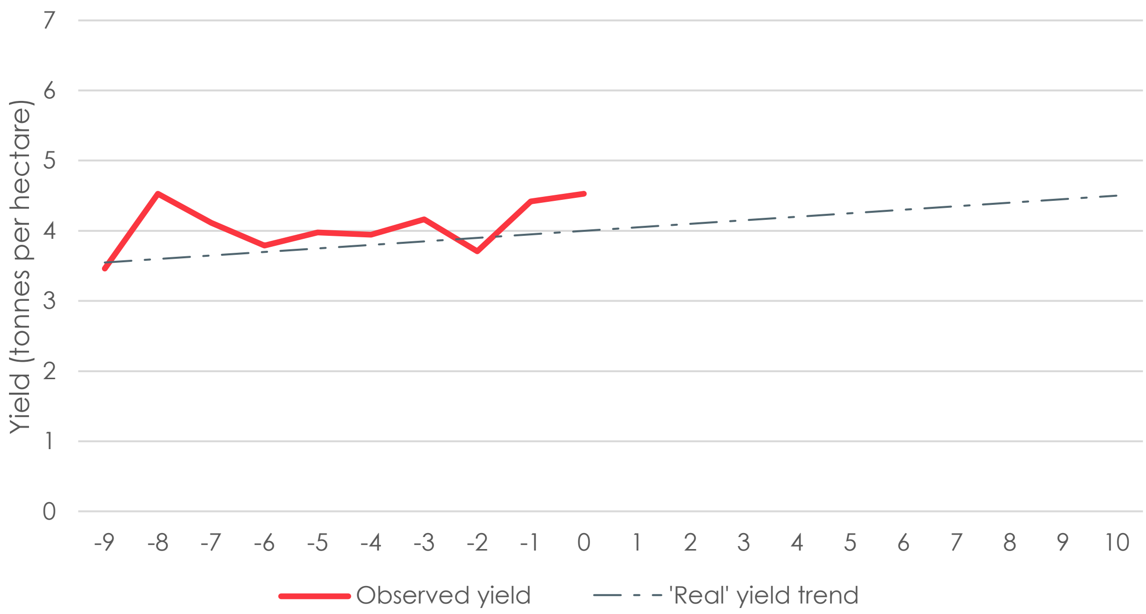


Figure 18. Observed yield for the years -9 to 0 for the illustrative farm

46 For the example, we used standard deviation 0.6 and mean 0 for this yield deviation term. The example is only meant to be illustrative, the yield variation is intended to be broadly consistent with real yield variation but is not based directly on statistical analysis for any given crop or region.

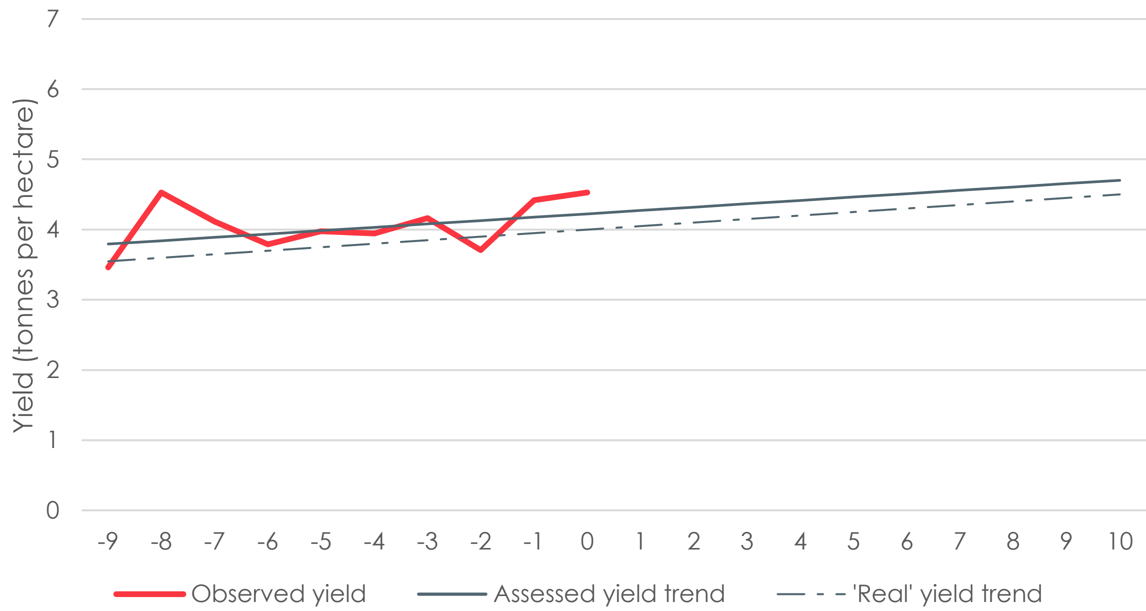


Figure 19. The trend yield calculated based on ten years of observations is above the known 'real' trend yield

B.2.ii) 'Observed' yields and low ILUC-risk feedstock crediting after project implementation

Having set up the yield history for our example project, we now calculate 'observed' yields for the next ten years of project implementation. We assume that the project is expected to deliver an immediate 0.8 tonnes per hectare (20%) yield improvement, and use the same random number generating scheme to calculate illustrative 'observed' yields as shown in Figure 20. In this case, yields for the project appear disappointing in the second and third years, approximately matching the estimated trend, but are above the trend for years four to ten. With yields above the estimated trend in several years, the project would generate 6.7 tonnes per hectare of creditable low ILUC-risk biofuel production under the Ecofys (2016) assessment methodology (Figure 21). This is below the 'real' amount of low ILUC-risk feedstock that we know has been produced (because by hypothesis the yield is 0.8 tonnes per hectare higher than it would have been) – but the certifier could never know this only by a simple analysis of the observed yields.

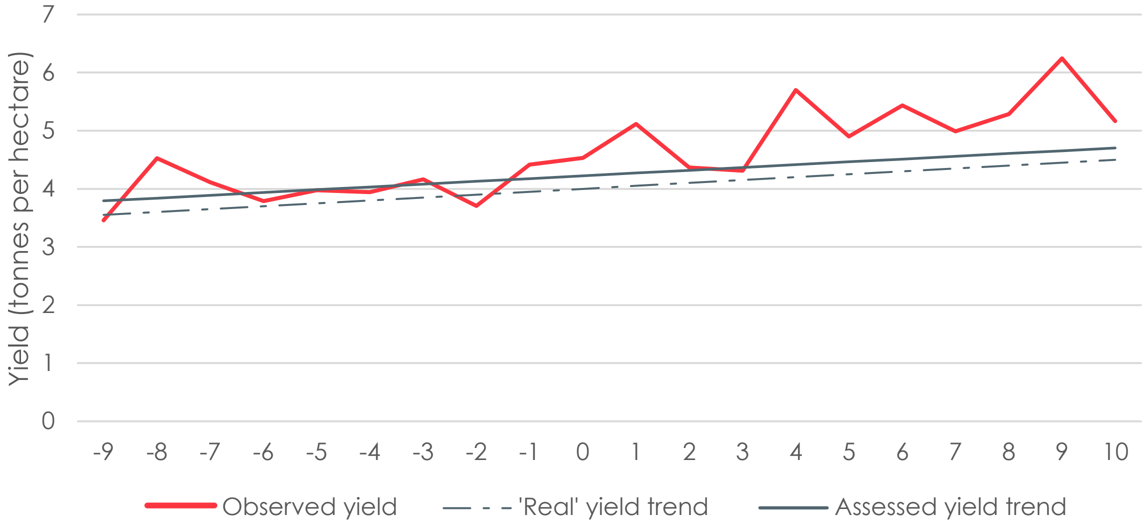


Figure 20. 'Observed' yields for the illustrative project, compared to the estimated yield trend and underlying (unknown) yield trend)

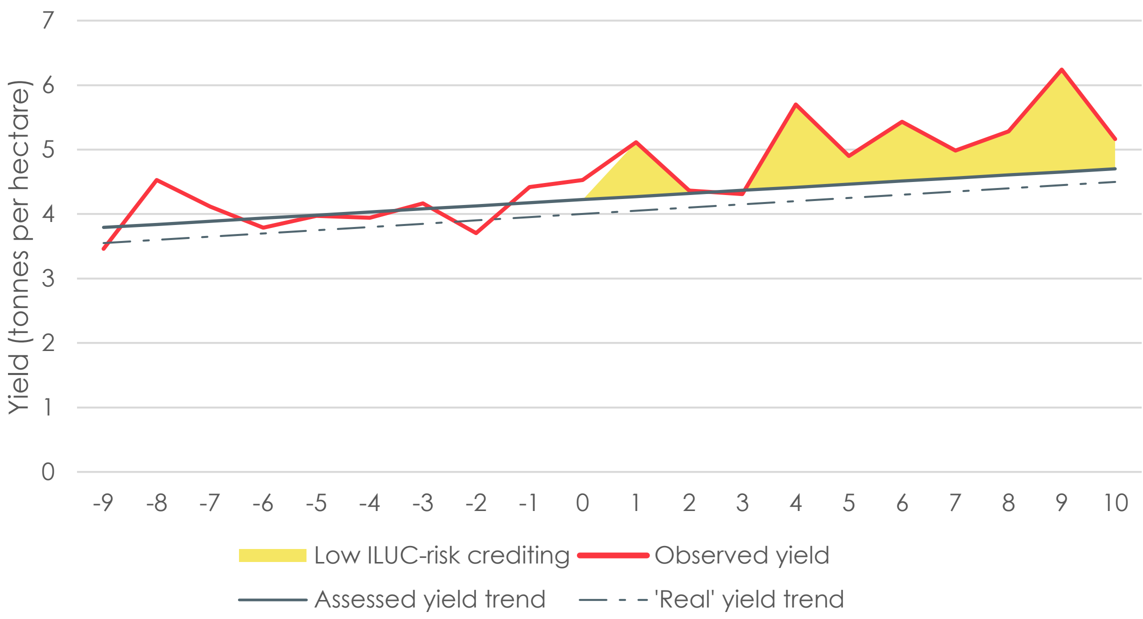


Figure 21. Feedstock to be credited as low ILUC-risk under Ecofys (2016) methodology

This is illustrated in Figure 22, in which we have added a line for the 'reference yield' – the yield that would have been achieved had the low ILUC-risk yield improvement project not been implemented. In real life, of course, this alternative reality case can never be absolutely known.

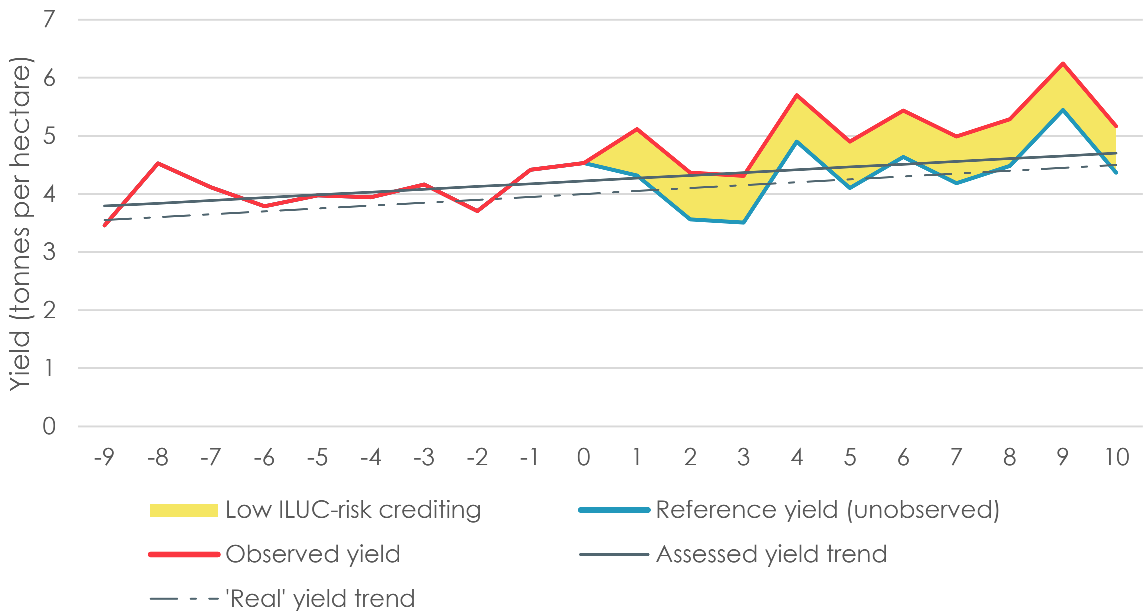


Figure 22. Illustration of the 'real' benefit from the yield improvement project in the example

In this case, the use of the Ecofys (2016) methodology results in the farmer being under-rewarded for the implementation of the yield improvement project, especially early on, but the total level of crediting over ten years is at least comparable to the actual amount of low ILUC-risk feedstock generated. Using the same input assumptions but with a different set of random yield variations, it is possible to come to a quite different outcome.

In Figure 23, we see a case produced using the exact same approach to simulate variability, but where the observed yields for the first ten years were below the long-term trend (due to poor weather, for instance) resulting in an underestimation of the trend yield. This is compounded because the yields delivered for the ten years of project implementation are above what would be expected even given implementation of the project. In this case, the Ecofys (2016) methodology would result in 13 tonnes of credits per hectare being awarded over ten years, which is well above the 8 tonne per hectare 'real' benefit.

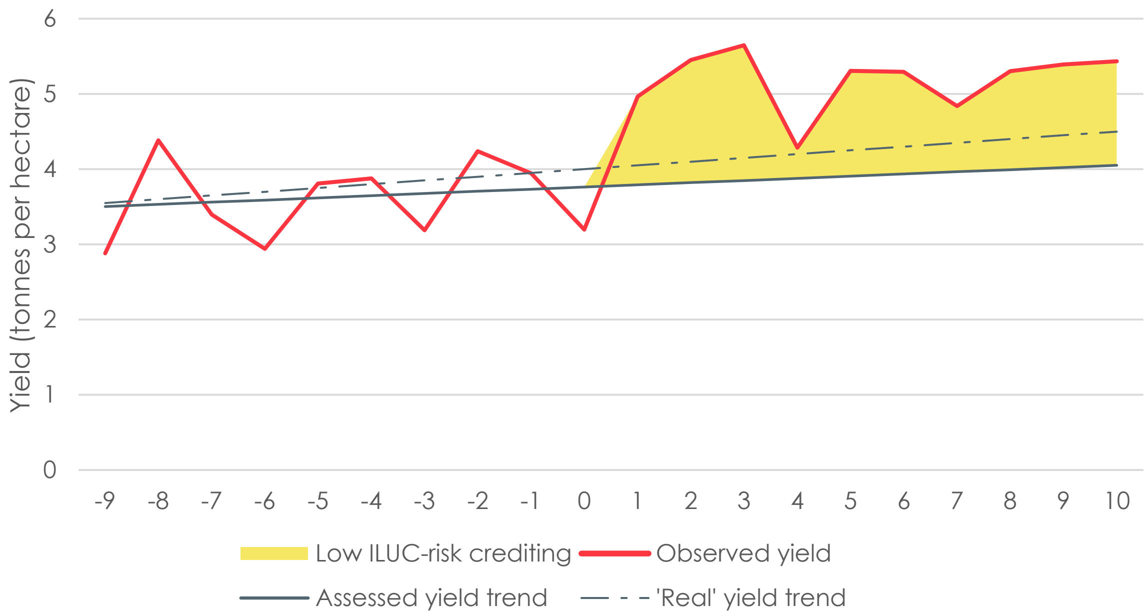


Figure 23. Case in which project is over-credited due to natural variability

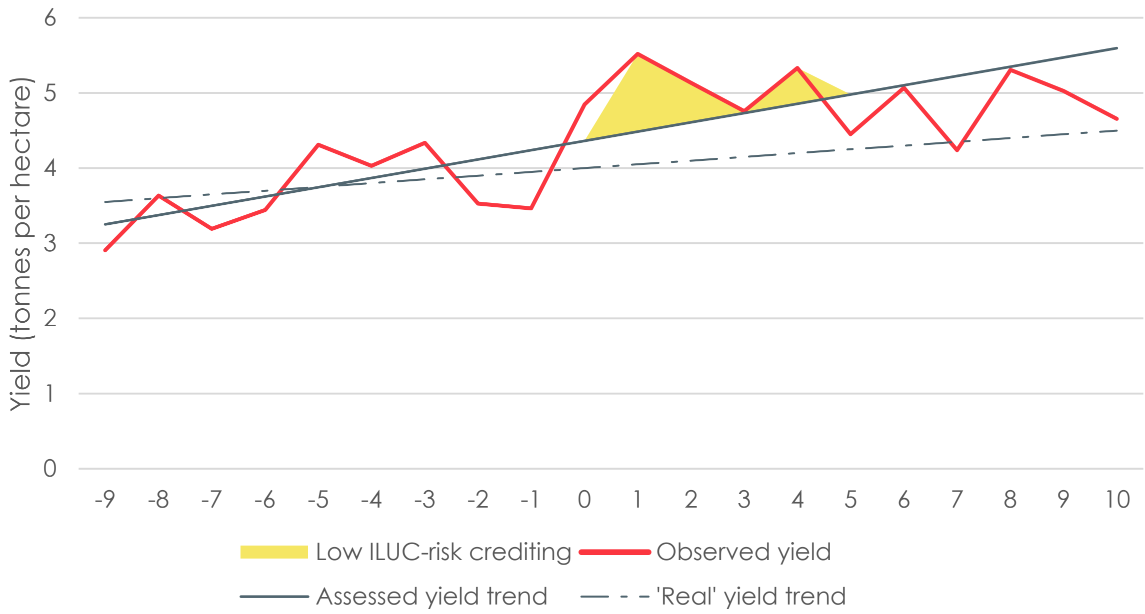


Figure 24. Case in which project is under-credited due to natural variability

The opposite outcome is shown in Figure 24. In this case, the estimated yield trend is above the real underlying trend due to natural variability, while yields after project implementation are lower than would be expected – even remembering that we are assuming that the project is a success and delivers the intended benefit. In this case, despite acting in good faith and successfully implementing the project, the farmer is eligible for only 2 tonnes of credits per hectare under the Ecofys (2016) methodology – that's only 25% of what would have been hoped for.

B.2.iii) Conclusions

The purpose of providing these illustrations is twofold. Firstly, the cases above show that the existence of natural yield variability should be expected to lead systematically to cases of both over-crediting and under-crediting at the project level. Secondly, it should be understood that across many low ILUC-risk projects, the Ecofys (2016) methodology would tend to result in more credits being issued than were in fact warranted. This is because natural variability can result in over crediting, but would never result in negative crediting, so excess crediting due to variability would never be balanced out.

Over-crediting is undesirable, but at the project-level under-crediting is arguably worse, because it could prevent successful yield improvement projects undertaken in good faith from achieving returns on investment. If there is a high risk that a good faith project will fail to deliver credits, farmers will be less likely to commit to investments to improve productivity.

Annex C.Example formal language on criteria for low ILUC-risk certification

C.1. Identification of feedstock production systems that are potentially low ILUC-risk

1) The recast Renewable Energy Directive (2016/0382 (COD)) defines low ILUC-risk biofuels in Article 2(c). Two categories of feedstock may be considered for certification as low ILUC-risk:

    a) Feedstock produced within schemes that avoid displacement effects of food and feed crop based biofuels, bioliquids and biomass fuels through improved agricultural practices.

    b) Feedstock produced within schemes that avoid displacement effects of food and feed crop based biofuels, bioliquids and biomass fuels through the cultivation of crops on areas which were previously not used for cultivation of crops

    Displacement effects of food and feed crop based biofuels, bioliquids and biomass fuels can only be avoided in the case that additional feedstock production is delivered with the intention of introducing those feedstocks into the biofuel supply chain.

2) Improved agricultural practices may avoid displacement effects by allowing additional biomass feedstock to be produced on a given land area as compared to a counter-factual baseline in which those practices were not adopted.

    Additional biomass feedstock production may be achieved by:

    a) Increasing the yield of a single agricultural crop cultivated on the given land area. In this case, the increase in the harvest attributable to the improved agricultural practice is potentially low ILUC-risk.

        For such a feedstock production system, it should be shown that the improved agricultural practices have been adopted as a result of engagement with economic actors in the biofuel supply chain.

    b) Adding an additional crop to an existing crop production system, either by multiple cropping (adding an additional harvest for the additional crop separated from the harvest of the existing crop or crops. In this case, the increase in the combined harvest attributable to the improved agricultural practice is potentially low ILUC-risk.

        For such a feedstock production system, it should be shown that the additional crop or crops is added to the cropping system as a result of engagement with economic actors in the biofuel supply chain.

    c) Adding a crop or crops to an agricultural system producing livestock, without reducing the production of livestock products from the system. In this case, the whole of the crop harvest is potentially low ILUC-risk.

For such a feedstock production system, it should be shown that the additional crop or crops is added to the livestock system as a result of engagement with economic actors in the biofuel supply chain.

3) Cultivating crops on areas which were previously not used for cultivation of crops may avoid displacement effects when it is reasonable to conclude that the land area in question would not have been used for agricultural production in the absence of the feedstock production project. It may be reasonable to conclude that land would not otherwise have been used for feedstock production if:

   a) The land has been abandoned from previous agricultural use, as a result of either an overall reduction in agricultural area in a region, a shift of agricultural area within a region, or degradation in the quality of the land in question.

      For such a feedstock production system, it must be demonstrated that the land was in regular agricultural production within the last thirty years, but has been unutilized for at least the last five years, and is not within a system of shifting cultivation.

   b) The land is demonstrably likely to be abandoned without certification as a low ILUC-risk feedstock production system.

      For such a feedstock production system, economic analysis must be presented to show that continued cultivation would be uneconomic in the absence of engagement with the biofuel industry and certification as low ILUC-risk.

   c) The land has not previously been cultivated (within the last thirty years), but is in a contaminated or degraded state such that it would not be considered fit for conventional agriculture.

      For such a feedstock production system, it must be demonstrated that there is a ready availability of land with more favourable agricultural characteristics in the region in question.

   d) The land has not previously been cultivated (within the last thirty years) and is fit for conventional agriculture, but significant barriers exist such that one would not expect the land to be brought into production without the intervention of economic actors in the biofuel supply chain.

      For such a feedstock production system, the barriers that exist to cultivation must be documented, and it must be demonstrated that it is reasonable to believe that these barriers to cultivation would not be overcome without the intervention of economic actors in the biofuel supply chain.

C.2. General criteria that must be assessed by a scheme for the certification of low ILUC-risk feedstock

1) In order for certification by a scheme of low ILUC-risk feedstock production systems to be recognised for the purposes of the recast Renewable Energy Directive, the scheme must enforce a rigorous set of criteria for the demonstration of low ILUC-risk feedstock production that provide adequate assurance that displacement effects associated with biofuel use are indeed avoided by the system.

2) For any feedstock production system considered for low ILUC-risk certification, it must be demonstrated that the system is in compliance with the sustainability criteria for biofuels and bioliquids set out in Article 26 of the recast Renewable Energy Directive.

3) For any feedstock production system involving the cultivation of otherwise unused land considered for low ILUC-risk certification, annualised emissions from carbon stock changes caused by land-use change must be calculated as required by the Annex V of the recast Renewable Energy Directive, and it must be demonstrated that the fuel produced from such feedstock meets the relevant GHG emission reduction threshold set in paragraph 7 of article 26 of the recast Renewable Energy Directive when these annualised land use change emissions are taken into account.

4) For any feedstock production system involving the cultivation of otherwise unused land considered for low ILUC-risk certification, remote sensing data should be provided to confirm the use history of the land. In the event that remote sensing data is not available, then comparable alternative data sources such as local records or interviews should be used to establish the use history of the land.

5) For any feedstock production system involving increased agricultural productivity, the greenhouse gas intensity of feedstock production must be assessed through an actual value calculation as directed by Article 28 1.b) of the recast Renewable Energy Directive.

6) Any feedstock production system proposed for low ILUC-risk certification must provide to the relevant scheme a documented management plan detailing the type of project, how the scheme developer expects to produce feedstock that avoids displacement effects, and the amount of low ILUC-risk feedstock that the scheme expects to produce if successfully implemented.

7) A low ILUC-risk feedstock production system may be certified by a scheme for at most ten years. After this, should the developer believe that low ILUC-risk feedstock production continues then a new application for low ILUC-risk status should be made.

C.3. Demonstrating that feedstock production has avoided displacement effects of food and feed crop based biofuels, bioliquids and biomass fuels

1) Feedstock production systems may be considered to avoid displacement effects of food and feed crop based biofuels, bioliquids and biomass fuel when they achieve the production of additional feedstock material above the amount of material that would have been produced in a reasonable business as usual counter-factual scenario.

2) Identifying whether a feedstock production system achieves production additional to that which would be achieved in a reasonable business as usual counter-factual scenario requires the assessment of that production system against a set of appropriate additionality criteria.

3) Any feedstock production system seeking low ILUC-risk certification from a scheme may demonstrate additionality by application of the principles of the ‘Tool for the demonstration and assessment of additionality’ of the United Nations Clean Development Mechanism by a qualified auditor. The ‘Tool for the demonstration and assessment of additionality’

is designed for demonstration of the additionality of emissions reduction projects. An auditor assessing a proposed low ILUC-risk feedstock production system using the tool must therefore appropriately interpret requirements in the tool relating to reductions in greenhouse gas emissions for application to increases in feedstock production.

4) *[As an alternative to the use of the 'Tool for the demonstration and assessment of additionality', a scheme may allow additionality for a low ILUC-risk feedstock project to be assessed against a reduced set of additionality criteria, where those criteria provide adequate additionality assurance for a given project type. The reduced additionality criteria appropriate to the certification of projects of each possible type are detailed below in points 5 and 6.*

5) *Criteria for the assessment of the additionality of systems implementing improved agricultural practices:*

   a) *For a project increasing the yield of a single agricultural crop on a given area, feedstock production may be considered additional subject to meeting the following requirements.*

      i) *As part of the project plan, the feedstock producer must provide evidence of a statement of intent indicating the intention of one or more biofuel facilities to take delivery of the quantity of low ILUC-risk feedstock production planned for the project. This may be taken as evidence that the additional feedstock is to be produced with the intention of delivery into the biofuel supply chain.*

      ii) *As part of the verification process, it must be demonstrated that the low ILUC-risk feedstock produced is supplied to one or more biofuel facilities using a segregated supply chain.*

   b) *For a project adding an additional crop to an existing crop production system, feedstock production may be considered additional subject to meeting the following requirements.*

      i) *As part of the project plan, the feedstock producer must provide evidence of a statement of intent indicating the intention of one or more biofuel facilities to take delivery of the quantity of low ILUC-risk feedstock production planned for the project. This may be taken as evidence that the additional feedstock is to be produced with the intention of delivery into the biofuel supply chain.*

      ii) *As part of the verification process, it must be demonstrated that the low ILUC-risk feedstock produced is supplied to one or more biofuel facilities using a segregated supply chain.*

      iii) *A common practice analysis should be undertaken consistent with the requirements for common practice analysis of the 'Tool for the demonstration and assessment of additionality'. If the proposed project activity is identified as common practice, and no essential distinction can be identified that would render this common practice unattractive for the project in question without the intervention of economic actors in the biofuel supply chain, then the feedstock production may not be considered additional.*

   c) *For a project adding an additional crop to an existing livestock production system,* *feedstock production may be considered additional subject to meeting the following requirements.*

- i) *As part of the project plan, the feedstock producer must provide evidence of a statement of intent indicating the intention of one or more biofuel facilities to take delivery of the quantity of low ILUC-risk feedstock production planned for the project. This may be taken as evidence that the additional feedstock is to be produced with the intention of delivery into the biofuel supply chain.*
- ii) *As part of the verification process, it must be demonstrated that the low ILUC-risk feedstock produced is supplied to one or more biofuel facilities using a segregated supply chain.*
- iii) *A common practice analysis should be undertaken consistent with the requirements of the 'Tool for the demonstration and assessment of additionality'. If the proposed project activity is identified as common practice, and no essential distinction can be identified that would render this common practice unattractive for the project in question without the intervention of economic actors in the biofuel supply chain, then the feedstock production may not be considered additional.*

6) *Criteria for the assessment of the additionality of systems producing feedstock on otherwise unutilised land.*

- a) *For a project using land abandoned from previous agricultural use, feedstock production may be considered additional subject to meeting any one of the following requirements.*
  - i) *Demonstrating that total cultivated area has reduced in the region in question for each of the previous five years. For the purpose of assessing this criteria, the region in question should be defined as whatever area within the project's country lies within the same agro-ecological zone as the project area.*
  - ii) *Demonstrating that large areas of uncultivated land are available within the local region with more favourable agricultural characteristics than the land used for the project, and undertaking a common practice analysis for the cultivation of land of comparable quality to the project land, using criteria consistent with the requirements of the 'Tool for the demonstration and assessment of additionality'.*
  - iii) *Demonstrating that cultivation was abandoned on the land in question due to land degradation, and undertaking a common practice analysis for the cultivation of land of comparable quality to the project land, using criteria consistent with the requirements of the 'Tool for the demonstration and assessment of additionality'.*
- b) *For a project involving land likely to be abandoned without certification as a low ILUC-risk feedstock production system, the 'Tool for the demonstration and assessment of additionality' must be used.*
- c) *For a project involving land not cultivated (within the last thirty years), but in a contaminated or degraded state production may be considered additional subject to meeting one of the following requirements.*
  - i) *Demonstrating that the land in question is contaminated and that there are*

regulatory barriers preventing the use of feedstock cultivated on that land for non-energy markets.

ii) *Undertaking a common practice analysis consistent with the requirements of the 'Tool for the demonstration and assessment of additionality'. If use of land of the type proposed is identified as common practice, and no essential distinction can be identified that would render this common practice unattractive for the project in question without the intervention of economic actors in the biofuel supply chain, then the feedstock production may not be considered additional.*

d) *For a project involving land not cultivated (within the last thirty years) and fit for conventional agriculture, the 'Tool for the demonstration and assessment of additionality' must be used.]*

C.4. Determining the quantity of low ILUC-risk feedstock produced by a certified low ILUC-risk feedstock production system

1) For feedstock produced from a project based on improved agricultural practices, the amount of feedstock production that may be certified as low ILUC-risk shall be determined by estimating the increase in feedstock production in the system as compared to a counterfactual case in which the improved agricultural practice was not adopted.

2) After the first year of project implementation for a project based on improved agricultural practices, and at intervals of no more than three years thereafter, the project auditor must assess as part of the verification process whether the improved agricultural practice has been implemented as planned, and whether its operation has been sustained.

   a) Where it is identified that implementation of the improved management practice has been inadequate or unsuccessful, the scheme must provide defined procedures for appropriately reducing the amount of feedstock to be certified as low ILUC-risk, or if necessary for discontinuing project certification.

3) For a project increasing the yield of a single agricultural crop:

   a) The management plan for a project based on improved agricultural practice must detail the nature of the improvements to be made, and provide an evidenced assessment of the expected yield increase that will be delivered by the measure. The expected yield increase of the intended measures can for instance be demonstrated by reference to scientific literature, experience from field trials, information from breeders, or by appropriate calculations.

   b) The potential production of low ILUC-risk certified feedstock is defined as the expected yield increase multiplied by the area over which the improved agricultural practice is applied.

   c) Assuming that the auditor's assessment confirms that the improved agricultural practice has been implemented and sustained, then an amount of feedstock equal to half of the expected low ILUC-risk production identified in the management plan shall be certified.

   d) Certification of the remainder of the expected low ILUC-risk feedstock production shall be dependent on the demonstration of improved annual yield as compared to a calculated baseline yield:

i) The management plan must include the calculation of a yield trend based on yield data from the farm implementing the yield improvement measure for the previous ten years (or as long as is available), and on data regarding the yield trend for the crop being cultivated at the regional level.

ii) The baseline yield in the year before project implementation, shall be calculated as whichever is greater out of: the expected yield in that year based on least squares regression on the last ten years of yield data; or the average yield in the last ten years.

iii) The baseline yield in each year of project implementation shall be defined as plus the trend annual yield growth multiplied by the year, where the trend annual yield growth shall be taken as whichever is greater out of zero and the annual yield increase calculated by least squares regression of yield data at the national or regional level for the last ten years for the crop being cultivated.

e) Where the measured yield is below the baseline yield, no additional feedstock shall be certified as low ILUC-risk.

f) Where the measured yield is above the baseline yield, half of the amount of feedstock produced beyond the baseline yield may be additionally certified as low ILUC-risk.

g) The total amount of feedstock certified as low ILUC-risk in any single year may not be greater than 1.2 times the expected production of low ILUC-risk feedstock in that year detail in the management plan.

h) If after the fourth year of project implementation the average measured yield is below the average baseline yield for the same period, an additional audit to assess the success of implementation of the improved agricultural practice must be triggered. Following this audit, the expected annual production of low ILUC-risk feedstock should be reassessed and revised if appropriate.

4) For a project adding an additional crop to an existing crop production system:

a) The management plan for the project must detail the crop to be added, and provide an evidenced assessment of whether the yield of the existing crops are expected to be affected. The expected yield impact of the intended measures can for instance be demonstrated by reference to scientific literature, experience from field trials, information from breeders, or by appropriate calculations.

b) Where the management plan anticipates no negative impact on yield of existing crops, then the entire production of the new crop may be certified as low ILUC-risk.

i) After the fourth year of project implementation the auditor should assess whether there has been any negative impact on yield of the existing crops. If the assessment is revised, then the management plan must be updated.

c) Where the management plan anticipates a negative impact on yield of existing crops, then only the net additional production after accounting for that negative yield impact may be considered low ILUC-risk.

i) The expected additional production shall be calculated on a crop component basis, where the crop; components to be considered are: oils and fats; protein; sugars; starch. The expected net additional production shall be defined as the net additional mass of feedstock produced subject to the following conditions:

(1) Production of oils and fats in the system must be sustained or increased;

(2) Production of protein in the system must be sustained or increased, unless compensated by increased production of oils and fats.

(3) Production of sugars in the system must be sustained or increased, unless compensated by increased production of oils and fats and/or protein.

(4) Production of starch in the system must be sustained or increased, unless compensated by increased production of oils and fats, protein and/or sugars.

(5) The material certified as low ILUC-risk must have chemical constitution consistent with the balance of crop components for which production is increased (so, for instance, increasing protein production in a system would not allow produced oils from the system to receive low ILUC-risk certification).

ii) Assuming that the auditor's assessment confirms that the improved agricultural practice has been implemented and sustained, then an amount of feedstock equal to half of the expected low ILUC-risk production identified in the management plan shall be certified.

iii) Certification of the remainder of the expected low ILUC-risk feedstock production shall be dependent on the demonstration of improved annual yield summed across all produced crops as compared to a calculated baseline yield. This baseline assessment shall be undertaken in the same way as for a yield improvement project for a single crop, but with the resulting yield baseline decomposed by crop components.

iv) Where the measured yield summed across all produced crops is below the baseline yield summed across all produced crops, no additional feedstock shall be certified as low ILUC-risk.

v) Where the measured yield is above the baseline yield, subject to the crop component hierarchy detailed in paragraph 4(c)(i), half of the amount of feedstock produced beyond the baseline yield may be additionally certified as low ILUC-risk.

vi) The total amount of feedstock certified as low ILUC-risk in any single year may not be greater than 1.2 times the expected production of low ILUC-risk feedstock in that year detailed in the management plan.

5) For a project adding an additional crop to an existing livestock production system:

a) The management plan for the project must detail the crop to be added, and provide an evidenced assessment of whether the yield of the existing livestock system is expected to be affected. The expected productivity impact of the intended measures can for instance be demonstrated by reference to scientific literature, experience from field trials, information from breeders, or by appropriate calculations.

b) Where the management plan anticipates no negative impact on productivity of the livestock system, then the entire production of the new crop may be certified as low ILUC-risk. If productivity of the existing livestock system is expected to be reduced, the project may not be considered low ILUC-risk

i) After the fourth year of project implementation the auditor should assess whether there has been any negative impact on livestock productivity. If the assessment is revised, then certification of feedstock as low ILUC-risk must be discontinued.

6) For a project producing feedstock on land that would otherwise be unused, the whole amount of feedstock produced may be considered low ILUC-risk.

C.5. Requirements for monitoring of low ILUC-risk feedstock production systems

1) Conformity of a feedstock production system with the assessment criteria set by a scheme must be demonstrated at the planning stage of a project ('validation') and confirmed in the first year of a project's operation and at appropriate intervals thereafter ('verification'). Validation and verification must be undertaken by suitably qualified independent auditors.

2) For such auditing, 'group auditing' — in particular for smallholder farmers, producer organisations and cooperatives — can be performed. In such cases, verification for all units concerned can be performed based on a sample of units[47], where appropriate taking into account a relevant standard developed for this purpose[48]. Group auditing for compliance with low ILUC-risk feedstock criteria is only acceptable when the areas concerned are near each other and have similar characteristics.

Where sample auditing is allowable within a scheme, appropriate and dissuasive penalties for scheme participants must be put in place to be applied in the case that a sample audit identifies inconsistent compliance with scheme requirements. Penalties may include disqualification from the scheme, non-award of credits and cancellation of previously awarded credits. Where a scheme provides certification of sustainability aspects beyond low ILUC-risk status, disqualification from those other aspects of certification may be appropriate for participants found to be acting in poor faith and/or shown to be inconsistent in compliance.

3) For both types of audit activity referred to above a verifier should be selected who:

— is external: the audit is not performed by the economic operator or the scheme itself,

— is independent: auditors are independent of the activity being audited and free from conflict of interest,

— has the generic skills: the verification body has the general skills for performing audits, and

47 It is the responsibility of the verifiers to define the size of the sample needed to reach the necessary level of confidence.

48 e.g. International Social and Environmental Accreditation and Labelling Alliance (ISEAL) standard P035 establishing Common Requirements for the Certification of Producer Groups.

— has the appropriate specific skills: auditors have the skills necessary for conducting the audit related to the scheme's criteria.

4) A scheme for the certification of low ILUC-risk biofuels must have clearly defined procedures to be applied in the case that a low ILUC-risk biofuel project is found in verification to be in any way non-compliant with the requirements of the scheme. Where the non-compliance is such as to call into question whether low ILUC-risk feedstock has been produced, these procedures should include non-award of certificates, and where appropriate cancellation of previously issued certificates.

5) A scheme for the certification of low ILUC-risk biofuels must have clearly defined procedures to be applied to a low ILUC-risk feedstock project where verification has identified non-compliance with the requirements of the scheme, in order to rectify the non-compliance. Certification of low ILUC-risk feedstock production should be permitted to resume until it has been appropriately demonstrated that any non-compliance has been resolved.

6) In the interests of transparency, auditors' reports or summaries thereof relating to failed verifications of low ILUC-risk feedstock projects should be made available to the public and legislator via an appropriate online portal managed by the administrators of any recognised scheme for the certification of low ILUC-risk biofuels.