Tracking current and forecasting future land-use impacts of agricultural value chains. 67th Discussion Forum on Life Cycle Assessment, 3rd of November 2017, Zurich, Switzerland.

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Abstract

The 67th Discussion Forum on Life Cycle Assessment (LCA), organised by partners of the European project RELIEF (RELIability of product Environmental Footprints), focused on methods for better understanding the impacts of land use linked to agricultural value chains. The first session of the forum was dedicated to methods that help in retrospective tracking of land use within complex supply chains. Novel approaches were presented for the integration of increasingly available spatially-located land use data into LCA. The second session focused on forward looking projections of land use change and included emerging, predictive methods for the modelling of land change. The third session considered impact assessment methods related to the use of land and their application together with land change modelling approaches. Discussions throughout the day centred on opportunities and challenges arising from integrating spatially-located land use information into Life Cycle Assessment. Increasing amounts of spatially located land use data are becoming available and this could potentially increase the robustness and specificity of Life Cycle Assessment. However, the use of such data can be computationally expensive and requires the development of skills (i.e. use of

geographical information systems (GIS) and model coding) within the LCA community. Land Change modelling and ecosystem service modelling is associated with considerable uncertainty which must be communicated appropriately to stakeholders and decision-makers when interpreting results from an LCA. The new approaches were found to challenge aspects of the traditional LCA approach – particularly the division between the life cycle inventory and impact assessment and the assumption of linearity between scale and impacts when deriving characterisation factors. The presentations from the DF-67 are available for download (www.lcaforum.ch), and video recordings can be accessed online (http://www.video.ethz.ch/events/lca/2017/autumn/67th.html).

1. Introduction – framework for the assessment of renewable raw materials

Materials from renewable feedstocks are associated with a range of impacts relating to the use of agricultural land and any conversion of land for agricultural production. Such impacts are location-dependent but spatially-resolved impact assessments are often hampered by a lack of data, and in some cases, appropriate methods or models. In addition, the current location of agricultural production and their impacts are likely to change in the future due to the consequences of climate change and increasing demand from a growing and increasingly wealthy population. The 67th LCA Discussion Forum, organised in conjunction with the European industrial doctorate project RELIEF (RELIability of product Environmental Footprints) brought together experts from industry, universities, consulting companies and research institutes. Together, they discussed advancements in methods for assessing current and projected future land use and their associated environmental impacts and the use of such methods and data in decision-making.

Sarah Sim from Unilever opened the Discussion Forum by introducing the RELIEF project (for more information see www.relief-project.eu) and the relevance of the discussion topic: i.e. variability in land use and land use change-related impacts and its implications. In explaining the rationale for the structure of the workshop, Sarah shared Unilever's business framework for assessing the environmental impacts of renewable raw materials. The business decision-making context is divided into four quadrants reflecting the scale (supplier vs system) and time horizon (current impacts vs future impacts) (fig. 1). Different methods, models and data are required to supplement LCA when answering questions in the four quadrants of the framework. The first two sessions of the discussion forum were differentiated according to the time horizon of analysis: 1.) retrospective methods for the assessment of current land footprints (relating to the two quadrants on the left-hand-side of the framework in Fig 1) and 2.) prospective methods for modelling future land use change (the right-hand side of the framework). The third session focused on impact assessment methods related to land use and linking such impacts with land change modelling tools. At the end of each session, the speakers participated in a panel discussion.

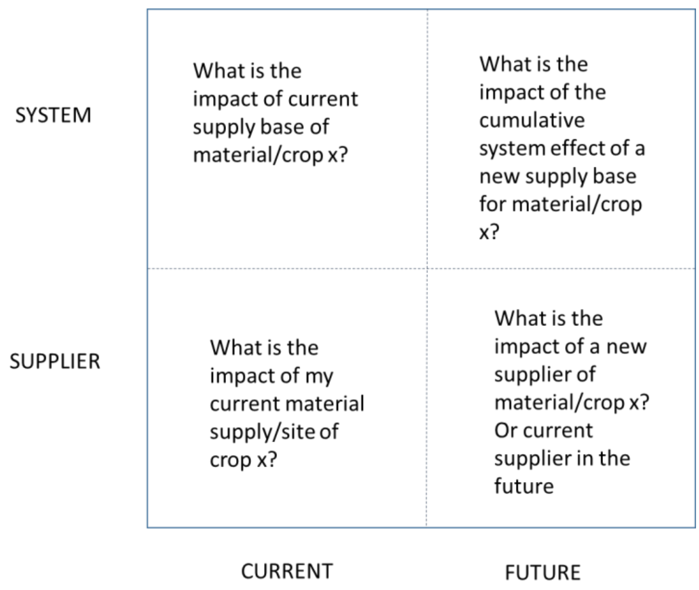

Fig. 1 Framework for assessing environmental impacts of renewable raw materials

2. Tracking and inventorying (current) land use and land use change

The first session covered methods for building robust life cycle inventories to describe land use associated with the current production of renewable materials and any historical land use change.. Such methods are required to answer the type of questions on the left hand side of the framework

(Fig 1). Jürgen Reinhard from Quantis introduced the topic, giving an overview of the development of approaches in ecoinvent and other databases: World Food Life Cycle Database (Nemecek et al. 2014), Gabi (Baitz et al. 2012), AgriFootprint (Blonk et al. 2012) and Agri-BALYSE (Koch and Salou 2013). Land use change was first incorporated in ecoinvent v2.2 for two crops: soybean and oil palm, then updated to include sugarcane and standardised using the method of Nemecek et al. (2016). Ecoinvent now covers all crops using a methodology largely based on BlonkConsultants (2014). Jürgen revealed some on-going developments (e.g. regional disaggregation in Brazil) and highlighted several other areas that require further development: the integration of forest degradation, of country-specific land management practices and propagation of land use change across country boundaries (indirect land use change). Sybrand van Beijma from Agrimetrics followed with a presentation about the use of historical satellite datasets to locate palm plantations in Indonesia and characterise uncertainty and variability in GHG emissions from land use change around mills. Whilst Sybrand's presentation demonstrated how to use satellite data to identify site-specific land use change, it also highlighted differences in GHG estimates of land use change between satellite datasets relating to factors such as imagery (e.g. size of pixels), number of land cover types and frequency of collection. Dan Moran's talk on calculating spatial footprints using Multi Regional Input Output (MRIO) analysis highlighted another approach for tracking land use patterns. His team uses commodity balance sheets and various publicly available data sources, such as the European Union's Emissions Database for Global Atmospheric Research (EDGAR) to derive spatially explicit biodiversity, carbon or air pollution footprints (Kanemoto et al. 2016; Moran and Kanemoto 2016, 2017). Javier Godar presented an overview of the new platform TRASE (Transparency for Sustainable Economies) that aims to improve the provision of data on global commodity flows. The platform uses innovative data sources; for example, custom declarations or real-time locations of shipping vessels to provide detailed inventories of trade flows between companies and countries. Whilst this kind of information could be utilised in the future for assessing environmental impacts of goods in complex supply chains, data availability is currently limited to a small number of commodities, it is expensive and access to some of the data sources has been challenged by some organisations.

In the panel discussion participants highlighted many opportunities and some challenges related to using spatial information in LCA. As new sources of data are rapidly becoming available, they provide a wealth of information and opportunity to make Life Cycle Assessments more refined and more complete. This will allow for better assessment of impacts that are spatially dependent such as impacts on biodiversity and various ecosystem services. Such new sources of information also provide some challenges. For example, uncertainties arise in locating different land use types using satellite imagery (e.g. distinguishing between forests and plantations and disaggregating agriculture into different crop types) and assigning specific carbon values to different land use classes. There are also differences in the availability of data for different geographies and time series. However, it was stressed that lack of information for some regions should not halt progress in integrating spatial data, where available. Although gathering, storing and processing spatial data can be costly, it is expected that the costs will decrease over time. It was also noted that data platforms will need to be more dynamic in the future, perhaps automating data updates and encompassing near 'real-time' monitoring and allowing users to navigate between different spatial scales.

3. Forecasting (future) land use and land use change

The second session focused on approaches to forecast future patterns of land use and land use change, corresponding to questions in the right half of the framework (Fig. 1). Aafke Schipper from the Dutch Environmental Assessment Agency (PBL) gave the first talk of the session and described the development of a high resolution global land allocation model for agriculture, pasture, forestry and urban land claims. The model uses the land allocation model in connection to global biodiversity assessment approach GLOBIO (Alkemade et al. 2009; Schipper et al. 2016). Peter Verburg from the Vrije Universiteit Amsterdam then provided a review of existing approaches to modelling global land use , highlighting sources of uncertainty and proposing areas for further development (Prestele et al.

2016). Potential advantages of predicting changes in more overarching land management systems instead of land use categories was emphasized (Asselen and Verburg 2013). David Leclère from the International Institute for Applied Systems Analysis (IIASA), was the last speaker in this session and presented approaches to link projected economic dynamics with constraints of the physical environment. He highlighted developments in econometric approaches to project both changes in land use area and intensity and how these can be linked to economic relationships in the Global Biosphere Management Model (GLOBIOM) modelling framework (Ermolieva et al. 2016)

In the discussion panel session, questions centred on the communication of uncertainty. An emphasis was put on the need to communicate the uncertainty that matters for particular research questions and stakeholders. Analyses of uncertainty can also enable the further development of models - e.g. partitioning between intensification and expansion of agricultural land currently presents a large source of uncertainty and therefore needs to be developed. As in the first session, the benefits of working at different spatial scales were highlighted. Not all models can run at the global level as trade-offs exist between different model performance criteria such as run time and/or computing cost versus the number of included parameters and the accuracy. Differentiation between different levels of detail can help to ensure the right balance between these criteria for specific application. However, working at different spatial scales also creates the challenge of ensuring consistency between different levels of detail. As different models were developed for different purposes, trying to harmonise or link them often proves challenging. Currently users of models who do not develop them may also find land change modelling approaches hard to apply (e.g. in the LCA context) due to gaps in capability. One way to ease the use of models would be to try to reach consensus in methodologies for a specific use. Models could also be made more transparent e.g. through better documentation, user interface, manuals describing applications and appropriate quantification and communication of uncertainty.

4. Short presentations

This session accommodated four additional talks. Michele de Rosa from 2.0 Consultants presented recent developments in indirect Land Use Change (iLUC) modelling. Wan Yee Lam from Radboud University described an approach for integrating satellite data to estimate spatially explicit greenhouse gas footprints of palm oil production in Indonesia. Xun Liao from Quantis presented on using publicly available trade and production data to estimate supply chain locations for agricultural products. Sebastien Humbert, also from Quantis, presented a draft guidance for assessing impacts of land use change within corporate supply chains.

5. Assessing impacts

The final main session dealt with methodological advances in impact assessment methods of relevance to LCA. Approaches for modelling the impacts on biodiversity and ecosystem services were particularly emphasised. Stefanie Hellweg from the Swiss Federal Institute of Technology (ETH) presented new developments to consider potential regional species loss, using the standard LCA convention (Chaudhary et al. 2015). Tim Newbold from University College London described the PREDICTS database (Newbold et al. 2015, 2016), which includes over 3 million observations linking biodiversity impacts with land use. He presented results of a global biodiversity assessment highlighting that currently over 50% of the global land surface may surpass the planetary boundary - limits of accepted biodiversity loss corresponding to 90% intactness of species abundance. Tim also highlighted needs for future biodiversity assessments, e.g. recognising mixed local landscapes such as agroforestry systems. Perrine Hammel from the Natural Capital Project described a new approach to consider biodiversity and ecosystem service impacts resulting from feedstock sourcing decisions. This predictive, spatially resolved approach is called Land Use Change Improved (LUCI)-LCA (Chaplin-Kramer et al. 2017). The method, demonstrated using a case study to predict impacts of increased demand for bioplastics, connects Land Change models with the ecosystem services model INVEST to estimate spatially explicit impacts that can be incorporated into standard LCA. Finally, Benedetto

Rugani described an approach to link land change modelling with system dynamics and spatially explicit ecosystem service modelling to compare different land use scenarios in Luxembourg.

The panel discussion revealed that additional research is needed to address uncertainties but more importantly to integrate the new approaches into standard Life Cycle Assessment. Discussion focused on whether some of the standard components of the LCA framework, like the clear separation of inventory and impact assessment or the need for linear characterisation factors, still hold with mounting evidence of non-linear responses in earth systems to human pressures and the new developments in spatially-explicit approaches for the development of inventories and for assessing impacts. Presentations and discussions demonstrated the possibilities and the need for integrating results which are the outcome of geographical, ecological, ecosystem and economic models for more refined impact assessment.

6. Synthesis

The day was summarised by Sarah Sim from Unilever. She noted that talks throughout the day incorporated science from a variety of disciplines: economics, ecology, systems science, geography as well as traditional LCA approaches. This is immensely encouraging but also presents challenges for harmonising the outputs of different models, e.g. linking results at different spatial scales. A clear research agenda emerged for the development of nested models representing (non-linear) impacts at different levels of granularity. In relation to forecasting future land use change, better modelling of economic shocks may also be required to predict likely effects of large-scale demand shifts in the future. There are implications for the 'data machine' needed to feed these models, e.g. automated or more frequent acquisition, processing and structuring of spatial, economic, biophysical and agent-based / behavioural data. These observations highlight a skills gap in the LCA community, although some practitioners are already accomplished in the use of Geographical Information Systems (GIS), economic models and various methods of coding.

For methods to be useful within business or policy decision-making contexts, the choice of methods and articulation of uncertainty in results need to be consistent with the type of question considered. Within Unilever, scale (supplier vs system) and time horizon (current vs future) have been usefully employed to frame questions about the environmental impacts of renewable materials, as well as for model and data selection and development. This framework is expected to be relevant for other organisations and may help guide research in this area.

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