Enhancing Land Use Change modelling with IO data

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1. Introduction

Land Use Changes (LUC) are responsible for around 11% of global GHG emissions, nearly the same as the transport sector. This is about half of the GHG emissions from coal-based electricity production worldwide. LUC do not only cause impacts related to GHG emissions, but are also largely responsible for biodiversity losses and health impacts caused by forest fires. This indicates the importance of including LUC effects in LCA. However, LUC are often excluded because ascribing the LUC to their drivers distinguishing between production sectors is challenging and requires a complex global inventory data modelling.

In order to address this, 2.-0 LCA consultants has been developing a model for indirect LUC (iLUC) modelling in LCA[1,2] since 2011 as part of a crowdfunded project. The model has been applied to more than 50 LCA studies and on several product categories. Recently, the model has been integrating into the multiregional hybrid Input-Output model EXIOBASE[4], thus providing an unprecedented level of detail in iLUC modelling.

2. Materials and methods

The model is based on the following assumptions: (i) changes in land demand drives land use changes; (ii) there is a global market for land; (iii) the market is divided by different market segments for different potential land uses of the land. The model establishes cause-effect relationships between the demand for land and effects on land transformation and agricultural intensification in the global market.

Differentiation between use of land among regions of the world is based upon information on potential land productivity in different locations. The land market modules of the model contains data on time-series of land use data and agricultural production data for all countries. The IO data allow identifying the land supplied by each country, by expansion of the cultivated area as well as by intensifying existing agricultural land, and linking the production trends with the land use trends. EXIOBASE models the complete global economy divided in 47 countries and region, each of them divided in 164 industrial sectors. The agricultural and land use module in EXIOBASE make use of FAOSTAT[4] data, which provide time series on area and production per crop. To have comparative yields, all crops are converted to dry matter. These data allow modelling the global supply of land (Fig. 1) to the global market for land, distinguishing between land expansion (land transformation) and land intensifications (increased production per unit of land). Analogously, the demand side is modelled for every country using land for crop cultivation, pasture, forestry and other purposes.

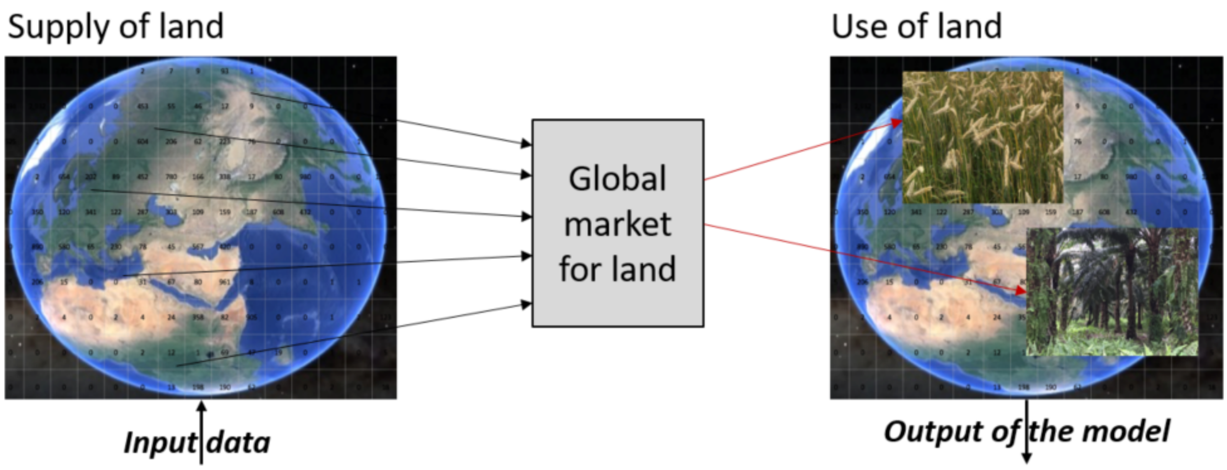

Figure 1: Illustration of the global supply and demand of land based on EXIOBASE data and the FAOSTAT time series on production, yield and area per crops.

The land transformation and intensification LCA activities are populated with data on carbon stocks of different land use types in all countries, and time series of fertiliser use in all countries. The current version of the model (version 4.3) includes the following elementary flows: emissions of CO_2, N_2O, NO_x, NO_3^-, NH_3 and resource inputs of accelerated denaturalisation caused by transformation of land. The iLUC model can be combined with any life cycle impact assessment (LCIA) model, though the nature occupation (biodiversity) impact category can currently only work with a new version of Stepwise[5], because this is currently the only LCIA method that can deal with temporal effects on land transformation.

3. Results and discussion

The integration of the iLUC model in the multiregional hybrid Input-Output model EXIOBASE provides an unprecedented level of detail in describing the global land supply and demand that allows tracing the cause-effect relationship between land use and actual LUC impacts. The model can be used in combination with other LCA databases in LCA software or it can be used on a factor basis with impacts per unit of productivity weighted land use. It is user-friendly, because it does not require additional data collection for the LCA practitioner, and the results are intuitively easy to understand and to visualise in contribution analysis in LCA software.

The framework has been applied to more than 50 LCA studies on several product categories[1]. Overall, the results show that for agricultural crops, iLUC increases the GHG emissions with 100-200%, for beef cattle 20-60%, for pigs 40-80%, for dairy products 40-60%, for wood products 50-300%, and for primary plastics 2-15%.

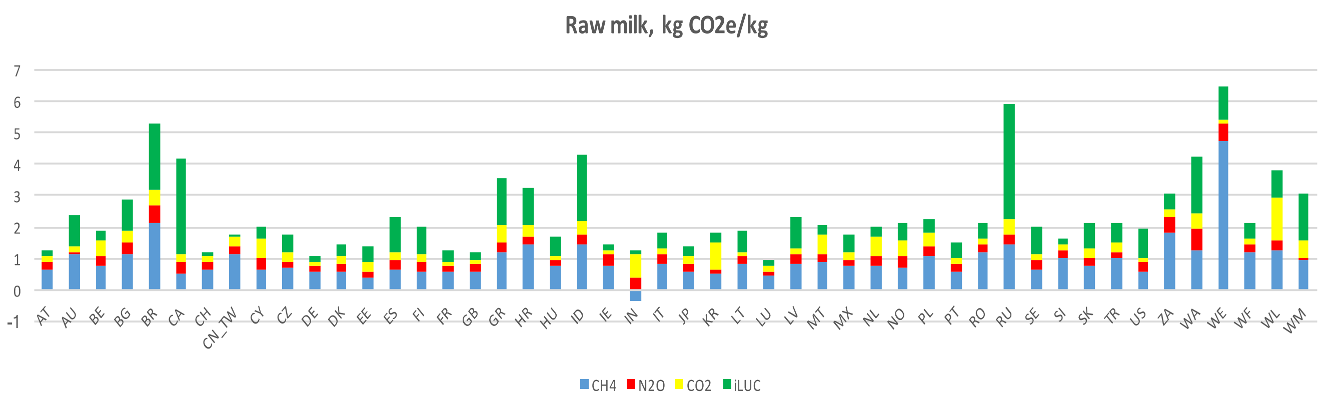

Figure 2: Contribution of iLUC expressed in kg of CO_2-eq. per kg of raw milk in different countries. The contribution from iLUC depends on the location due to the different Net Primary Productivity (NPP_0) of land and yield differences among countries.

Fig. 2 shows results obtained with the iLUC model integrated into the EXIOBASE database for 1 kg of milk produced in different countries as an example. In many cases, the resulting GHG emissions are more than twice when iLUC is accounted.

4. Conclusions

The model is location agnostic and can be applied to any decision-making context concerning long-term effects of small-scale changes. The iLUC framework is now integrated in the global EXIOBASE model, thus accounting for all crops in all countries in the world. There is potential for improving the regionalization of the market for land in order to improve the identification of final land use impacts.

5. References

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