Improved time accounting in the estimation of GHG emissions from indirect land use change

To estimate greenhouse gas (GHG) emissions from indirect land use change (ILUC), it is necessary to estimate the *amount* of land affected, the *types* of land affected, and the *carbon sequestration potential* and *carbon stocks* of the land affected.

In current ILUC estimations, the amount of land (indirectly) affected is typically determined relative to the underlying development in land use; the baseline. This is to determine the *additional* land being cultivated as a result of biofuels feedstock production on existing agricultural land. This additional land is then characterized in terms of land cover, carbon sequestration, and carbon stocks.

The last step in the estimation of GHG emissions from ILUC caused by biofuels is 'time accounting' in which a given amount of the ILUC emissions is ascribed to one unit of biofuels. At present, this is typically done by dividing the total ILUC emissions with the volume of biofuels produced at the existing agricultural land during an *assumed* biofuels production period. This approach does not incorporate the baseline (i.e. the constant land use changes caused by population growth, changing regional profitability of agriculture, etc.) and the result of the approach is highly dependent on the assumed biofuels production period, which is basically arbitrary.

This paper briefly outlines how the estimation of ILUC emissions from biofuels can be significantly improved by taking the 'land use baseline' into account, not just in the estimation of the amount of land affected but also in the time accounting step.

To begin with, the baseline needs to be established. Bruinsma (2009) predicts that cultivation of arable land will increase in the developing world up to 2050 whilst it will be decreasing in the developed world (resulting in a net increase). These projections represent a crude dynamic baseline being the background on which biofuels production should be viewed. Note that the baseline is regionally dependent. In some parts of the world, arable land use is increasing, in others, it is falling. The question is what the *additional* land use and climate effects of biofuels will be in this dynamic system. First, a baseline with increasing arable land use is considered.

If biofuels production (indirectly) leads to additional cultivation of land in a region where arable land use is already increasing, the additional (indirect) effect of biofuels production will be to speed up the expansion of agricultural land use. New land will thereby be taken into production earlier than it otherwise would have been. If biofuel production takes up a given amount of existing agricultural land for a year, another amount of new land will come into production one year earlier than it otherwise would have had (ILUC). If biofuels production is maintained in the next year (on the same existing agricultural land), yet another area of land will come into production one year earlier than it otherwise would have had. Notice that the two subsequent years of biofuels production each have the same ILUC effect (independent of any assumed production period).

Based on the projections by Bruinsma (2009), the 'accelerated expansion' described above would typically occur in the developing world (where land use expansion is already taking place). In the developed world where future arable land use is predicted to decline, the indirect effect of biofuels would be a delay in the release of agricultural land. Here, one year of feedstock production would indirectly postpone the reversion of a given amount of land by one year. Another year of biofuels feedstock production (on the same existing agricultural land) would again (indirectly) delay the reversion of an area of agricultural land by one year. As in the case of an expanding baseline, the

ILUC effect would be the same for two subsequent years of biofuels production when baseline land use is contracting (independent of production period assumptions).

In both situations (accelerated expansion and delayed reversion), the atmosphere will contain more carbon than it otherwise would have had during a period of one year. For 'accelerated expansion', carbon stocks will be released earlier and, for 'delayed reversion', carbon will start to be sequestered later than in the baseline. This must be weighed against the direct GHG emissions avoided by substituting fossil fuels with biofuels.

Direct emissions are typically measured in GWP(100), i.e. the cumulative radiative forcing (CRF) of an emission relative to the CRF of a (pulse) emission of one unit of CO_2 seen over 100 years. In order to calculate an ILUC factor consistent with the unit for direct emissions, the following approach can be used.

First, the CRF of the emissions from the land indirectly affected by biofuels production is calculated for a 100 year period. Secondly, the CRF within the same period of time is calculated for the same land area but for the emissions that would have occurred in the baseline (a shift in emissions by one year). The difference in CRF between these two situations is then divided by the CRF of a pulse emission of one unit of CO_2 seen over 100 years. This procedure will result in an ILUC factor equivalent to the GWP(100) – consistent with the unit used for direct emissions.

In the case of accelerated expansion, the ILUC emissions will consist of above- and below-ground carbon being released into the atmosphere. In the baseline, the same emissions will occur only one year later. In the first baseline year, carbon sequestration will take place but this will again be lost as a result of the conversion happening after a year.

In the case of delayed reversion, the ILUC emissions will be zero in the first year and thereafter carbon will be sequestered year by year. In the baseline, carbon sequestration will take place from the beginning, i.e. the difference in atmospheric concentrations will be one year of carbon sequestration.

While the procedure described above is independent of an assumed biofuels production period, it does require knowledge about the land use baseline. However, it is important to stress that it is only necessary to know how the baseline develops at the time when biofuels are produced. If a piece of land comes into production one year earlier than it otherwise would have had, it must be assumed to follow the same trajectory after one year as it would have had in the baseline. Likewise for delayed reversion; if a piece of land goes out of production one year later than it otherwise would have had, it must be assumed to follow the same path after one year as it would have had in the baseline.

Assumptions about the production period however do have some relevance. The reason is that if 30 years of biofuels production are to be considered, the land use baseline must be projected 30 years into the future.

Reference

Bruinsma J (2009): *The resource Outlook to 2050. By how much do land, water and crop yields need to increase by 2050?*, FAO Expert meeting on how to feed the world in 2050, 24-26 June 2009.