Constraining the need for more land:

Managing crop production, land use, biofuels and iLUC

Note to the Commissie Duurzaamhiedsvraagstukken Biomassa

Introduction

This note has been prepared at the request of the Commissie Duurzaamheidsvraagstukken Biomassa (Commission on Sustainability issues of Biomass; further referred to as CDB). CDB elaborates issues of sustainable biomass for bioenergy (mostly biofuels) production. This is done from the Dutch perspective, i.e. domestic production plus imports from mostly tropical areas. CDB is also known as the Corbey Commission. This note is focussing exclusively on CDB's advice[1] on the way indirect land use change (iLUC) effects can be incorporated in biofuel sustainability policies.

Aspects of assessing land use change impacts will be discussed, as will be their consequences for implementation in policy. The note offers information on the following issues: trends in biofuel production and land use, modelling land use for biofuels, and iLUC policy implications. The paper ends with a short discussion and some conclusions.

Biofuel production and land use

Table 1 provides recent production figures for biofuels around the world. After a period of high growth, average ethanol increase in 2009 has been moderate (+8% on a global basis) while biodiesel production rose with 20%. Strongest growth in ethanol was realised in the USA and (although very modest in absolute terms) Africa, while Brazil, Colombia and the EU showed largest increase for biodiesel. The USA has overtaken Brazil as major producer of bioethanol, while Europe still is the main source of biodiesel.

Table 1 Biofuel production (bln l)

	Bioethanol		Biodiesel	
	2008	2009	2008	2009
North America	34.7	40.5	1.7	1.9
Latin America	27.9	26.9	2.3	3.0
Asia / pacific[1]	2.7	2.7	1.0	n.a.
Africa[1]	0.1	0.1	n.a.	n.a.
Europe	2.7	3.2	8.8	10.5
World	68.0	73.3	13.7	16.4

[1]Figures for Africa and 2009 figures for Asia could not bee obtained.
Source: ethanol figures taken from BP[2]; biodiesel figures from EBB[3] (figures for Europe), DOE[4] (USA), and several online reports (Latin America[5])

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[1] CDB, 2009. Make agriculture part of the solution! Recommendation on Indirect Land use Change (ILUC). http://www.corbey.nl/index.asp?page_id=150 (accessed 17 August, 2010).

[2] BP, 2010. Statistical review of world energy. http://www.bp.com/productlanding.do?categoryId=6929&contentId=7044622, accessed 18 August, 2010.

[3] Source: http://www.ebb-eu.org/stats.php#, accessed 18 August, 2010.

[4] http://www.eia.doe.gov/emeu/mer/renew.html, accessed 18 August, 2010.

[5] http://news.xinhuanet.com/english/2009-11/07/content_12404264.htm, http://www.thebioenergysite.com/articles/371/argentina-biofuels-annual-2009,

While historic production improvements are impressive, further increases are needed to fulfil the growing demand for biofuels as fostered by ambitious blending policies mainly in the USA and Europe but also elsewhere. There is no doubt that this will have implications for land use: more crops will be needed. This note discusses what impact this may have on land use change. But first we take a look at the way crop production increases have been realized in the past.

Crop production increases

In contrast to what commonly is assumed, spectacular food production increases of the past did not require large increases in land demand. Total cereal area increased with less than 10% since 1961, and production increases must be mostly attributed to yield improvement (Table 2). Cereal yields more than doubled, rising from 1.4 tonne/ha in 1961-1963 to 3.3 tonne/ha in 2005-2007. The largest improvements were realized in North America, Europe and Asia; increases in Oceania and Africa being far less impressive.

Table 2 Cereal production, area and yield since 1961

Continent	**Production (mln tonnes)**		**Area (mln ha)**		**Yield[1] (tonne/ha)**	
	1961-1963	2005-2007	1961-1963	2005-2007	1961-1963	2005-2007
Africa	51,3	146,3	58,7	104,8	0.9	1.4
South America	37,9	123,7	27,4	36,4	1.4	3.4
North America	193,8	422,5	80,6	78,3	2.4	5.4
Asia	349,2	1111,8	274,5	327,0	1.3	3.4
Europe	265,0	409,3	192,7	120,9	1.4	3.4
Oceania	11,1	28,0	9,1	18,9	1.2	1.5
Total/average	908,3	2241,6	643,0	686,3	1.4	3.3

[1] Yields are presented as three-year averages.
Source: FAOSTAT (2010)

Developments for other crops have not been so spectacular, as cereals receive more attention in research and inputs during cultivation. Yield improvement shave, further, showed strong fluctuations, alternating periods of strong growth with (like the 1960's in North America and Europe or the 1970s and 80s for Asia) by periods of relatively slow development (Table 3).

Table 3 Average annual yield increase since 1961 (kg/ha/y)

Continent	**Decade**					
	1961-1971	1971-1981	1981-1991	1991-2001	2001-2007	1961-2007
Africa	8	19	1	15	25	12
South America	15	40	43	83	51	41
North America	97	32	52	85	84	60
Asia	40	61	53	36	56	43
Europe	71	15	60	53	6	45
Oceania	0	14	52	-3	-92	14
Total/average	49	41	43	37	39	39

[1] Yields are presented as three-year averages.
Source: FAOSTAT (2010)

As most biofuels still are made of food crops, biofuel production competes directly with food production for crop feedstocks, land and inputs. One of the main questions is how much room exists for increasing biofuel feedstock demand. Giving the growing demand for food – and prevailing incidence of hunger and malnutrition especially in Africa – considerable efforts will be needed to increase crop production on behalf of food requirements.

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http://gain.fas.usda.gov/Recent%20GAIN%20Publications/General%20Report_Bogota_Colombia_5-8-2009.pdf. All accessed 18 August, 2010.

Global land availability is, however, very large be it that not all land is of sufficient quality. Some 5 billion ha of the earth's 13 billion ha of land is classified as agricultural, alongside with 4 billion ha of forest. Agricultural land consists mostly of grassland, only 1.4 billion ha being arable land. It is assumed that a considerable part of available good – productive – land has already been opened. Consequently, nature land – or any other land – that is converted to agriculture has a good chance of being less productive.

Thus we see that historic production increases were mostly depending on yield increases. Expansion of arable areas, with some exceptions, has been limited. Yield improvements have been realized for all crops, but they have not been uniformly distributed over the world, nor have they been stable. This suggests that conditions required for yield improvement are not always met..

Modelling land use for bioenergy

Given the increasing demand for food, combined with policy driven needs for biofuel feedstocks, and awaiting development of technologies that allow biofuel generation from non-food feedstocks, on the short run we will be confronted with increasing competition for crop material and, hence, for land (inputs). Following the rising demand for quantified information on land competition fuelled by biofuel production quota, a number of studies have analysed the role of biofuels as competitors with food (demand and) production for land. It is beyond the scope of this note to discuss modelling exercises in detail. Instead, results of some recent evaluation studies are presented.

Croezen et al. (2010[6]) compared different studies assessing iLUC and its impact on GHG emissions from biofuels. They identify two main approaches: (i) the use of economic models to assess the combined impact of future population and income growth – on the one side – and biofuel crop demand – on the other side, and (ii) the use of generic iLUC factors to be applied in GHG balance calculations as proposed by CDB. Outcomes of major biofuel modelling exercises (including work by IIASA, IFPRI, JRC, Purdue and LEI) are compared, and ranges of calculated GHG emissions caused by iLUC are presented. Extra land needed to fulfil existing biofuel targets is presented in Table 4. This varies between 0.2 (for a scenario with high yield increases) and 15 mln ha. Average land requirement is 7.7 mln ha, 17% of which is found in the EU, the remainder in exporting countries (mostly Brazil and other Latin American countries). Note that in some cases (notably under Aglink's high yield growth scenario); net land use change can be negative, thus releasing land.

The authors evaluate several ways to assess iLUC impacts on GHG reductions by biofuels: (i) applying the highest GHG impact calculated by any of the models, (ii) applying an average iLUC value from all model results, (iii) applying a crop specific iLUC factor based on model GHG calculations, and (iv) applying a more generic iLUC factor based on biofuels land use statistics. According to Croezen et al., the last option (iv), requiring no complex modelling, is the most practical approach.

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[6] H.J. Croezen, G.C. Bergsma, M.B.J. Otten and M.P.J. van Valkengoed, 2010. Biofuels: indirect land use change and climate impact. Delft, CE Delft.

Table 4 Land needed to fulfill current EU biofuel targets (mln ha)

Continent	**Aglink**		**IFPRI**		**Banse**	**Average**
	BAU	HY	BAU	FT		
EU	1.5	0.8	0.8	0.5	4.0	1.5
Africa	0.2				1.0	0.2
South America	1.7	1.0	5.2	7.3	6.0	4.2
North America	0.4	-0.01				0.1
Asia	0.6	-0.4	0.2	0.2		0.1
Russia	0.4	0.2	0.6	0.6		0.4
Oceania	0.3	0.1				0.1
Other (not specified)	0.2	-1.6	1.3	1.2	4.0	1.0
Total	5.2	0.2	8.2	9.8	15.0	7.7
EU as share of total	28%	%	10%	5%	27%	17%

Source: Data presented by Croezen et al., 2010

More details of the models and their outcome are provided in a JRC study (Edwards et al., 2010[7]). Model outcomes are compared by expressing land use increases due to biofuel expansion as marginal values (extra land needed for a given unit of biofuel energy), thus ruling out differences in assumptions, time-frame, etc. An overview of the outcomes is presented in Table 5.

Table 5 Extra land needed to generate 1 MToe of energy to fulfill EU biofuel targets ('000 ha)

	Ethanol		**Biodiesel**			**Model owner/operator**
	EU	US	EU	US	Far east	
Aglink	574	510	230	242		OECD, Paris
Fapri	394		435			CARD, USA
Impact	116-223	107-223				IFPRI, Washington
G-TAP	794	165	376		82	Purdue, USA
LEI-TAP	731	863	1928		425	LEI, the Netherlands
CAPRI						LEI, the Netherlands

Source: Data presented by Edwards et al., 2010

LEI-TAP generally provides the highest land requirement assessments; Impact the lowest. According to Croezen et al., models do not only show large differences in estimated land requirements. They also differ as to which region is to provide necessary crop feedstocks.

A second JRC study (Burnell, 2010[8]) provides a detailed comparison of three models: Aglink, ESIM (Banse) and Capri. The models were used to assess the impacts of the current EU biofuels policy on land use and on agricultural production. Results and model specifications are compared. The models show large differences with respect to level of aggregation (commodities, land units), which makes it difficult to compare spatial outcomes in a disaggregated way. Models also have different methods to incorporate policies, or biofuel supply and demand or in the way by-products are generated during biofuel production.

Given these differences, it comes as no surprise that modelling outcomes seem insufficiently unanimous as to predict what (indirect) land use effects the EU policy will have. Large differences are found as to what areas will be needed, both within and outside Europe, what crops will have to be produced and what GHG effects displacement of current food production may be expected.

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[7] R. Edwards, D. Mulligan and L. Marelli, 2010. Indirect land use change from increased biofuels demand. JRC, Ispra, Italy.

[8] A. Burnell (ed.), 2010. Impacts of the EU biofuel target on agricultural markets and land use: a comparative modelling assessment. JRC-IPTS, Sevilla, Spain.

It must, therefore, be concluded that reliability of current model outcomes is insufficient to generate the information required to asses GHG impacts of iLUC for policy applications. Models appear sensitive to assumptions and aggregations of data and outcomes, while essential elements of biofuel production such as generation of co-products still are not fully accommodated. It must be feared that it will take some time before modelling outcomes can play a direct role in iLUC policy design.

A generic approach

In an attempt to assess the impact of Europe's biofuel policies on land use change, we will use results of a review study based on an extensive expert consultation. King (2010[9]) estimated future European biofuels related imports. By 2020, more than 50 mln tonnes of materials (fuels, biomass) will have to be imported: mostly ethanol, (15 bln litres or 12 mln t) and vegetable oil, plus 36 mln tonnes of biomass (presumably soya from North and Latin America, wheat from Ukraine, Russia plus cassava from Africa; Table 6).

Table 6 Future (2020) biomass and biofuel imports to Europe

	Ethanol	Vegetable oil	Biomass	Total
	Bln l	Bln l	Mln ton	Mln t
North America	29.0			29.0
Brazil	0.5	3.5	13.1	13.6
Ukraine	1.3			1.3
Russia	3.8			3.8
Africa	1.2		2.5	3.2
Australasia		4.1		3.3
World	35.8	7.7	15.5	54.1

Source: calculated from King (2010)

Land requirements to fulfil Europe's 2020 import needs can be calculated at 20 mln ha (Table 7), most of which are in the USA (10 mln ha) and Brazil (6 mln ha) plus Ukraine and Russia (exact estimation will depend on the types of biomass feedstocks that are imported, maize for example is showing considerably higher yields than soya that was used to calculate imports from the USA). Land requirements in Asia or Africa are limited.

Table 7 Land requirements related to Europe's biofuel and biomass imports (mln ha, 2020)

	Ethanol	Vegetable oil	Biomass	Total	Annual average
North America			10.0	10.0	1.0
Brazil	2.1	3.5	0.2	5.9	0.6
Ukraine			0.5	0.5	0.1
Russia			1.9	1.9	0.2
Africa	0.6		0.1	0.8	0.1
Australasia		0.9		0.9	0.1
World	2.8	4.4	12.8	19.9	2.0

Source: calculated from King (2010)

Land estimations provided in Table 7 exceed those provided by modelling exercises discussed above (ranging from 0.2 to 15 mln ha). Still, figures presented here can give us some insight in the area that potentially might be occupied elsewhere to fulfil Europe's future biofuel needs. The way this area may result in deforestation (or opening up of other nature areas) remains uncertain. In the worst case, all land that is needed to produce biofuels will be

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[9] The future of industrial biorefineries. World Economic Forum, Geneva. http://www3.weforum.org/docs/WEF_FutureIndustrialBiorefineries_Report_2010.pdf, accessed 100802.

compensated by opening of virgin areas. If that would be the situation (many fear this will indeed be the case), this would result in an annual deforestation of two million ha.

Table 7 also shows that most land use will take place in the USA (one mln ha per year) and in Brazil (0.6 mln ha). Land requirements in other regions would be smaller. Although these figures seem modest, one must have to keep in mind that these compensations are permanent (or at least as long as current biofuel policies in Europe will remain unchanged).

There are several ways to compensate for the extra agricultural land or crops that are needed to fulfils EU´s 2020 biofuel targets. One obvious source of additional biomass is yield improvement. Two third of Europe's indirect claim on agricultural land in 2020 would be found in emerging or industrial economies (USA, Brazil, Ukraine, and Russia). Of these, the USA and Brazil historically have shown strong yield improvements while also in the Ukraine perspectives for rising yields per ha are considerable. It seems fair to expect these countries to realize further yield increases in the near future, especially for biofuel crops.

To give an example: maize has been focus of special attention in the USA, both for breeding and crop management. An annual yield increase of 2% in the USA would generate the equivalent of 0.6 mln ha, or 60% of the amount that needs to be compensated in this country for Europe's future biofuel demand. Obviously, this area may also be needed to compensate other increasing demands – like increased demand for food or feed, or the domestic biofuel demand in the USA. Still, it shows that a consistent yield increase – in this case US maize yields - can help to provide a substantial amount of extra biofuel feedstocks. Similar developments may be expected elsewhere (e.g. sugar cane and soya in Brazil and wheat in the Ukraine).

Potentials for yield increase

In a study on potential crop yield improvement, Hengsdijk and Langeveld (2009) show that there is ample room for improvement. Figure 1 provides an assessment of the yield gap for maize. For North America, for example, a yield improvement of almost six tonnes per ha – as compared to current yields - appears possible. Figure 1 also shows that such increases are not all related to higher use of water or agro-chemical inputs (fertilizers, pesticides). Almost half of the increases in North America can be realised making better use of available knowledge and options for improved mechanisation. This seems the case for most regions where maize is cultivated, be it that shortage of water and nutrients play a more yield restricting role in developing countries of Latin America and Asia. Thus, while (maize) yields still can be improved, this does not mean that all improvement will require extra inputs (water, nutrients).

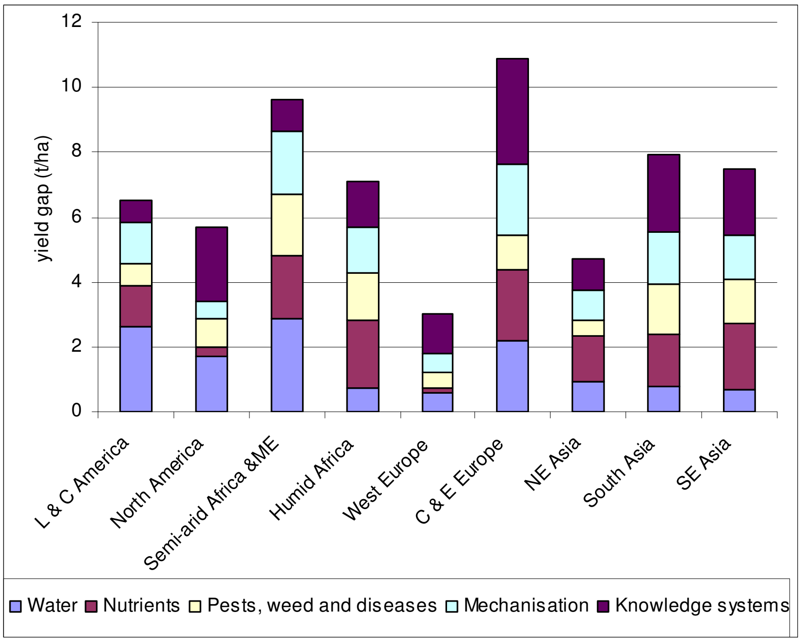
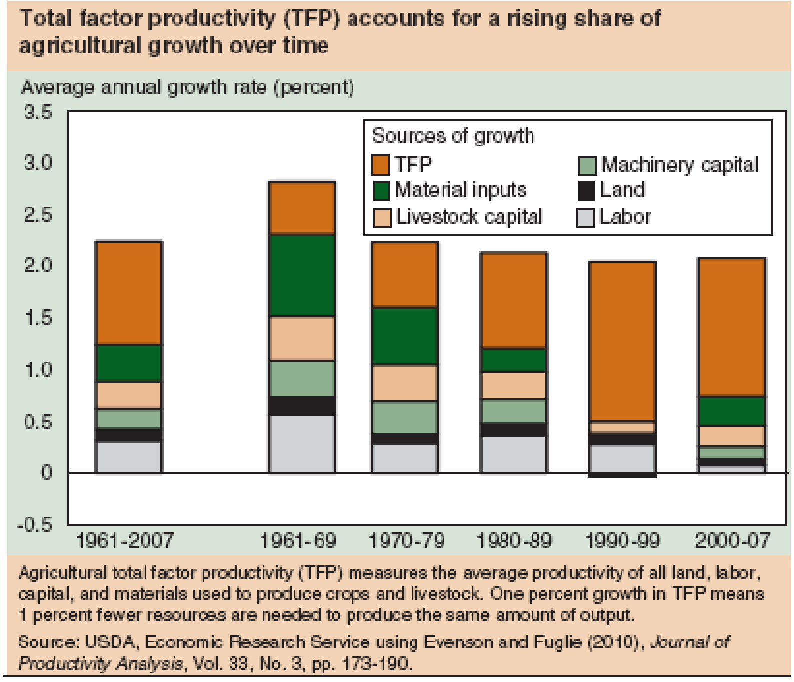


Figure 1 Yield gap for maize in different regions of the world
Source: Hengsdijk and Langeveld, 2009

These findings are confirmed in a study by USDA. The authors of this study demonstrate that factor productivity (amount of output realized per unit of input, expressed here as ´Total Factor Productivity´ or TFP) has been a major contributor to yield increases in countries like the USA, Brazil, India and China (Figure 2). That is good news. Water is already scarce in many regions and availability of fertilizers may become more difficult in the future and these will also be needed to guarantee future food production.


Total factor productivity (TFP) accounts for a rising share of agricultural growth over time

Agricultural total factor productivity (TFP) measures the average productivity of all land, labor, capital, and materials used to produce crops and livestock. One percent growth in TFP means 1 percent fewer resources are needed to produce the same amount of output.

Source: USDA, Economic Research Service using Evenson and Fuglie (2010), *Journal of Productivity Analysis*, Vol. 33, No. 3, pp. 173-190.

Figure 2 Contribution of increased factor productivity to yield increases
Source: cited by Fuglie (2010[10])

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[10] K.O. Fuglie, Accelerated productivity growth offsets decline in resource expansion in global agriculture. Amber Waves, September 2010, p. 46-51.

Policy implications

Above we have seen that future biofuel crop production can be supported by yield increases based on improved factor productivity rather than merely on area expansion. EU´s biofuel policy is leaning on biofuel's potential to reduce Greenhousegases (GHG), and there is strong pressure to ensure that this potential is not lost by factors such as indirect land use change. CDB has made proposals as to how an iLUC factor could be used for this purpose. As mentioned above, Croezen et al. evaluated several ways for its calculation. Below, we will discuss some general principles for an effective design and implementation of the iLUC factor.

Level playing field

As a rule, policy measures should be implemented in such a way that possible distortion effects are minimized. Measures to incorporate the GHG impact of indirect land use should, for example, not hamper innovation – the search for more efficient ways to produce, convert and apply biomass for biofuels. Also, economic (dis)advantages for specific groups of producers (domestic or abroad, high or low tech, large or small scale) must be avoided. Special care in this respect is needed if measures affect special types of land use (e.g. of irrigated or perennial crops), specific groups of farmers or land labourers, etc.

In order to be effective, iLUC factors should, further, be as realistic as possible – as factors that are too low or too high may cause disadvantages for certain types of land use or groups of land users. They should also be as specific as possible, providing alternative values for regions, crops and biofuel types while they should be flexible enough to accommodate changes in land use and biofuel production. This means they must be evaluated on a regular basis. In general, effective iLUC policies should robust, proportional and fair. By robust we mean that it must lead to GHG reductions under a range of conditions (e.g. different – fossil – oil price levels). What we mean by proportionality and fairness is discussed below.

Proportionality

The value of the iLUC factor will have to be determined by assessing the net effects of different types of land use change. Increasing demand for biofuel crops with other factors causing a reduction of agricultural area on the one side and factors leading to increased availability of crops (or crop land) on the other side. It is further proposed that the end-result is correlated to the area of nature areas and forests that are actually converted.

Deforestation in the last decade of the 20th century has been indicated by Mongabay[11]. For the USA, forest area in this period has increased slightly while the amount of agricultural land has been declining. Brazil, on the other hand, is showing an annual loss of forest land of close to 3 mln ha[12]. Approximately half of this is illegal, but recently the extent of illegal logging in Brazil has shown a considerable decline (Lawson and MacFaul, 2010[13]). Mongabay assessed total annual deforestation of tropical forests at 10 mln ha, Brazil and Indonesia accounting for half of this area. There are signs, however, that illegal logging in Brazil is showing a considerable (-50 to 75%) decline. Exact reasons for this are difficult to give, but it is assumed that – next to an economic slowdown – improved enforcement of anti-deforestation laws is playing a role here (Lawson and MacFaul, 2010).

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[11] www.mongabay.com/deforestation.htm, accessed 18 August, 2010.

[12] http://rainforests.mongabay.com/deforestation_alpha.html, accessed 18 August, 2010.

[13] S. Lawson and L. MacFaul, 2010. Illegal logging and related trade. Chatham House, London.

A similar decline has been reported for Malaysia, an important exporter of biofuel feedstocks. It must be stressed that this is a very new development, possibly appearing to be a temporal one. It may, on the other hand, indicate that extra efforts of the Brazilian government to protect the Amazon forest (while simultaneously stimulating production and export of biofuels) are being successful. Brazil has, after all, met serious criticism as to its steady decline of forest area alongside with aggressive promotion of biofuel production and exports.

It generally is assumed that both processes – deforestation and increasing biofuel production – are closely linked, but it is difficult to find proof for this relationship. Consider, for example land use changes in Brazil since 2000 (Figure 3). Deforestation appears to appear at a constant rate of 3 million ha per year, showing no clear relation with changes in arable or pasture land.

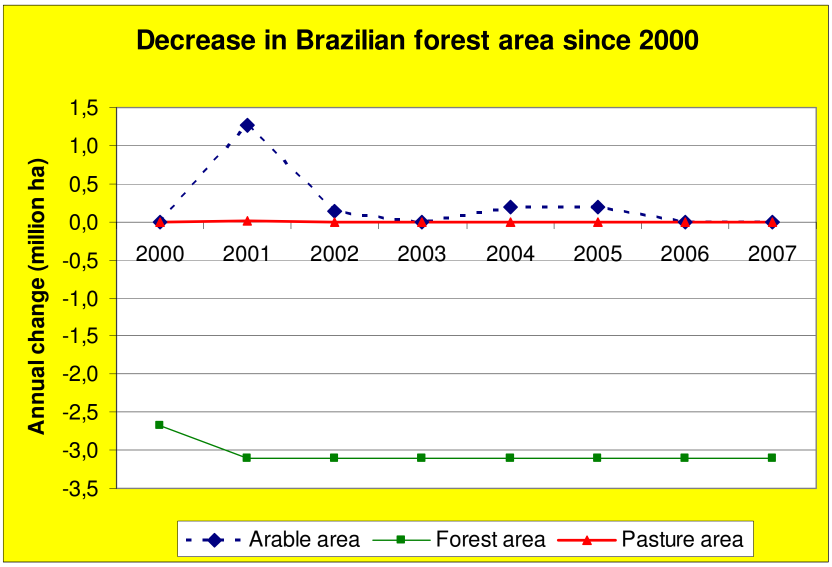

Figure 3 Deforestation and changes in arable and pasture area in Brazil since 2000
Source: FAOSTAT

This does, of course, not mean that there is no relation between biofuel production and deforestation. Obviously, increased demand for land (for cane, or soybean) can play a role in the complex dynamics of the agricultural frontier in the Amazon or elsewhere. But there are many other factors that affect availability of agricultural land that are normally not considered: urbanization, expansion of infrastructure (building of roads, bridges and industrial sites), soil erosion, etc., and they all can play a role.

It is proposed here to ensure that iLUC levies that are introduced in biofuel GHG balances through policy (to discourage indirect land use by biofuels) are not disproportional. Levies should be imposed only for that share that biofuels are really causing indirect land use change (and carbon releases). In Brazil, for example, a forest loss of 22 mln ha since 2000 is accompanied by an increase of 1.8 mln ha of arable land and 0.8 ha of pastures. This suggests that close to 20 mln ha of agricultural land has been lost because of other reasons. If that is the case, the dominant position of biofuel production in (loss of agricultural land for food production and) deforestation should be reconsidered.

It is, therefore, recommended to make assessments of (major sources of) land change before calculating or applying iLUC levies. Such land balances should be updated on a regular basis.

Data sources

One issue that so far seems to be ignored in the debate on iLUC factors and their application to biofuels is the question what data source are to be used to calculate iLUC factors. CDB does not specify which type of data is to be used, nor at which scale iLUC factors should be calculated. We identify three types: (i) agricultural area, (ii) arable area, and (iii) harvested area. Table 6 provides background on the data types, and assesses their potential use for calculation of iLUC factors. Agricultural area includes fallow (temporally not in use) and grasslands. It is easily obtained and can be checked easily but has problems with identifying extensive land use from nature areas. Arable area land is estimated by national or international agencies on a regular basis but is usually no more reliable than agricultural land estimations. Harvested area consists of annual arable crops only, and can easily exclude grassland or nature area. It is, however, showing large interannual fluctuations as determined by changes in weather, economic or social conditions in rural areas.

Table 6 Potential sources of land use data for calculation of iLUC factors

Land use type	**Source**	**Verification**	**Remarks**
Agricultural area	Remote sensing	Technically feasible, at relatively low prices.	Including fallow and grasslands. Regular updates. Poor distinction between extensively used land and nature (unless very small scale).
Arable area	(Inter)national agencies	Unknown.	Update unclear.
Harvested area	FAO, statistical agencies	Depends on quality of local institutions.	Annual update. Large fluctuations, e.g. from weather variation or economic or social conditions. No distinction of multiple cropping.

Clearly, selection of the data type that is used to calculate iLUC factors can have a large impact on the outcome of the calculations. Agricultural area data may make insufficient distinction between arable land use and grassland. They also need supplementary data on land use for biofuel crop production, as do arable area statistics. Statistics for arable crops generally are reliable and regularly updated. They are also subject to all kind of variations not related to biofuel crop expansion. The largest problem is, however, the fact that reported increases in crop production (e.g. of biofuel crops) sometimes are to be attributed to intensification (i.e. increasing number of crops harvested on the same plot in one year). Compare, for example, increases in Brazil since the turn of the millennium: plus 2.1 million ha of agricultural land, 1.8 mln ha of arable land and 9.7 (!) mln ha of harvested land.

Variations in agricultural area, arable area and harvested crop area as reported by FAO are depicted in Figure 4. Largest variation is found in agricultural and harvested area.
The impact of annual variations can be limited by using long term averages (e.g. 20 year). It will also depend on the scale of the area under consideration. Individual countries, especially developing countries situated in regions with variable climates – tropics, will show larger variations than continents or combinations thereof. As a rule, smaller regions will also allow better estimations of different activities affecting availability of agricultural land and of nature conversion (amount and type).

Following the points raised above, it is recommended to use arable land data in the calculation of land use change, as this does not include fallow or grassland area and accommodates changes in harvested area realized by land use intensification. Long term averages can be used to reduce interannual variation (which is relatively small). Depending on the purpose of the iLUC factor to be calculated, smaller scales (national or sub-national level) data are recommended as these can provide more accurate results. Individual (or specific groups of) biofuel producers, incorporated in a well known production chain may offer the best perspectives for accurate iLUC calculations. Providing feedback on land use change may give them a clear incentive to reduce carbon releases within the production chain. In order to be effective in the long run, it is crucial that principles of iLUC calculation is similar around the world. Therefore, it is proposed to start an international comparison on calculation methodology.

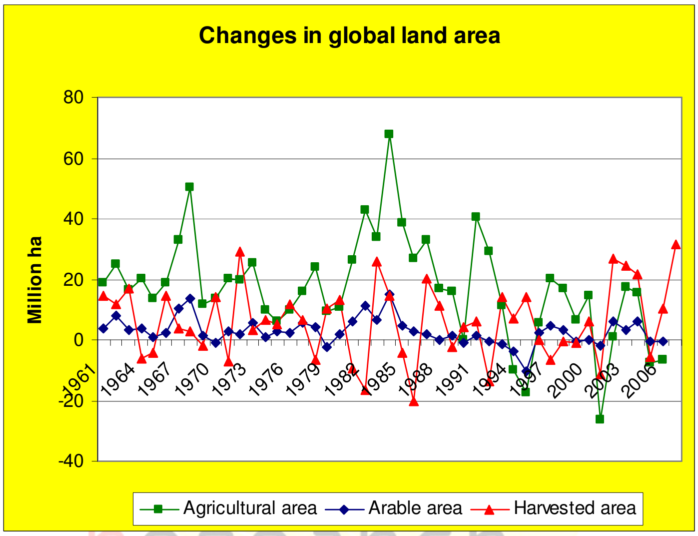

Figure 4. Global agricultural area, arable area and harvested area (mln ha) since 1961
Source: FAOSTAT (http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor, accessed 16 August, 2010).

Fair policies

Above we discussed that iLUC factors should be imposed on biofuel producers in proportion to the share they have in indirect land use and carbon stocks released as a consequence. Although it has been recommended that other factors (sectors, actors) are held responsible for *their* role in deforestation, this does not further affect the GHG balance of biofuels. This is, however, only true as long as others playing a role in land use change are not involved in energy production

Things will be different, if producers of fossil energy are affecting availability of agricultural land or in other ways having an impact on agricultural production. If this is the case, producers of fossil energy should be subjected to iLUC levies as well. It would not be correct if they could afford to affect land availability (e.g. making agricultural land unsuitable by pollution) without this affecting their GHG footprint.

It goes beyond the scope of this note to provide estimations of land lost by pollution; however, oil spills, for example, can seriously affect considerable areas of (agricultural) land. The oil slick caused by the BP oil spill in the Mexican Gulf has reached measures of hundreds of square miles and it could – in theory – affect large areas of coastal land (mostly marshes and forests both rich in carbon). Specific data on land affected (and carbon releases caused by pollution) are lacking, but one estimate amounted to an area of 0.6 mln area affected in the state of Louisiana alone.

It is recommended that the impact of these losses is incorporated in the GHG balance of fossil fuels. In the case of the Mexican Gulf, this extra CO_2 emission will increase the carbon footprint and thus – by definition – increase the reference value against which biofuels produced in the same area would be compared with. The same principles would be applicable to other oil leaks. It would also apply to other fossil land use changes, e.g. caused by open coal mining.

Discussion

Biofuel production has shown a strong growth in recent years, and this must be expected to remain the case at least for the near future. Land required to produce biofuel crops will however compete with other land uses – notably production of food, feed or fibres. In order to limit this competition, CDB proposes to develop an instrument to incorporate GHG effects of indirect land use directly in the GHG balance calculation of the specific biofuel. While this seems a logic and sympathetic idea, implementation may be hampered by several practical problems.

First, the calculation of an iLUC factor requires data of sufficient quality. As discussed above, three types of data could in theory be used for this purpose: agricultural area, arable area or harvested area. One must realise that the character of these data types are distinctly different. The former two refer to physical units of land that can be identified by using maps or satellite data. The latter refers to the amount of land that has been harvested, inherently introducing the issue of cropping intensity (the number of harvests realised on one single plot during one year).

If harvested area is to be used in calculation of indirect land use, it should be corrected for changes in cropping intensity. If this is not done, production of biofuels in areas with increasing intensity – thus reducing the demand for land – will be hampered. (See also remarks on this in the literature review on the impact of land use change from biofuels.[14])

It is recommended to base iLUC calculations on changes in arable area, as the concept of arable land does not include grassland. This offers the opportunity to put a GHG levy on pasture to arable conversion. Steps should be taken to ensure international harmonization of iLUC calculation methodology. It is further recommended that quality of such data is well monitored, as they can easily be subject to manipulation. Fraud should be punished in proportion to the advantage that was gained from it.

A second issue that needs to be addressed is the role of non-agricultural activities affecting the availability of arable land (and, hence, the need for indirect land use change). Activities like urbanisation, infrastructure expansion, but also soil degradation and pollution may reduce the amount of available land at the disposal of food (or fuel) production. Biofuel producers in regions with strong reduction of anon-agricultural activity reducing availability of agricultural (arable) land would be affected unnecessarily harsh if land loss caused by these activities is not distracted from the calculations of land displacement requirements. It is proposed that CDB takes measures to assure that iLUC levies for biofuel producers are proportionally to the share of the land use change they are causing. This would mean that the inherent assumption that one ha of biofuel production is assumed to cause the same area of land use change is no longer maintained.

It would hold only if the total loss of agricultural land from other sources (urbanisation, soil erosion, etc.) in a given region is not too high. Disproportional reductions of arable land (e.g. by land slides, or large scale open mining) could form a barrier for biofuel producers in that

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[14] DG Energy, 2010. The impact of land use change on greenhouse gas emissions from biofuels and bioliquids.

area who will face iLUC factors that area primarily based on non-biofuel activities. Related to this is the scale on which iLUC factors are to be calculated. It is recommended that regions for which such factors are determined are more or less homogeneous in terms of land use change (especially caused by non-food and non-fuel producers).

The proportionality principle also holds for incidental (temporal) losses of land related to fossil energy production, e.g. by open mining or oil spills. As implementation of iLUC is not supposed to lead to unjustified disadvantages for biofuel production, land use change caused by producers of fossil fuels should not be attributed to biofuel producers but to the fossil producers themselves. One way to do so would be to incorporate GHG emissions related to fossil energy production into the reference GHG value of fossil fuels that are produced in the process.

Many regions show ample room for improvement of crop yields. Realization of the potential will, however, require considerable efforts. Biofuel producers who invest to improve yields – of biofuel crops, or food crops – should be compensated for this proportionality to the amount of arable land that is released as a result of their efforts. It is recommended that explicit mention of this option is made in legislation identifying the use of iLUC factors. The same applies to producers realize more efficient processing methods for biomass feedstocks, e.g. by using crop residues or by improving biomass to energy efficiency. It is, further, recommended to include in this comparison multiple types of bioenergy, including biogas. In this respect, proper arrangements should be made for co-product generation. It is felt that the ensemble of these stimuli will help producers to make more integrated and efficient use of biomass, and hence lead to more efficient conversion technologies.

Conclusion

The compulsory use of an iLUC factor in the calculation GHG performance of biofuels will be facing some major challenges. Although appealing, implementation of such a factor in practice can be cumbersome. It is recommended that statistics used to calculate land use changes be referring to arable land rather than agricultural land or harvested area. GHG levies for biofuel producers causing indirect land use should, further, be proportionally to their contribution to observed land use changes. Other activities (not related to biofuel production) should also be held responsible for their share in land use change.

Effective iLUC factors should be robust, i.e. reducing carbon releases under a wide variety of conditions. They should be fair, not leading to disproportional high (or low) levies for specific products or (groups of) producers. In this respect, harmonization of calculation methodology is of crucial importance.

There is ample room for more efficient biofuel production and implementation of iLUC factors should primarily focus on the promotion of more efficient ways to produce crops (higher yields and factor productivity) and convert biomass to biofuels. This requires accommodation of co-product and multiple (energy) output generation in the conversion process. Biofuel producers investing in more efficient production should, finally, be compensated for their efforts proportionality to the amount of arable land released as a result of their efforts.