



LOW CARBON MEAT

**Reducing the carbon footprint of meat
through greater use of biorefining
cereal grains in Europe**

January 2010

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1. EXECUTIVE SUMMARY

This paper makes the case for a more sustainable system of meat production in Europe using locally grown high-protein animal feeds. When produced from biorefining EU cereal crops, these can substantially reduce the global carbon emissions from EU meat production.

Meat production is one of the main causes of man-made climate change, accounting for nearly a fifth of global greenhouse gas (GHG) emissions. Feed production causes over 40% of emissions from livestock production. Most of this is due to land use change such as deforestation and desertification, especially in regions such as South America where agricultural expansion for animal feed crops adds to deforestation pressures. Today, the EU is the world's largest importer of high protein animal feeds, mostly soy meal from South America. The EU is therefore a major contributor to the global GHG emissions caused by meat production.

The biorefining of EU cereal crops produces a high protein animal feed, commonly known as 'Dried Distillers Grains & Solubles' (DDGS). DDGS can replace a proportion of the soy meal used in EU animal diets and so reduce EU soy imports. This approach makes greater use of Europe's capacity for sustainable agriculture to reduce deforestation pressures in South America. The global GHG savings from increased use of DDGS as a high protein animal feed in Europe are obtained at no additional cost to the animal production industries or to the consumers of animal products.

Work is still evolving on how to quantify the net GHG savings impact of high protein animal feed from biorefining in Europe. Ensus has made an initial assessment to demonstrate the scale of the opportunity. This assessment is largely based on accepted external sources and methodologies such as those offered by the RED.

Whilst the results vary by animal type, the overall potential for GHG savings could be as much as a third of the emissions from livestock. Given that livestock cause nearly a fifth of global GHG emissions, the potential savings are very substantial.

These savings can be compared to a cereal grain biorefinery's GHG savings achieved from the biofuel coproduct alone. In the case of the Ensus biorefinery, biofuel GHG savings amount to around 70% of avoided fossil fuel GHG emissions when this is used as a substitute for petrol. Animal feed GHG savings are of similar magnitude, more than doubling these GHG savings. If these meat supply chain savings are added to the biofuel savings, the combined savings are around 1.5 times the avoided emissions from petrol.

2. GREENHOUSE GAS IMPACTS OF LIVESTOCK PRODUCTION

Meat production is one of the main causes of man-made climate change, accounting for nearly a fifth of global greenhouse gas (GHG) emissions – more than all transport emissions combined. 43% of livestock emissions are related to feed and pasture, a further 30% are released by manure, 25% are emitted as methane directly from animal digestive processes, with the remainder (just 1%) from housing, transport and processing of animal products (UNFAO, 2006).

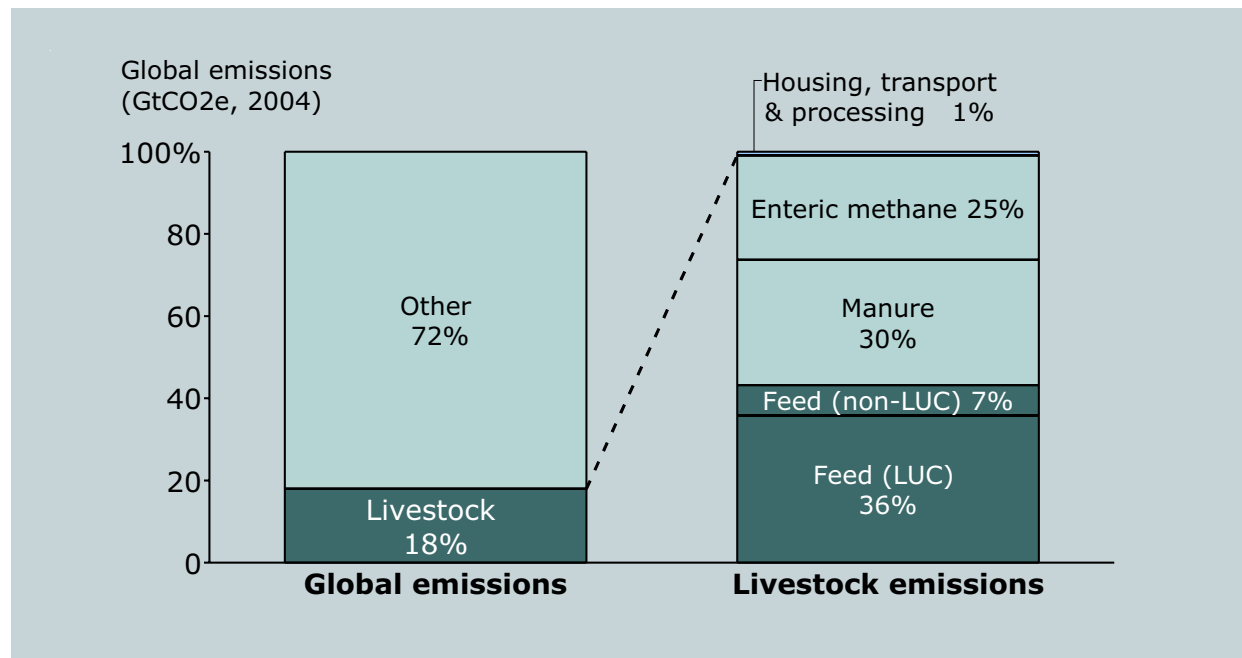


Figure 1) Global GHG emissions from livestock
Source: (UNFAO, 2006)

Global production of animal feeds, including cultivation of feed crops and pastures, represents the largest source of these emissions. The largest component of feed emissions is land use change (LUC), which accounts for over a third of total emissions from livestock production. Land use change GHG emissions are released by deforestation, desertification and other land use changes as agricultural area is expanded for animal feed and pasture. The overall efficiency of land use for animal production systems is therefore one of the main determinants of the carbon intensity of livestock production.

Europe has a large livestock industry, supported in part by a highly efficient and sustainable arable crop sector. EU farmers operate to strict standards set down by the EU's reformed Common Agricultural Policy, which safeguard the environment, biodiversity, food safety, animal welfare and animal health (EC, 2003). Arable crop yields and output have historically risen at or above the rate of demand growth for many agricultural commodities produced in the EU. Cereal grain crops such as wheat and maize are a central part of European agriculture, accounting for over a third of EU agricultural area and output. EU cereal crop yields have historically ranked amongst the highest in the world, and the EU typically exports 10-20 million tonnes of cereal grains each year – mostly animal feed wheat (UNFAO, 2009d).

The EU's food supply chain relies not only on EU agriculture but also increasingly on feed imports. Economically efficient animal production systems require around 20% protein by mass in feed rations. Cereal crops typically include less than 14% protein by mass, and so feed protein levels must be elevated by incorporating high protein ingredients. Protein crops such as soy beans are used for this purpose, but the EU cannot match the production economics of extensive soy bean agriculture in South

America. Compared to Europe, South America’s tropical climate and geography are better suited to low cost soy bean production, which has expanded rapidly to serve the global demand for soy beans and soy meal (soy beans from which oil has been extracted). Over the past 30 years, the EU’s meat, dairy and egg industries have become increasingly dependent on imported protein sources of animal feed, mostly soy meal and beans from Argentina and Brazil. In 2006 the EU was less than 25% self-sufficient in high protein animal feeds, and today is the world’s largest importer.

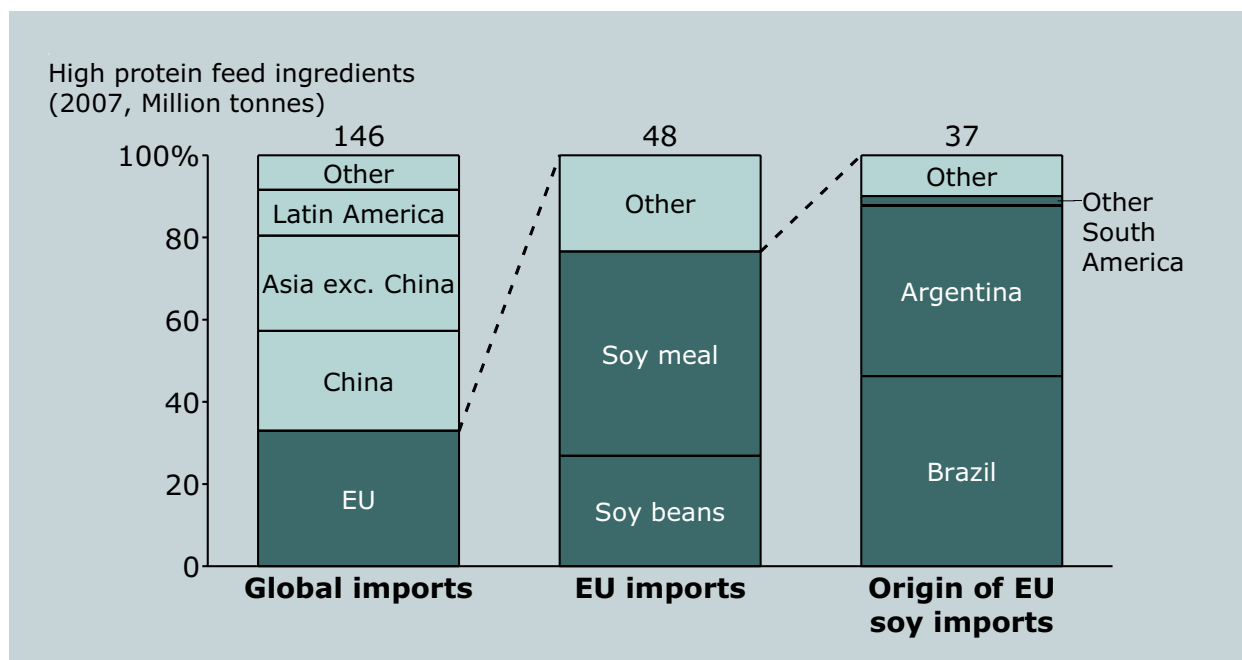


Figure 2) EU trade in high protein feed ingredients
 Note: Includes meal equivalent in beans & oilseeds traded
 Source: (UNFAO, 2009b; UNFAO, 2009d; Friends of the Earth, 2008)

The EU’s dependence on imported animal feed from South America contributes to increased GHG emissions from land use change. South American agricultural expansion adds to deforestation and other land use change pressures, leading indirectly to GHG emissions from this land use change (FEFAC, 2009).

Today, livestock production in Europe depends on over 100 million hectares of global agricultural land. EU livestock consume over 160 million tonnes of cereal grains (over half of all EU cereal crops), 54 million tonnes of high protein meals and around 10 million tonnes of other feed crops each year (Strategie Grains, 2009). Production of these feed crops requires around 25 million hectares of cereal cropland within Europe, and a further 20 million hectares of land outside Europe for production of high protein feed ingredients such as soy meal – This is in addition to 56 million hectares of permanent grazing pastures (Eurostat, 2008).

3. THE ROLE OF BIOREFINING

3.1. What is biorefining?

Biorefining increases the protein content of cereal grains by removing grain starch and turning it into biofuel, leaving a high protein animal feed. The production process is carefully managed to deliver the highest sustainability benefits and process economics across three co-products:

- A high-protein animal feed commonly known as 'Dried Distillers Grains & Solubles' (DDGS)
- Bioethanol, a biofuel for petrol substitution
- Some biorefineries are equipped to capture carbon dioxide for use in the food and beverage industries

Cereal grains such as wheat are more productive crops than soy beans. In Europe, cereals can produce as much protein per hectare as soy beans grown in South America but capture more of the sun's energy to give a far higher yield per hectare. The EU's climate is ideally suited to production of cereal grains; wheat yields in Western Europe are typically seven tonnes per hectare compared to two or three tonnes per hectare for South American soy beans. The EU produces more feed wheat than it needs, but the surplus cannot be used as a high-protein feed ingredient because the high level of starch reduces the protein concentration. The higher productivity of cereals leads to additional starch production in the growing crops, and this is stored in the grains. This starch dilutes grain protein concentration to 8-14%, significantly below the 20% level necessary for efficient animal production systems.

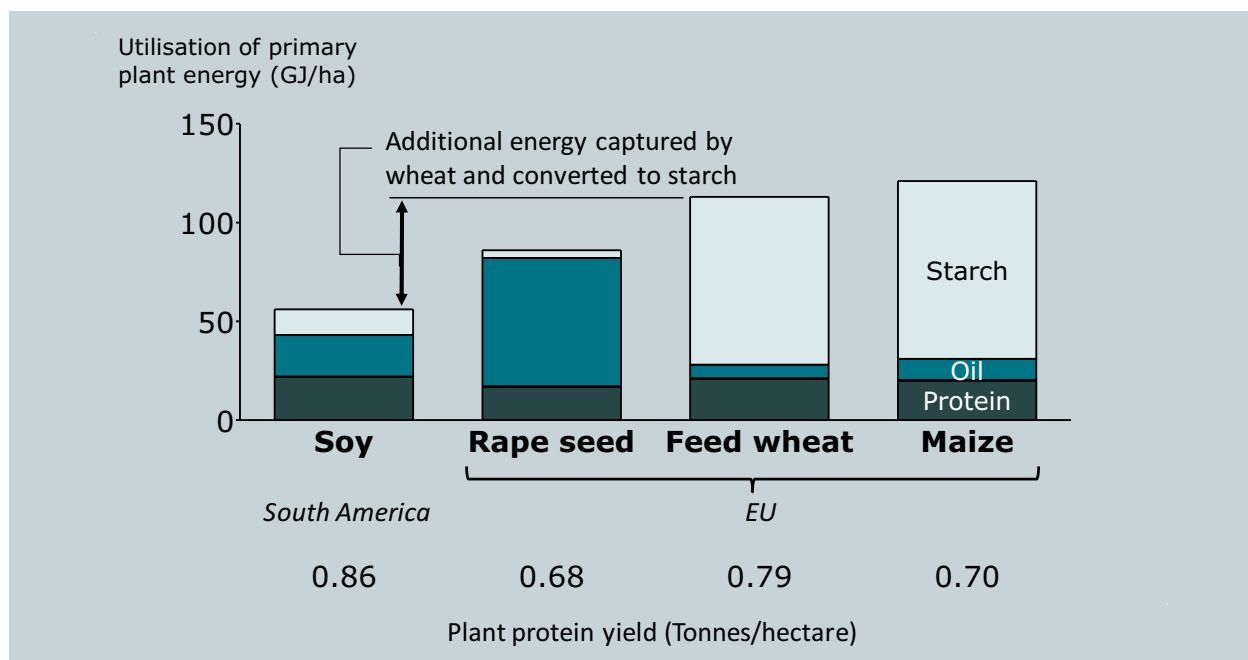


Figure 3) Land use efficiency of crops
Source: (Ensus, 2008b)

Cereal grain biorefineries can convert this starch to form a valuable biofuel and a high-protein animal feed. The biorefinery removes starch by a process of mechanical milling, cooking and fermentation which does not significantly degrade or remove the plant proteins present in cereal grains. In addition, protein is produced during fermentation from non-protein nitrogen in grains and from the yeast employed in the process (Jones *et al.* 1994). The resulting animal feed co-product has a final protein concentration of 25-35% and can replace some of the imported soy meal in EU animal feed diets.

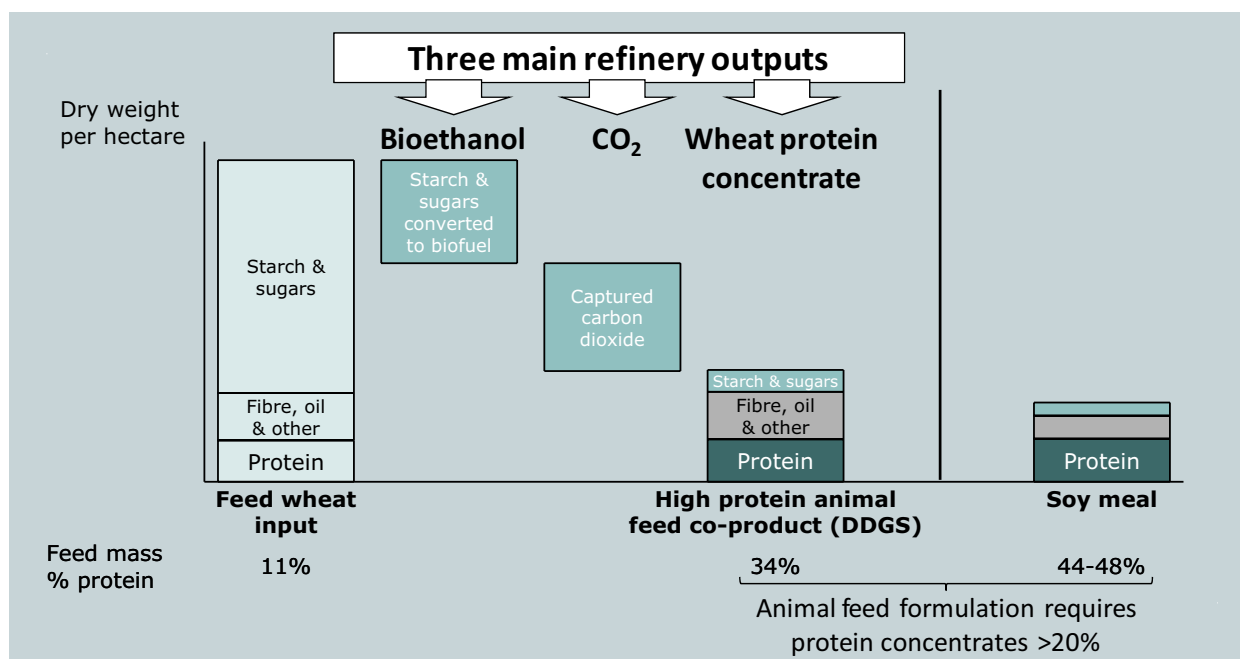


Figure 4) Wheat biorefining process
Source: (Lywood W *et al.* 2009)

3.2. Impact on global land use

Additional grain demand for biorefinery feedstock production may be met by a combination of increased yields and increased cultivated area. Europe has spare agricultural capacity and produces 10-20 million tonnes of exportable surplus grains each year. EU agricultural output may be further increased in three ways:

- Closing yield gaps between east and west EU countries;
- Accelerating the development and widespread deployment of yield-enhancing technologies and practices;
- Halting the decline in cultivated area and bringing idle land back into production.

1kg of DDGS has the potential to replace 0.59 kg of soy meal and 0.39 kg of cereals in EU animal feeds. The market for DDGS in Europe at currently advised incorporation limits is 21 million tonnes, far in excess of the 1.3 million tonnes of DDGS produced in the EU in 2008 (Lywood W *et al.* 2009). As DDGS feed use becomes more widespread and feeding applications are further optimised, it is likely that currently recommended feed incorporation limits will rise (CE Delft, 2008a).

Increasing EU production of DDGS through biorefining can therefore be expected to reduce net imports of soy beans and soy meal. In 2009, EU imports of high protein meals are expected to show an unprecedented 7% fall compared to 2008. The FAO attributes this fall to the increasing supply of domestically produced high-protein feeds including DDGS and rape meal, providing some evidence that the substitution of DDGS for soy meal imports has begun to happen (UNFAO, 2009b).

At current rates of cereal crop yield growth, Europe's arable land in productive use is expected to continue to contract as yield growth enables the EU to meet its cereal demand from less area. Biorefining cereals will enable more of the EU's arable land to be put to productive use to reduce EU dependence on imported soy meal, whilst maintaining current cereal exports. In doing so, South American land use for EU soy meal imports will be reduced, as shown in Figure 5.

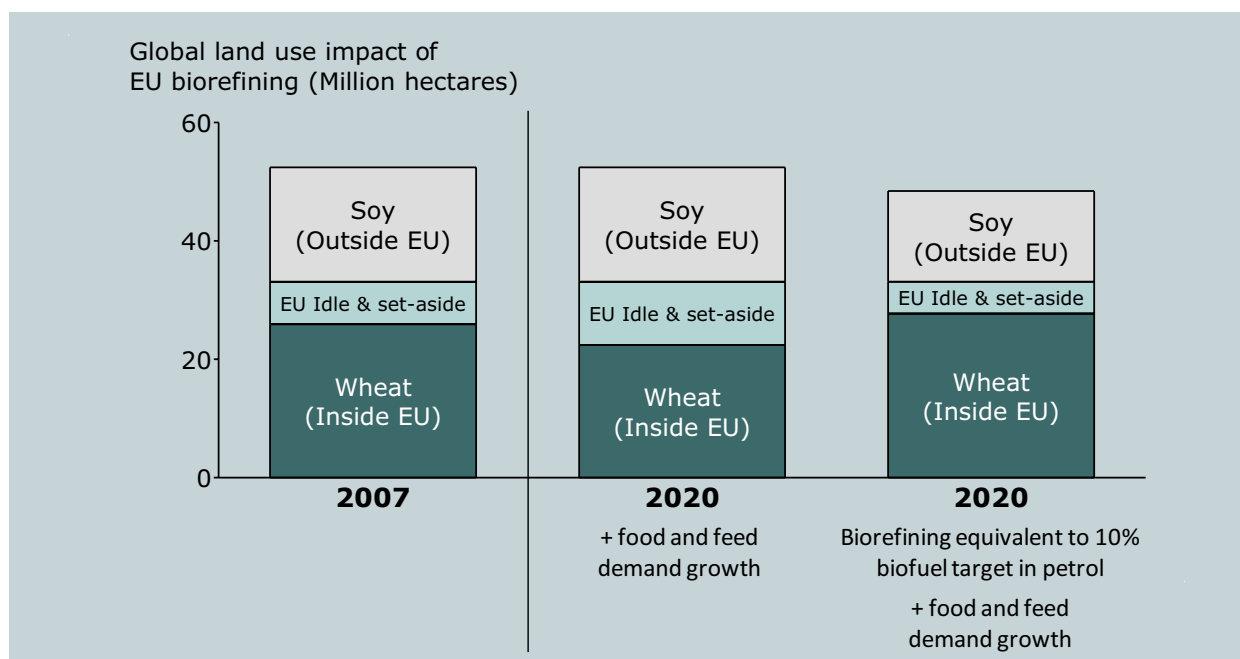


Figure 5) Global land use impact of EU biorefining

As a result, additional cereal grain production for biorefining within Europe will reduce the land area outside Europe needed for high protein feed imports. Figure 5 shows the global land use impact of meeting the EU's 10% biofuel target in petrol through biorefining around 40 million tonnes of cereal grains. In fact, the EU has the agricultural capacity to expand cereal production well beyond this level (Ensus, 2008a). It is the combination of Europe's cereal production capacity, rising biofuel demand, and dependence on imported high protein animal feeds that create the exceptional potential for cereal grain biorefining in this region.

Cereal grain biorefineries enable the EU to use its surplus capacity for sustainable agriculture to reduce deforestation pressures and associated land use emissions in South America.

3.3. Impact on food chain GHG emissions

Increased EU feedstock production will cause GHG emissions through land use change associated with any area increase, and from soils, cultivation and crop inputs applied. Further emissions are caused by the transport and processing of this feedstock in the biorefineries where DDGS is produced. The EU's Renewable Energy Directive (RED) provides an accepted methodology and set of default inputs that allow feedstock production, logistics and biorefinery emissions to be calculated and allocated in part to the DDGS co-product.

Offsetting these increased emissions is a reduced demand for feed ingredients, such as cereals and soy meal that are displaced by DDGS in EU feed rations. The substitution ratios (kg of feed ingredients substituted per kg of DDGS used) depend on the animal groups to which the DDGS is fed, as the nutritionally equivalent substitution ratios are slightly different for different species. In practice, substitution ratios may be different in individual animal diet formulations, depending on feed formulation constraints and other available ingredients. For example, DDGS may substitute for a mix of rape meal, soy meal and cereals in ruminant rations. However, the displaced rape meal will then be reallocated into other feed formulations where it will displace additional soy meal and cereals (FEFAC, 2009).

Work is still evolving on how to assess the net GHG savings impact of these two changes caused by biorefining in Europe. Ensus has made an initial assessment to demonstrate the scale of the opportunity. This assessment is largely based on accepted external sources and methodologies such as those offered by the RED.

Whilst the results vary by animal type, the overall potential for GHG savings could be as much as a third of total emissions from livestock. Given that livestock cause nearly a fifth of global GHG emissions, the potential savings are very substantial.

These savings can be compared to a cereal grain biorefinery's GHG savings achieved from the biofuel coproduct alone. In the case of the Ensus biorefinery, biofuel GHG savings amount to around 70% of fossil fuel GHG emissions when this is used as a substitute for petrol. Animal feed GHG savings are of similar magnitude, more than doubling these GHG savings. If these meat supply chain savings are added to the biofuel savings, the combined savings are around 1.5 times the avoided emissions from petrol.

3.4. Impact on cost

The increasing production and consumption of DDGS in EU animal feed rations since 2003 has been largely driven by the duty incentives and mandated demand for the biofuel co-product. DDGS supplied into the EU animal feed markets is valued approximately according to the set of nutritionally equivalent feed components it replaces.

In May 2008, with soy meal valued at £285/t and feed wheat valued at £167/t, the nutritionally equivalent value of wheat DDGS was £220/t (Lywood W *et al.* 2009). Historic EU market data over a period of several years confirms that DDGS has traded at a price broadly in line with the prevailing value of its digestible protein, energy and fibre content throughout the agricultural commodity cycle.

As a consequence, the sustainability benefits associated with an increased use of DDGS as a high protein animal feed are obtained at no additional cost to the animal production industries or to the consumers of animal products.

4. CONCLUSIONS

This paper makes the case for a more sustainable system of meat production in Europe using locally grown high-protein animal feeds. The EU can reduce the global GHG emissions linked to its meat production by reducing imported animal feeds with high embedded emissions, such as soy meal. DDGS, biorefined from EU cereal crops, can replace a proportion of the soy meal used in EU animal diets and so reduce EU soy imports. This approach makes greater use of Europe's capacity for sustainable agriculture to reduce deforestation pressures in South America caused by soy grown for EU imports.

5. APPENDICES

5.1. Global food and feed challenges

Global population growth and changing diets have led to a rapid increase in demand for meat that is set to continue. Several kilograms of animal feed are required to produce one kilogram of meat. This is 'feed conversion ratio' is between 2 and 4 for poultry, for pigs it is around 3, and for cattle it is between 5 and 10 (UNFAO, 2006; Tara Garnett, 2007). Today, over half of the world's grain output is fed to animals (FEFAC, 2009; IGC, 2009). To keep pace with rising demand for animal feed, in addition to demand for food crops, the world must increase agricultural output by 70% by 2050 (UNFAO, 2009c). Global demand for animal protein in food grew at 2.7% p.a. from 1961-2003. This growth has arisen due to a combination of rising global population (1.7% p.a.) and increasing per capita consumption of animal protein (0.9% p.a.). Over this period, animal protein consumption as a proportion of total food protein consumption in food rose from 31% to 39% (UNFAO, 2009a).

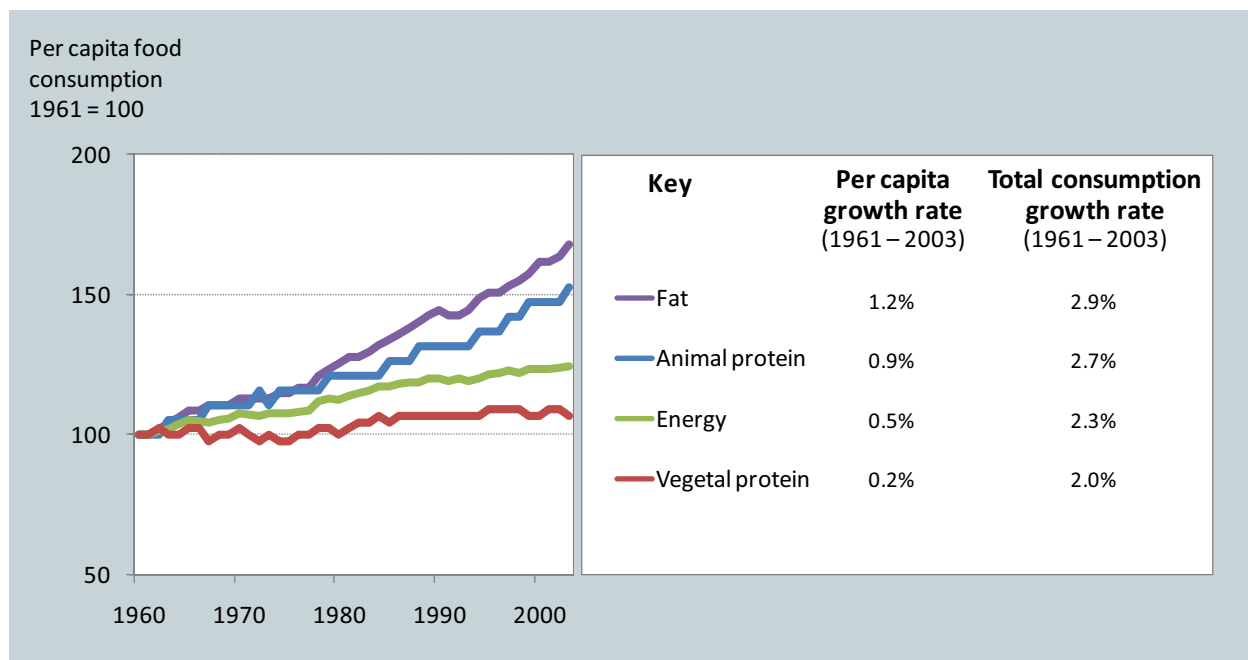


Figure 6) Global food consumption trends
Source: (UNFAO, 2009a)

To meet rising global demand for animal food products, the supplementary feeding of arable crops to livestock has risen sharply. The incremental demand for the main animal feed components between 1961 and 2007 comprised 44% starch & sugars, 24% protein, 24% fibre and 8% oil & other and reflects nutritional needs of economic livestock production (UNFAO, 2009d).

In aggregate, the additional demand for feed components requires approximately double the protein concentration available in cereal crops. The protein levels in the main protein feed meals (soy meal, rape meal and sunflower meal) are significantly higher than in protein level in overall demand growth as shown in Figure 7.

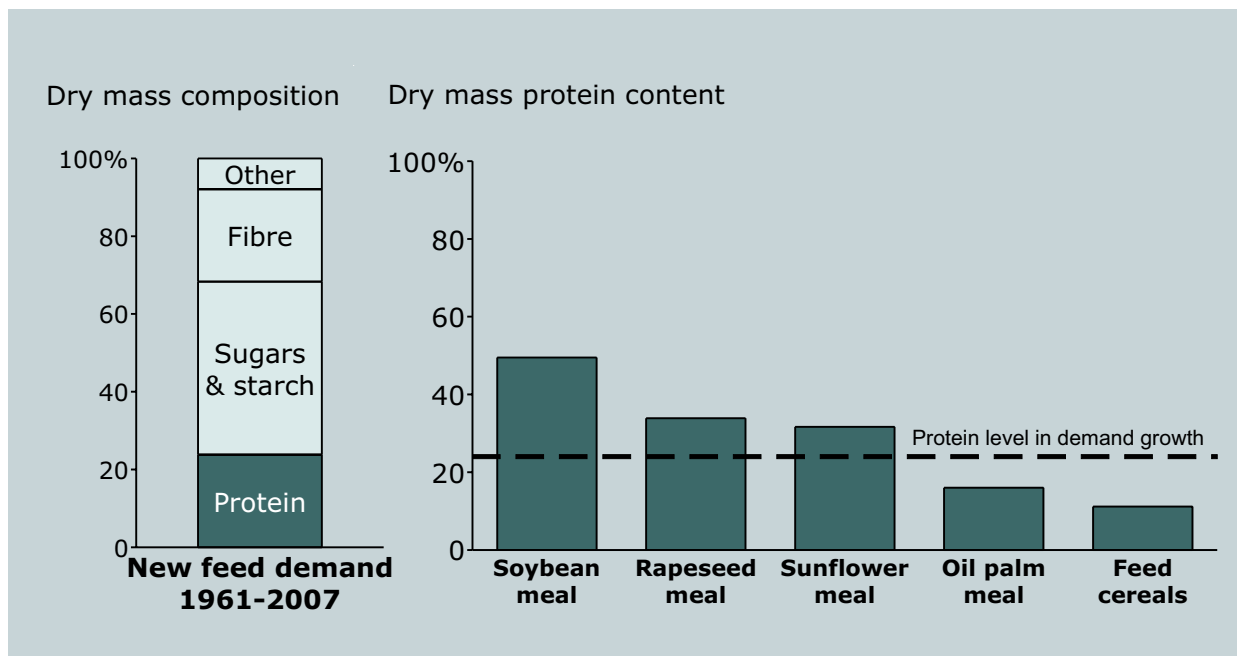


Figure 7) Dry mass composition of global feed crop demand
Source: (UNFAO, 2009d)

As a consequence, oilseed and meal crops such as soy beans have played an increasing role in meeting global feed demand over recent decades. Production of high-protein feed meals grew at 5.0% p.a. from 1961-2007, and with soy meal, oil palm meal and rape meal providing 95% of the output increase (UNFAO, 2009d). Soy beans offer a higher concentration of protein and oil than is present in cereal grains and can be produced extensively at low cost. However, high protein oilseed and meal crop yields are typically far lower than yields of cereal crops owing to their lower solar conversion efficiency as shown in Figure 8.

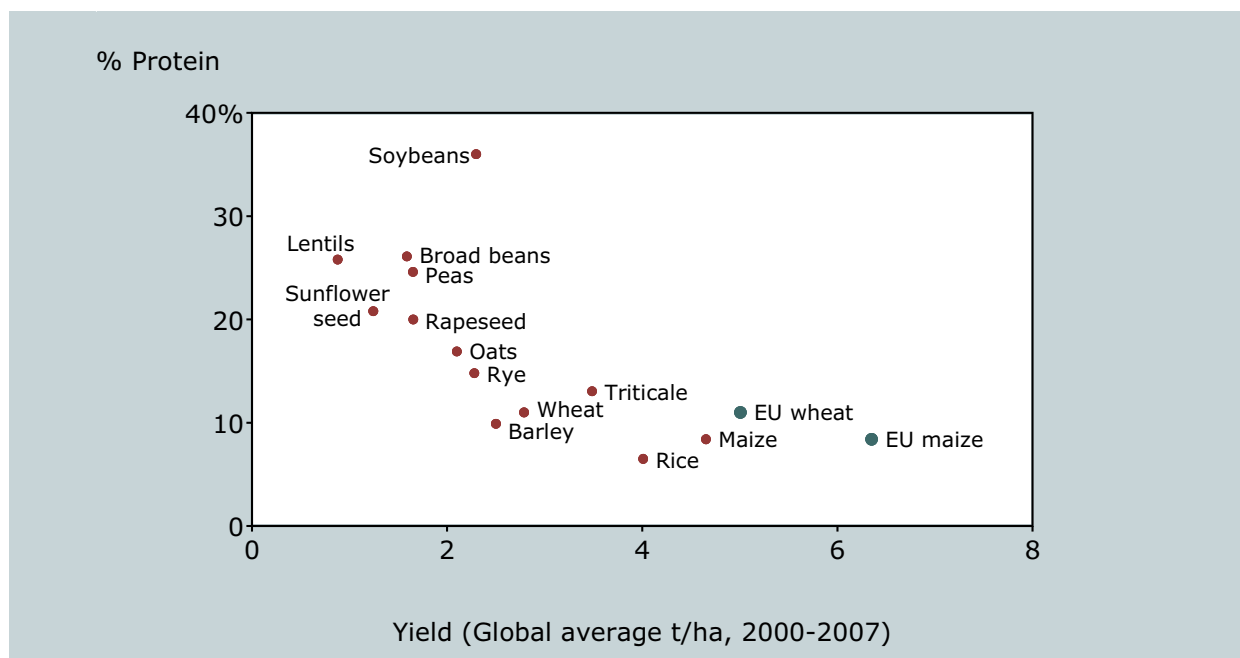


Figure 8) Crop yield vs. protein content
Source: (USDA, 2009; UNFAO, 2009d; Premier, 2008)

Global demand growth has exceeded yield growth for oil crops such as soy beans, whilst yield growth for cereal crops has been similar to the overall rate of demand growth for cereal crops.

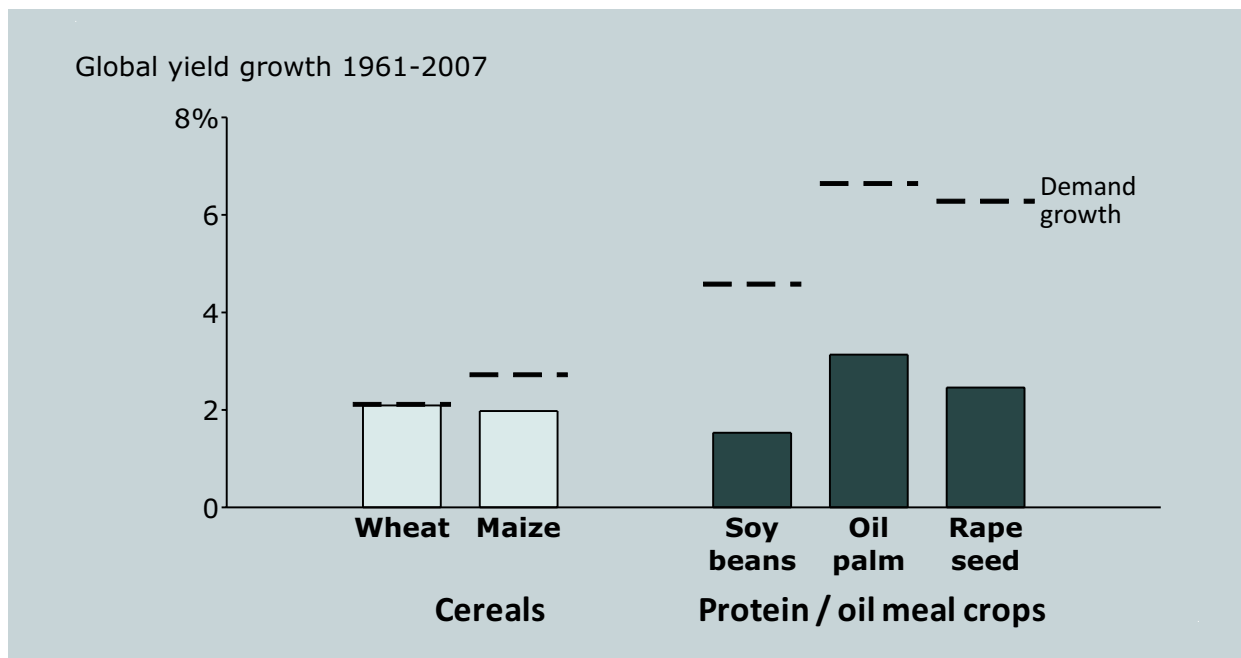


Figure 9) Yield growth of cereals and oil crops
Source: (UNFAO, 2009d)

Consequently increased oil crop output has been achieved by area expansion, predominantly in tropical and sub-tropical developing regions such as South America. Furthermore, the low cost of land in South American countries provides little incentive for the industrial-scale growers that serve export markets to seek yield improvements as the primary source of output growth. In contrast, global cereal crop area has remained practically unchanged, with area reductions in temperate regions such as Europe and North America balancing maize area expansions in tropical countries.

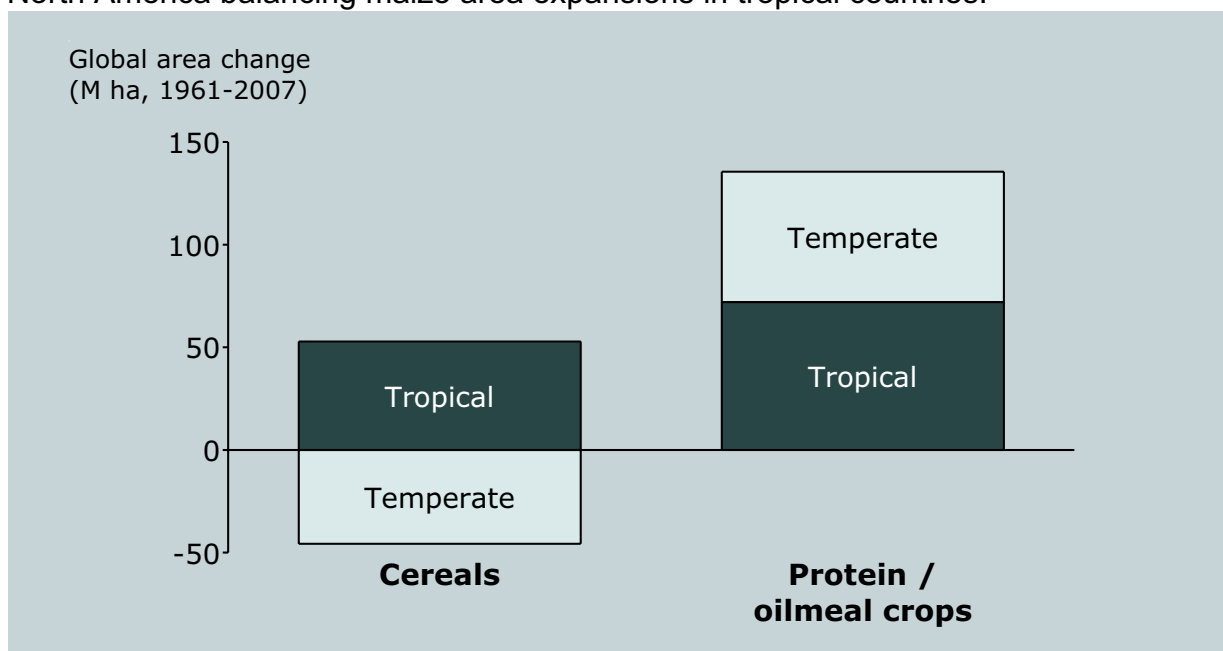
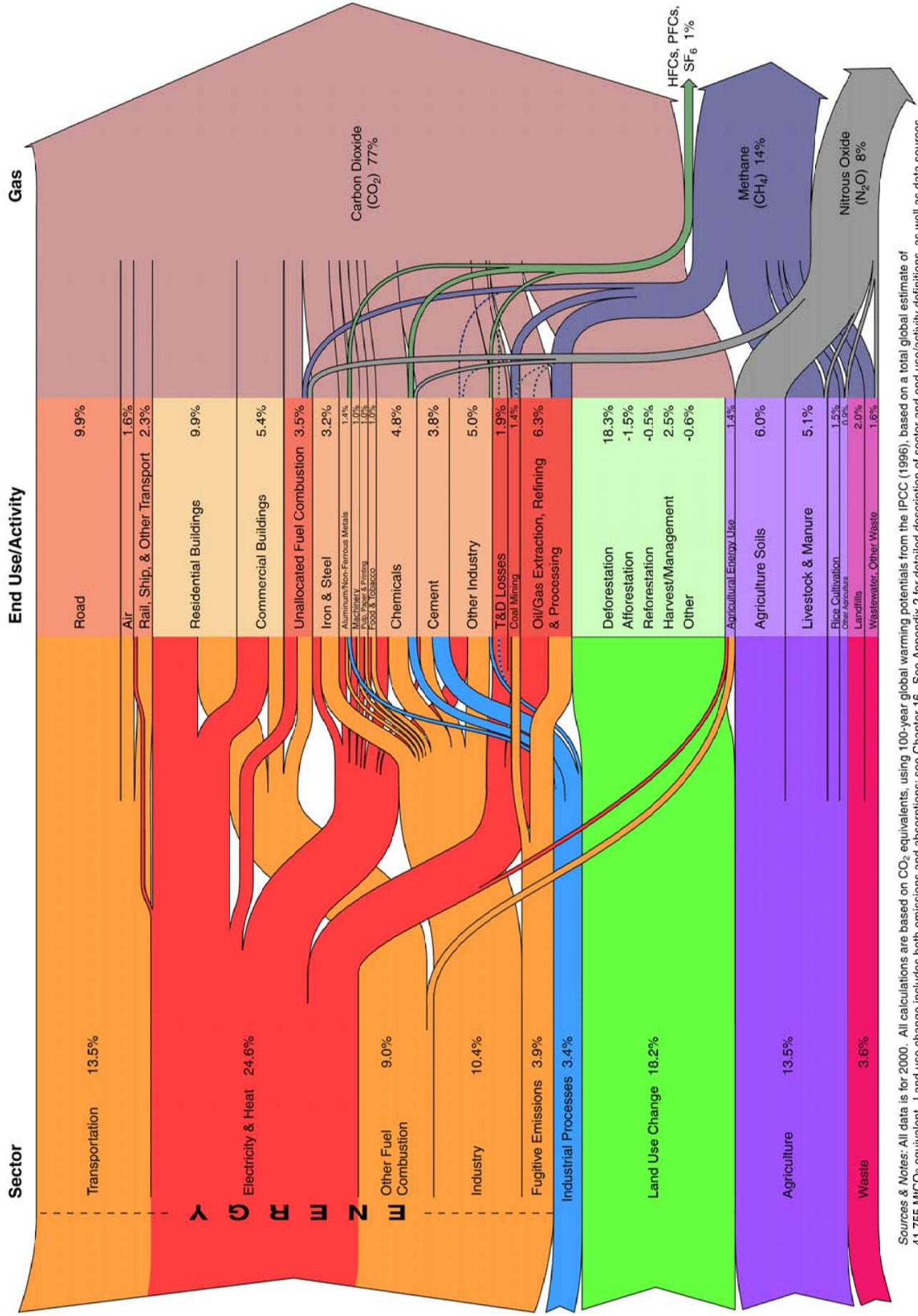


Figure 10) Global crop area changes
Source: (UNFAO, 2009d)

Increasing demand for high protein feeds has therefore led to a global surge in agricultural land use for low yielding crops in tropical regions. It has contributed to increased rates of land use change in South America where this has the highest GHG impact due to the high carbon stock of land before conversion to agriculture (See appendix 5.3).

5.2. Sources of global GHG emissions, 2000



Sources & Notes: All data is for 2000. All calculations are based on CO₂ equivalents, using 100-year global warming potentials from the IPCC (1996), based on a total global estimate of 41,755 MTCO₂ equivalent. Land use change includes both emissions and absorptions; see Chapter 16. See Appendix 2 for detailed description of sector and end use/activity definitions, as well as data sources. Dotted lines represent flows of less than 0.1% percent of total GHG emissions.

Source: (WRI, 2009)

5.3. Global GHG emissions from land use change, 2000

In 2000, land use change accounted for nearly a fifth of all global GHG emissions. Net land use change emissions are composed almost entirely of emissions associated with deforestation. Other adverse land use change is approximately balanced by reforestation and afforestation occurring predominantly in temperate regions.

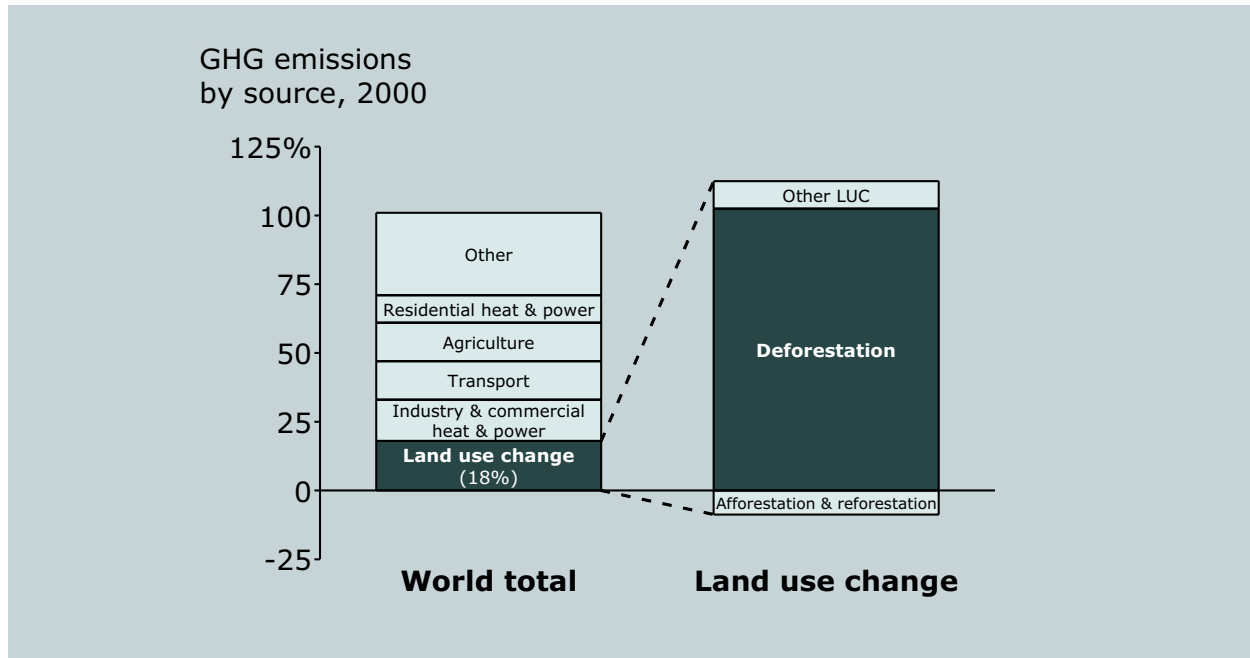


Figure 11) Global emissions, 2000
Source: (WRI, 2009; Stern N, 2007)

Deforestation is concentrated in the tropics - South America, Sub-Saharan Africa and South East Asia. In contrast, forest areas in northern temperate regions are expanding, supported by a warming climate.

Net changes in forest area 2000-2005

- >0.50% decrease per year
- >0.50% increase per year
- Change rate between -0.50 and 0.50% per year

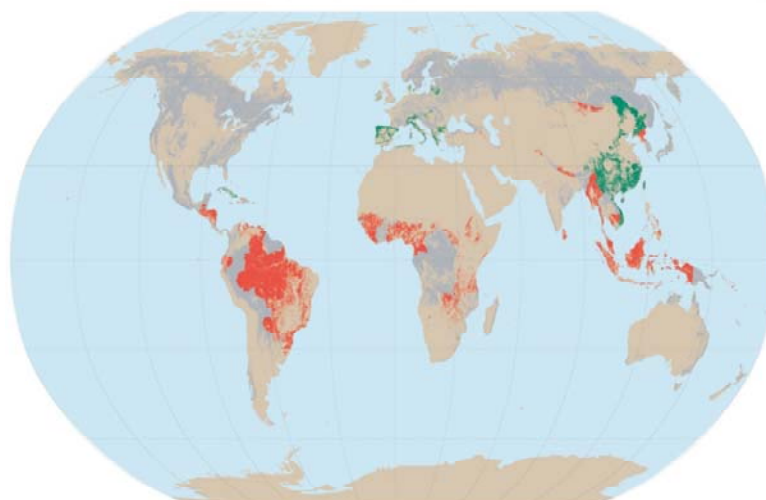


Figure 12) Net changes in forest area, 2000-2005
Source: (UNFAO, 2005) (Stern N, 2007)

5.4. EU trade and consumption of soy meal

Livestock product	Soy meal kg/kg
Beef & veal	0.232
Milk	0.021
Pork	0.648
Poultry meat	0.967
Eggs	0.640

Table 1) Soy meal use in EU livestock products
Source: (Friends of the Earth, 2008)

Origin	Million tonnes	% of total
South America		
Brazil	18,524	51%
Argentina	12,365	34%
Paraguay	995	3%
Uruguay	89	0%
Sub-total		87%
North America		
US	3,508	10%
Canada	785	2%
Sub-total		12%
Other	363	1%
Total	36,628	100%

Table 2) EU soy meal import supply
Source: (Friends of the Earth, 2008)

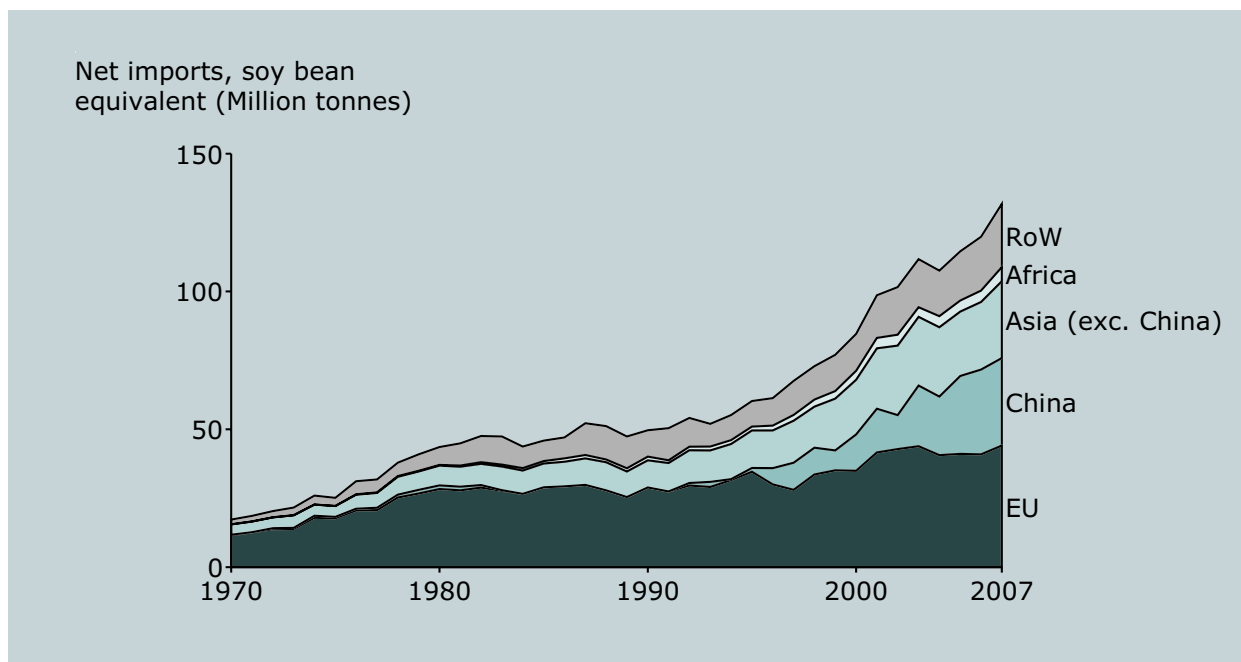


Figure 13) Global soy imports, 1970-2007
Source: (UNFAO, 2009d)

Soy bean equivalent (Million tonnes)	2007	2020F	Change
EU	44	38	-13%
China	32	65	105%
Rest of world	56	122	118%

Table 3) Projected soy imports, 2020
Source: (LMC, 2007)

5.5. The potential market for wheat DDGS in Europe

	EU compound feed market (M t, 2007)	Wheat DDGS			
		Advised incorporation rate (%)	Potential incorporation rate (%)	Advised incorporation feed mass (M t)	Potential incorporation feed mass (M t)
Ruminants	39	40%	40%	16	16
Pigs	52	5%	30%	3	16
Poultry	47	5%	15%	2	7
Other	10	-	-	-	-
Total	150	-	-	21	38
Source	(FEFAC, 2007b)	(CE Delft, 2008b; HGCA, 2007)		Calculated, 2007 basis	

Table 4) Incorporation rates of wheat DDGS in EU animal feed

5.6. EU food security

By 2020 the EU has potential to expand production of cereals by around 100 million tonnes (REA, 2009). Biorefining enough cereals to meet the EU's biofuel targets for petrol would require around 40 million tonnes, just 40% of the potential expansion (Ensus, 2008a).

If processed into high-protein feed materials through biorefining, this additional grain could produce 13 million tonnes of DDGS. This would represent 4.5 million tonnes of protein added to the EU's domestic animal feed supply, improving the EU's sufficiency ratio for high protein feed components from less than 25% to around 40%.

In this scenario, South American soy meal would account for under 40% of the EU's high protein feed component supply, down from 55% in 2006 (Friends of the Earth, 2008),(FEFAC, 2007a). This increased diversity of supply will substantially reduce the EU's exposure to supply disruptions in the three adjacent countries in South America that supply most of the EU's feed protein today (for example due to weather, disease, economic or political factors).

In addition, the increased share of EU feed protein demand that is supplied by EU agriculture will reduce the EU agricultural sector's exposure to global market price volatility. By doing so, it will provide a more economically stable environment for agricultural investment and expansion in line with future demand growth. This is particularly important for the EU's animal production industries which are currently exposed to global soy bean and meal market price volatility, and which must also bear the costs of the EU's world-leading sustainability, food safety and animal welfare standards.

<i>Million tonnes of feed protein</i>	2006	Impact of additional DDGS supply	2020F
Soy meal protein			
South America	13.0	-3.5	9.6
Other	15.3		15.3
Other imported protein	-10.1		-10.1
EU protein concentrates	5.3		5.3
Additional EU DDGS		4.5	4.5
Total in concentrates	23.5		24.6
EU self sufficiency	23%		40%
South America supply	55%		39%

Table 5) EU supply of high protein feed components
Source: (FEFAC, 2007a)

Note: Animal feed market size in EU is approximately flat, with growth in pigs & poultry offset by ongoing decline in beef & dairy herds.

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