Part 4. Ecological debt and the case of agriculture and food supply

4.0. Introduction

The present modular research has been undertaken in parallel with the modular research energy/climate change. Both have similar purposes: to elaborate the concept of ecological debt of Belgium as was established in the core research (chapter 1) with regards to a certain sector of the Belgian economy. With the present modular research it was initially intended to focus on the whole of agricultural net flows towards Belgium and to assess ecological debt as a result of it. However, due to the large share that the Belgian livestock sector takes in foreign trade of agricultural commodities, the research is delineated to this sector only. Furthermore, only the input side of the Belgian livestock sector will be examined (see 4.1.1. for more details).

First, the history and the economic and political mechanisms behind the current system of fodder crop flows towards Belgium will be analysed. This enables the formulation of strategies toward mitigation of ecological debt as a result of the Belgian livestock sector material requirement (chapter 4.1.). Before further elaborating the concept of ecological debt, material flows and land requirement abroad of the Belgian livestock sector is analysed in detail. In chapter 4.2., physical trade balances of 18 fodder crops and their historical evolution will be assessed. Further, the land requirement to produce these crops will be calculated. In order to assess ecological damage as a part of ecological debt, the land requirement for the 18 crops in all countries where they are cultivated, will also be analysed. Finally, two intrinsic parts of ecological debt as established in the core research (chapter 1), will be further elaborated with regards to the Belgian livestock sector. Both the issues of ecological damage and (in)equity of global arable land distribution are addressed in chapter 4.3.

4.1. International context of the Belgian agricultural sector

4.1.1. Introduction

Table 1 compares Belgium’s international (financial) trade figures for the entire volume of traded goods and for all agricultural products in the years 1993, 1998 and 2003 (Ecodata, 2004).

	All products		**Agricultural products**	
	Export	**Import**	**Export**	**Import**
1993	107.8	98.0	13.4 (12.4 %)	12.1 (12.4 %)
1998	161.0	148.0	18.5 (11.5 %)	17.0 (11.5 %)
2003	225.8	208.1	21.8 (9.7 %)	20.1 (9.7 %)

Table 1 – Trade figures (in billion €) of import and export of all products and of agricultural products of Belgium in the years 1993, 1998 and 2003. The share of agricultural products in total trade is also given as a percentage. (Source: Ecodata, 2004).

Although the share of agricultural products in total trade only amounts to 10 %, the absolute value of agricultural trade of Belgium is considerable. Import and export values of agricultural products have remained more or less equal for all years over the last decade. They increased in absolute terms from around 12 billion euro in 1993 to around 20 billion euro in 2003. In the late fifties, agriculture's share of total trade was only 5 % for export and around 17 % for import.

In the period 1994-97, the average degree of self-sufficiency for agricultural products was around 150 % for plant products and around 170 % for animal products (Bogaert *et al*., 1999; LEI, 1995). Although these figures do not indicate the nature of the traded agricultural products, it is clear that the Belgian agricultural sector as a whole creates an overproduction which is exported. Bogaert *et al.* (1995) calculated the trade balances of animal fodder crops and the trade balances of animal products with 7 developing countries (Argentina, Brazil, China, Philippines, Indonesia, Malaysia and Thailand). Aggregating the results of these 7 countries, it was found that between 1994 and 1997 the balances were all negative, indicating a net import for both animal fodder crops and animal products. Nevertheless, the trade balances for fodder crops were between 2.5 and 4.5 times higher than the trade balances for animal products. These figures allow to draw following conclusions:

- the Belgian agricultural sector as a whole creates an overproduction which is exported; and
- trade with developing countries usually consists of imports of animal fodder crops.

In other words, domestic animal production is maintained by fodder crops produced abroad.

As the above-mentioned indicators of (un)sustainability (self-sufficiency for animal products, trade balances of animal fodder crops) are clearly linked to the nature of the Belgian livestock sector, the original goal of the present modular research will be limited to this part only of the Belgian agricultural sector. Ecological debt as a result of production abroad for direct human consumption (fruits, sugar, coffee, tea, meat, fish, etc.) or for industrial applications (rubber, cotton, etc.) will further not be taken into account. A further delineation consists of only assessing the input side of the livestock sector. In other words, ecological debt as a result of exporting overproduction or waste created by the livestock sector will not be dealt with in this study.

This chapter will deal with the origin and history of the above-mentioned characteristics of the Belgian livestock sector. With the foundation of the Benelux in 1944, Belgium was a pioneer in the European economic integration. In 1958, the Benelux together with France, Germany and Italy signed the Treaty of Rome which was the official start of the European Economic Community (EEC), the precursor of the current European Union (Zobbe, 2001). The integration and more specifically, the establishment of a Common Agricultural Policy (CAP) has exerted enormous influence on the scope of the agricultural sectors of the different EU member countries today. As a result, the Belgian agricultural sector is highly interwoven with the CAP. Therefore, 4.1.2. briefly presents the history of the CAP, with specific attention to the Belgian situation. Further (4.1.3.) other determinants of the current global and EU agricultural state of affairs will be discussed.

4.1.2. The European Common Agricultural Policy

4.1.2.1. The European Agricultural Sector between 1880 – 1945

The year 1880 was chosen as starting point of this analysis because it was the time when trade and industrial expansion were starting to have a severe impact on rural livelihoods (Demblon & Aertsen, 1990). Two factors contributed to a general decline in European rural income: first, the extraction of rural labour forces as a production factor for the industry. Since labour is mobile between sectors and land and capital are not, farmers could only increase their cultivation land surface to improve their incomes. Yield improvement through mechanisation was still absent in the agricultural sector of the time, as all innovations were concentrated on industrial expansion. Secondly, and strongly connected to the first factor, there was the arrival of cheap overseas grain that flooded Western Europe at the end of the nineteenth century. Due to fast growing populations and the improvement of the purchasing power as a result of the industrial expansion, domestic agricultural supply was insufficient to fulfil growing demands for food. As a consequence, it became necessary to import grains. In 1850, these imports only amounted to 50 000 tonnes, in 1880 400 000 tonnes whereas in 1890 they had risen to already 1.6 million tonnes. They caused a drop in grain prices, thus reducing labour force in the agricultural sector. The impact of import of cheap grains was not equal in all European countries as grain production and agriculture played a different role in the overall economies of these countries (Demblon & Aertsen, 1990; Zobbe, 2001).

European reconstruction after World War I was followed by a short period of agricultural prosperity. After the global economical crisis that occurred between 1930 and 1934, mechanisation and motorisation became more and more prevalent in Belgian agriculture. All efforts went to improving international competitiveness, higher yields, improved quality and increase in scale (Demblon & Aertsen, 1990).

In the 1950s, the main type of farm in Europe in the 1950s was a small-scale family-owned farm which to a greater or lesser extent had structural problems. In 1955, the share of the agricultural sector in the GDP of Belgium was 7.9 %. This is relatively low compared to the Netherlands and France (around 10 %) and Italy (21 %) in the same period.

There were six countries that made the first steps towards a Common Agricultural Policy: Belgium, Netherlands, Luxembourg (together BENELUX), Italy, France and Germany. The Netherlands was the only country with a positive net foreign trade balance in the period 1955-59. Different patterns of economic development among these countries lead to different structural policy approaches. In Belgium, Luxembourg, France and Germany, agricultural policy was implemented through market organisations for the main products, with governments intervening in the market to guarantee a producer price higher than the world market price. In the Netherlands, the government only intervened in the agricultural market to maintain stable prices. There was no explicit price policy in Italy, but the state generally controlled all trade in agricultural products. As high price policies were commonly shared as a basis for the individual countries, a CAP based on price support was actually a logic consequence of an already existing situation (Zobbe, 2001).

4.1.2.2. *Origin of the Common Agricultural Policy (Zobbe, 2001)*

Discussions on the different agricultural policies of different European countries began immediately after World War II. Initial talks took place in the Council of Europe and the OECC (Organisation for European Economic Co-operation) between seventeen nations, based on proposals from France, Great Britain and The Netherlands. After Word War II, two important issues were at stake with regard to agriculture:

(i) to ensure the security of food supplies; and
(ii) to secure the income of European farmers.

Productivity and production had to be raised as actual food consumption was well under demand and actual needs. A high dependency on food imports was seen as strategically and politically problematic and furthermore foreign currency, especially dollars, were a scarce resource. The first negotiations failed, mainly due to different viewpoints from France and The Netherlands, arguing for a supra-national agricultural policy, and Great Britain, opposing any form of supra-nationalism and with a strong will to maintain (trade) relations with the Commonwealth. It soon became clear however that the six countries mentioned in 4.1.2.1. had a more common view on agricultural policy. Together with the European Coal and Steel Community (1951), agriculture laid the ground for the creation of the European Economic Community (EEC). Agriculture was rather quickly included in the economic integration process of Western Europe as (i) agricultural and industrial products were difficult to separate on an integrated market, (ii) the shares of total exports and imports represented by agriculture were of great importance, (iii) food prices were an essential cost factor in the non-agricultural sector, and (iv) changes and adjustments were necessary to promote general economic growth.

On January 1st, 1958 the Treaty of Rome between the six afore mentioned countries came into force and the EEC became reality. Article 39 specifies a set of objectives for the Common Agricultural Policy:

a. to increase agricultural productivity by promoting technical progress and by ensuring the rational development of agricultural production and the optimum utilization of production factors, in particular labour;
b. increasing the individual earnings of persons engaged in agriculture;
c. to stabilise markets;
d. to ensure the availability of supplies; and
e. to ensure that supplies reach consumers at reasonable prices.

To achieve these objectives, intra-Community trade in agricultural products had to be protected against competition and distortions from the world market. Therefore, a system of market organisation based on price support had to be designed. This would, together with structural agricultural policies maintain farmers' livelihoods. Structural policies were developed aiming at controlling (reducing) the number of farms, the number of livestock units the overall production, and preferring family (i.e. small scale) farms as the cornerstone of European agriculture, and helping farmers to withdraw from agriculture through finding alternative occupations or taking early retirement. In 1960, the European Commission proposed 3 principles of the CAP:

1. free intra-Community trade: no barriers to trade in agricultural products between the member states;

2. Community preference: suppliers from within the Community were to be given preference over those from outside the Community;
3. common financing: funding for the CAP would be through a central European budget for all revenues and expenditures generated by the policy.

To implement the third principle, all agricultural products were given their own market organisations with institutional prices that were centrally defined. Institutional prices differed in some cases considerably in comparison to world market prices: e.g. in 1968: white sugar (438 % of world market price) and butter (397 % of world market price). In order to maintain high prices at all times, market organisations were combined with a system of variable import levies and export refunds.

Two policy regimes can be applied in order to implement institutional prices: price support and deficiency payments. With *price support*, the raised price (institutional price) also appears in the price of the final products. This means that farmers' income is actually secured directly and paid for by consumers. With *deficiency payments*, the price paid by consumers equals the world market price. The farmers' income is then paid by the national fiscal budget – thus by taxpayers. In the case of price support, demand for agricultural products would decrease in comparison to a system based on deficiency payments, as prices are higher. The policy regime of price support was quickly decided upon by the six EEC members because of two obvious advantages:

1. as demand is lower with the price support system, imports of agricultural products would decrease and thus brings about increase in foreign currency reserves;
2. deficiency payments necessitate tax increases, which are not popular with the general public. In the case of Belgium in 1967, total tax revenue should have been increased from 5.8 billion $ to 6.3 billion $, an increase of 8.6 % in order to comply with the CAP as defined for that year.

Since the six EEC members had different views on how to implement structural policies to address the 'farm problem', the overall political will was lacking to implement structural agricultural adjustments. Moreover, such a policy would be very costly if it were to succeed. This means that price support was the only strong instrument of the EEC's CAP in the first decades of its existence.

4.1.2.3. *Reforms of the Common Agricultural Policy*

The adoption of a price support policy regime without any form of structural adjustments created an overproduction and hence did not bring a solution to the farm problem. Export restitutions were paid to farmers to be able to sell the overproduce at prices lower than the actual producer prices (equal or below world market prices), while at the same time maintaining farmers' income (Zobbe, 2001). This evolution had an impact on countries importing and exporting from and to the European Union. This impact will be discussed in 4.1.3.

The first to tackle the structural farm problem was the Dutchman Sicco Mansholt in 1968. He was the first commissioner on agriculture in the EEC and later (1972) became president of the European Commission for 7 months. He had the ambitious plan of restructuring EU farming by 1980 into a mixture of commercial farmers and part-time farmers. This was to be achieved by a combination of selective investment aids to potentially viable farmers and retirement incentives to non-viable farmers. It was a revolutionary plan, as it emphasized structural reforms in the European agricultural sector, which had been neglected before since efforts were mainly directed to the one-sided price support policy instrument. The Mansholt Plan was nevertheless rejected after the 1973 energy crisis. The EU established a Disadvantaged Area Scheme (1975) which – contrary to the Mansholt Plan – encouraged non-viable farmers to continue farming in poorer areas (Ellis, 1999).

In 1977, the European Commission became more aware of growing agricultural surpluses, caused by price support as the main CAP instrument. In that year, a *prudent price policy* was agreed upon which turned out to involve cutting real prices of farm produce by some 3 % annually. This policy lasted until 1993. Yet, these reductions in price support proved to be insufficient to reduce agricultural surpluses (Ellis, 1999).

Quotas had always existed from the beginning of CAP for sugar beet, but in 1983 the European Commission imposed restrictions on milk production at farm level as well. However, other commodities remained free to expand. As a result, the CAP budget continued to soar and surpluses kept on growing. Therefore, in 1988, the stabiliser approach was used. With this policy, a maximum guaranteed quantity was set for commodities such as grain. If farmers collectively exceeded that ceiling, an automatic price cut was triggered. This approach also didn't result in the expected reductions. As a consequence, the budget for farm support kept on growing. Finally in 1988 a set of binding controls was established, which put a definite ceiling on the cost of price supports (Ellis, 1999).

As all above-described policy measures seemed to be unable to tackle the 'farm problem', a large CAP reform was undertaken in 1991. In the light of the WTO negotiations on agriculture – The Uruguay Round, which was finalized in 1995 (see 4.1.3.) - there was large pressure on the European Commission to reduce guaranteed institutional prices for farm products. The main argument of the WTO for insisting on price support reduction was that this policy distorts world trade, as it hampers exports of non-EU countries to the EU. This policy shift got known as the MacSharry reforms and aimed at (i) further reducing guaranteed prices for beef and cereals and compensating them by direct payments to farmers; and (ii) extension of supply control beyond sugar and milk to beef, sheep, cereals and oilseed crops. The direct aid consisted of premiums paid per head of livestock, or 'area aid' payments per hectare. The MacSharry reforms for the first time underlined the dual function of present-day farming, namely (i) producing commodities; and (ii) guarding of the countryside (Ellis, 1999).

The general goal of the Agenda 2000 decisions of 1999 - a continuation of the MacSharry reforms - was to support the broader rural economy rather than agricultural production. Agenda 2000 reform also aims at encouraging more environmentally-friendly farming and promotes an integrated approach to rural development in all rural areas. Ellis (1999) foresaw that direct payments would account for some 80 % of total income once new direct payments were fully in place. In 2006, direct payments would have to make up some 70 % of total CAP budget, whereas in 1996 after the MacSharry reforms this was 60 %. Direct payments made up only 9.3 % of the CAP budget in 1990; refunds and intervention accounted for 90.7 %. Following Agenda 2000, CAP expenditure will be frozen until 2006 (ECDGA, 2001).

Critical analyses of the European Common Agricultural Policy so far have paid almost exclusively attention to intra-EU concerns. Effects on third parties, in particular developing countries, have hardly been addressed (Kuyvenhoven, 2001).

4.1.2.4. The Yaounde, Lomé and Cotonou Agreements

The Yaounde, Lomé and Cotonou agreements are a number of conventions in which the principles and objectives of the European Union (Community at the time) cooperation with African, Caribbean and Pacific (ACP) countries were set out. The cooperation started with a first association between ACP and EC members in 1963 with the Yaounde I agreement. The cooperation dates back to the birth of the European Treaty of Rome, establishing the EEC in 1957, which expressed solidarity with the colonies and overseas countries and territories, and a commitment to contribute to their prosperity. Its main characteristics are the partnership principle, the contractual nature of relationship, and the combination of aid, trade and political aspects, together with its long-term perspective. Yaounde I was followed by Yaounde II (1969)[1], Lomé I (1973), Lomé II (1980), Lomé III (1985), Lomé IV (1995) and finally the Cotonou agreement of 2000. Separate 'trade protocols' on sugar, beef, veal and bananas are the main features of the Lomé conventions. The 'stabilisation of export' receipts (STABEX) were established in the 1970s and provided funds to offset losses on a wide number of agricultural products: cocoa, coffee, groundnuts, tea. These receipts enabled to tackle crop failures and price falls. The signing of the ten year Lomé IV (1990 – 2000) marked another turning point in the history of EU-ACP cooperation. The then European Community embarked on a dialogue with the World Bank and IMF (see 4.1.3.) on how best to support structural adjustment programs (SAPs) as a means to economic growth (EU, 2003). Although EU-ACP agreements stimulate production and export of agricultural products from developing countries (with possibly concomitant social and ecological damage), the crops cultivated in the frame of the agreements are not primarily intended to the European livestock sector. Therefore, a further analysis of the special relation between EU and ACP member countries will not be undertaken.

4.1.3. Other determinants of the current global and EU agricultural situation

4.1.3.1. The World Trade Organisation (WTO)

In 1985, the main trading nations of the world entered into agricultural negotiations, organised under the General Agreement on Tariffs and Trade (GATT). After negotiations that lasted for 8 years, GATT was transformed into the Uruguay Round Trade Agreement (URTA) and institutionally consolidated by the World Trade Organisation (WTO). It was the first time in history that global agricultural policy was brought under global rules (except for non-WTO members). As the European Union as a whole participates in WTO, the global agricultural trade agreements urged adjustments to the European CAP and to similar policy regimes world-wide. Three principle commitments have been made by all countries under URTA (Ellis, 1999):

a) *reduction of domestic support*: this support is measured in URTA by an Aggregate Measure of Support (AMS). It is calculated as the difference between internal support prices and world prices, multiplied by the quantity produced, for all major commodities. In WTO terminology subsidies in general are identified by "boxes". For agriculture, three different boxes are applied (WTO, 2001a):

[1] Years between brackets are the year in which the agreements are actually signed. Negotiations took several years.

- the *amber box*: contains all support measures considered to distort production and trade. All support coupled to production (price-support, export refunds and intervention prices under CAP) are included in this box. Under URTA, total value of these measures are to be reduced.
- the *green box*: these subsidies are to be government-funded. They include direct income support for farmers that are completely decoupled from current production levels or prices. They also include environmental protection and regional development programmes.
- the *blue box* is an exemption from the general rule that all subsidies linked to production must be reduced or kept within defined minimal levels. It covers payments directly linked to agricultural land surface or animal numbers. They only count for schemes which also limit production by imposing production quotas or requiring farmers to set aside part of their land. Currently only the EU, Iceland and Norway are using the blue box.

The EU says it is ready to negotiate additional reductions in amber box support as long as the concepts of the blue and green boxes are maintained.

b) *increased market access*: all kinds of levies, custom duties, and quotas on import restrict agricultural trade with the EU. It was therefore agreed that all non-custom duty forms of protection were to be replaced by an equivalent sum tariff.

c) *reduction of export subsidies*: export subsidies are continuously applied by the EU to compensate for lower world market prices when European overproduce is exported. The USA and some other countries use export subsidies only occasionally. URTA foresaw by 2001/02 a reduction in EU agricultural exports by 21 % and a reduction of EU expenditure on them by 36 %.

In 2001, at the fourth Ministerial Conference in Doha, Qatar, WTO member governments agreed to launch new trade negotiations, resulting in the *Doha Declaration*. With regard to agriculture, commitments made in URTA were to be further carried out (WTO, 2001b). The fifth WTO trade negotiations in Cancún, Mexico (2003) had similar objectives, but broke down unexpectedly due to – among other things – disputes on how to organise free trade in agriculture. This means that the January 2005 deadline for completing this round of talks will almost surely be missed (OECD, 2003).

4.1.3.2. *International Financial Institutes (IFIs)*

In 1944, the International Monetary Fund was created to restore the volume of international trade that had dropped due to instability since the replacement of the gold standard by the US dollar in the 1930s. In 1945, the IMF and the International Bank for Reconstruction and Development (IBRD) were officially established. IRBD together with 5 affiliated agencies is part of the World Bank group. The original purpose of the World Bank was the reconstruction of Europe after World War II by granting loans. Both World Bank and IMF worked closely in conjunction with the Marshall Plan for the redevelopment and economic stabilisation of Europe (MUNF, 1995).

Today, IMF provides short term loans (3 years) mainly to developing countries. Its purposes are (i) the facilitation of international trade, thereby contributing to a rise in employment and national income; (ii) the promotion of exchange stability; and (iii) the establishment of a multilateral system of payments, eliminating foreign exchange restrictions which hamper world trade. The USA contributes most to the fund (18 %) and therefore holds the greatest decision-making power. Germany, Japan, France, and the UK follow with approximately 5 % contribution each (MUNF, 1995).

The World Bank's current objective is the economic development of nations by making loans where private capital is not available. The World Bank works closely in conjunction with IMF in performing its tasks. It makes available loans on a long-term basis, repayable in up to 15 years. The World Bank is run by 24 executive directors. Each country (177 in total in 1995) is represented by a board of governors (MUNF, 1995).

Loans made available by IMF and World Bank are since the 1980s made contingent to the execution of *Structural Adjustment Program*s (SAPs). These programs target macro-economic policy changes that oblige recipient nations to liberalize their trade and investment policies (Welch & Oringer, 1998). The measures involved in the structural adjustment programmes are inter alia (i) liberalisation of foreign exchange and import controls, (ii) reduction in domestic money supply; (iii) reduction of government spending; (iv) privatisation of publicly owned firms; (v) reduction of restrictions on foreign investment; and (vi) depreciation of the currency (MUNF, 1995). Each of these measures are intended to make more foreign currency available to the recipient country and to divert its economy to a more export-oriented one.

IMF and World Bank loaning policies and the SAPs have since their first implementations in the '80s been subjected to lots of criticism as for their negative socio-economic and ecological impacts (Lee, 2001; MUNF, 1995; TWT, 2004; Welch & Oringer, 1998):

<u>Socio-economic impact of SAPs</u>

1. <u>The export-oriented SAPs perpetuate the debt crisis</u>. Due to increased export of commodities, global prices for (agricultural) exports have collapsed, which increases debt pressure on the exporting countries. The legitimacy of some of this financial debt is questioned in the case of lending to corrupt regimes.
2. <u>Lack of country-specific policies</u>. SAPs can basically be summarised as economic shock therapies which are ineffective in achieving poverty alleviation goals. Adjustment policies should be designed to the very specific economic situation of the country on which they are imposed.
3. <u>Unsatisfactory degree of participation</u>. The citizens of the countries who will be most affected by the decisions are left out of the decision-making process of IMF and World Bank.
4. <u>IMF and World Bank are nearly the only (monopolistic) lending institutions for developing countries</u>. Reallocation of IMF and World Bank budgets to a diverse selection of bilateral, non-governmental and private institutions would have a better success record through creative and flexible approaches towards development objectives.

<u>Ecological impact of SAPs</u>

1. More than half of the World Bank's $ 24 billion annual loans support projects in environmentally sensitive areas. Between 1986 and 1993, 15 % of World Banks loans were intended for projects which forcibly displaced 2 million people. The funding of large dam constructions is the main cause of displacement of people.

2. The important role that can be played by actors at the community level with regard to developing and monitoring local ecosystems, is not acknowledged.
3. In all sectors, projects implemented with World Bank loans do not take environmental costs into account. Substantial amounts of water are used for irrigation or for processing industries without concomitant support for water conservation nor implementing sustainable wastewater management. Energy resources are managed in the same way.
4. The emphasis of World Bank agricultural lending programs is on the development of export crop production. The result is the imposition of farming practices which emphasize high-intensive cultivation methods, designed to achieve high rates of return. This includes inter alia the introduction of hybrid seeds requiring intensive watering, chemical fertilizer and pesticide use. This brings about a wide range of environmental problems that will be discussed in Chapter 3.3. According to World Bank's own evaluation process, of 82 agricultural projects, 45 % were considered socially and environmentally unsustainable.

4.1.4. Conclusions

The international context – or the dependence on foreign produced crops - of the Belgian livestock sector has to be evaluated in a European context. Agricultural policies of EU members are determined by a global EU Common Agricultural Policy. This policy was the result of a continental approach to the 'farm problem' after world war II: low agricultural income and insufficient food supply. The problem originated at the end of the nineteenth century when the industrial revolution withdraw labour forces from agriculture and when rising population urged for substantial imports of grains. However, the price support system agreed upon by the first six European Community members to tackle the farm problem, brought about some undesired side-effects. Overproduction of livestock increased demand for fodder crops which could be imported from outside Europe at (cheap) world market prices.

Under pressure of the World Trade Organisation (WTO), the 'McSharry' reforms of the CAP resulted in a decrease in direct price support and in maintaining production quota for certain agricultural commodities. Nevertheless, current WTO pressure to implement free trade in agricultural products and export oriented lending policies of IMF and World Bank enhance export production in developing countries. In spite of reduction in overall EU agricultural overproduction, free trade remains ecologically unsustainable as ecological damage of (fodder) crop production in these countries is not internalised in market prices. The impact on (rural) population in the South of this inequality is tremendous: human settlements and subsistence agricultural production are jeopardized by substitution of former subsistence agricultural lands or former virgin forests by export oriented (fodder) crop production areas. Andersson & Lindroth (2001) state that international trade blurs the responsibility of Northern countries for the ecological effects of production and consumption. Multinational agro-industrial companies are the only profit makers in the current global agricultural sector. Farmers in North and South are tied to supplies and sales from and to the globalised agro-industry (Demblon & Aertsen, 1990).

4.2. Foreign raw produce for the Belgian livestock sector

4.2.1. Overview of foreign produced crops

In order to make an assessment of the sustainability of the Belgian agricultural sector, Bogaert *et al*. (1999) established 22 indicators for the sustainability agriculture in Belgium of which 2 are directly related to the Belgian livestock sector: (i) ratio of trade balances of animal feed and animal production; and (ii) the Belgian self-support ratio for animal and vegetable products. The first indicator reveals that the above-mentioned ratios of trade balance with developing countries[2] were 450 % for 1994, 205 % for 1995, 285 % for 1996 and 247 % for. This indicates a substantial flow of raw production for animal feed from these countries toward Belgium, while purchasing power of developing countries proves to be insufficient for Belgium's expensive animal products. The second indicator is the ratio of own produce of a certain agricultural product and the total available amount (= own produce + import – export). The self-sufficiency for Belgian animal products was approximately steady around 170 % (1994 – 1997), indicating surpluses on the Belgian market for animal products. Specific input figures for the livestock sector are not mentioned. Nevertheless, self-sufficiency for cereals fluctuated around 50 % in the same period, indicating greater imports than own produce. The Belgian Compound Feed Federation (Bemefa, 1999; 2000; 2001; 2003) provides an overview of the commodities applied by their members: cakes of oilseeds account for 30 %; and cassava around 10 % of total fodder crop commodities. The latter has unquestionably been produced outside Belgium since cassava cultivation is limited to humid and subhumid tropical regions (Raemaekers, 2001). Coppens (2003) reports the worldwide consumption of oilseed cakes for 2002: cakes of soybeans (66 %), copra (1 %), palm pits (2 %), groundnut (3 %) and cotton seed (7%). Many of these oilseeds cannot be grown in Belgium because of specific climate requirements (Raemaekers, 2001). They account for 79 % of all oilseeds used worldwide for animal production. Bemefa (1999; 2000; 2001; 2003) also mentions 30 % to 40 % use of not further specified cereals.

These figures prove that the Belgian livestock sector is highly dependent on import of raw commodities from abroad. Table 2 gives an overview of 18 crops produced abroad for the Belgian livestock sector (Bemefa, 2003; Hasha, 2002; conversation with Prof. S. De Smet[3], Prof. J. De Cuypere², Ir. G. Sturtewagen[4]). They are subdivided in a 'protein' and a 'starch' group, according to the main nutritious substance they contain.

[2] Argentina, Brazil, China, Philippines, Indonesia, Malaysia and Thailand
[3] University of Ghent, Faculty of Agricultural and Applied Biological Sciences, Department of Animal Production
[4] Employee of DSM compound feed firm

Group	Crop	Scientific name	Transformed to
Protein	Soya	*Glycine max* (L.) Merr.	oilcake of beans, flour, oil
	Groundnut	*Arachis hypogaea* L.	oilcake of beans
	Cotton	*Gossypium hirsutum* L.	oilcake of seeds
	Flax	*Linum usitatissimum* L.	oilcake of seeds (linseed)
	Rape	*Brassica rapa* L.	oilcake of seeds (rape- or coleseed)
	Sunflower	*Helianthus annuus* L.	oilcake of seeds
	Coconut palm	*Cocos nucifera* L.	oilcake of copra (dried flesh of fruit)
	Oilpalm	*Elaeis guineensis* Jacq.	oilcake of kernels
	Pea	*Pisum sativum* L.	dried beans
	Alfalfa	*Medicago sativa* L.	flour
Starch	Cassava	*Manihot esculente* Crantz	tuber
	Corn	*Zea mays* L.	grain / meal
	Wheat	*Triticum aestivum* L.	grain / meal
	Barley	*Hordeum vulgare* L.	grain / meal
	Rye	*Secale cereale* L.	grain / meal
	Oat	*Avena sativa* L.	grain / meal
	Sorghum	*Sorghum bicolor* (L.) Moench	grain / meal
	Millet	Various species[5]	grain / meal

Table 2 – *Crops produced abroad for the Belgian livestock sector*

As indicated in the latter column, the crops can be subjected to transformation before transport. Oil crops, the first eight in the protein group, often are transported as oilcakes (Mounts & Pryde, 1983). These are the protein-rich remains of crushing beans, seeds or flesh of fruit (in the case of copra). Van Gelder & Dros (2004) report domestic crushing as percentage of production, in the main soybean producing countries: Brazil: 58 %; Argentina: 66 %; Paraguay: 26 %. Consequently, imports of oilseeds as well as oilcakes will have to be taken into account with regard to the Belgian livestock sector.

4.2.2. Material flow toward the Belgian livestock sector

4.2.2.1. Introduction

The purpose of the present modular research is to assess ecological debt caused by foreign cultivation of raw fodder commodities for the Belgian livestock sector. Since material flow analysis sheds light on the extent of ecologically unequal exchange (see 1.4.4.), it will be performed as a first step in elaborating the ecological debt of the Belgian livestock sector. In this perspective, the Belgian livestock sector will be regarded as part of the Belgian socio-economic system for which the total material requirement can be quantified. The extractions for the livestock sector are twofold: domestic production and import of fodder crops. As in the present research ecological debt is considered to have been historically accumulated between states (see discussion in 1.3.3.2. and 1.3.4.4.), domestic production will be left aside. Another duality is the division between direct material input and hidden flows. The latter will however not further be taken into account as it implies imports of final products. As a cause of the subsidy policy of the EU (see 4.1.2.), prices of these final products are relatively high in

[5] *Millets* is a grouping name for different species of edible 'grasses': *Setaria italica* L. (foxtail millet), *Panicum mileaceum* L. (proso millet), *P. ramosum* L. (browntop millet), *Echinochloa frumentaceae* (barnyard or Japanese millet, *Pennisetum glaucum* L. (pearl millet), *Eragrostis tef* (tef), *Eleusine coracana*, etc.

comparison to cif[6]-prices of raw material to produce them and imports of these finalized fodders will therefore be limited (Andersson & Lindroth, 2001; Bogaert *et al*., 1999; Demblon & Aertsen, 1990; Elamin, 2000; ECDGA, 2001; Hasha, 2002; Nilles *et al*., 2002). As a consequence, this chapter will deal with imported direct material input for the Belgian livestock sector. As an onset towards the ecological impact of land requirement (4.2.3.) and the inequality of land use for foreign fodder crop production (chapter 4.3.3.), imports will be reported in physical units (Hubacek & Giljum, 2003).

4.2.2.2. *Methodology*

The crops listed in table 2 (4.2.1.) will be used as a starting point for the analysis. For each of the listed crops, annual import and export figures since 1960 were searched for. This year was chosen as a starting point for the analysis because the global trade relations of European agriculture in general boosted in the decade of the sixties. The Dillon Round of the General Agreement on Tariffs and Trade (1962) confirmed this international evolution (Hasha, 2002). As mentioned in 2.1., figures of derived products of oilseeds will also be explored where relevant: oilcakes, flour, oil.

The Statistics on Foreign Trade of Belgium[7] were used as data source for import and export figures. Until 1997 these statistics referred to the Belgian-Luxemburg Economic Union (BLEU). From 1998 on, they only apply to Belgium (NBB, 2000). However, in 1995 meat production (in physical units) in the Grand-Duchy of Luxemburg contributed for only 0.1 % to total EU meat production, whereas for Belgium this was 4.4 % (EC, 2000). This indicates that Luxemburg animal production is insignificant in comparison to Belgian animal production. Consequently, a transformation of the figures before 1998 to bring them in harmony with the recent trade data will not be performed.

The import and export data from the Statistics on Foreign Trade of Belgium refer for all volumes (1960 – 2001) to permanently traded goods as well as to temporarily traded goods that are re-imported or –exported after transformation in Belgium or abroad (NBB, 2000). The Statistics on Foreign Trade of Belgium provide the net mass of the traded goods in 100 kilograms unit before 1995; in 1000 kilograms unit from 1995 on (NBB, 2000).

For the material flow analysis, an overview will be given of the physical trade balances (PTB) of the commodities listed in table 2. Physical trade balances are calculated as imports minus exports in physical units (here: kg) (Newson, 2001). These trade balances can be regarded as net flows to Belgium of raw material for the livestock sector.

[6] **C**ost **i**nsurance **f**reight; price of a product at the border of the importing country

[7] Source: 1960 – 1995: National Institute of Statistics (NIS), Brussels; 1995 – 2001: National Bank of Belgium, Brussels

4.2.2.3. *Results*

4.2.2.3.1. Soya

<u>Soy processing </u>(Berk, 1992; Coppens, 2003; Semon *et al.*, 1997; Van Gelder & Dros, 2004)

In order to fully understand the presented figures, some explanation on the processing of soybeans is indispensable. Soybeans are composed of 37,2 % proteins, 18 % fats and 5,7 % fiber. Of all generally used oilseeds, they contain the highest amount of protein. Moreover the composition of amino acids in the proteins is highly suited for animal consumption. Originally used for oil extraction, the beans are nowadays more valued for the extraction remains: the soycakes (syn. soymeals) that are fed to livestock worldwide. Before extraction, soybeans are cleaned, dried and hulled. Next, the beans are treated with steam and flattened to flakes. The extraction itself used to take place by means of hydraulic pressing or by expeller pressing – these methods have generally been abandoned. The currently applied solvent extraction method takes places by either percolating a solvent over the flakes or by immersing the flakes in the solvent (usually hexane). Later, the solvent is reclaimed through a series of evaporators. As this crude soybean oil contains impurities, they will be subsequently removed by implementing various techniques that will not further be elucidated. With regard to animal feed however, the lecithin recovery needs to be mentioned. Lecithin is a lipid (fat) which plays an important role in animal and human physiology. As no figures were found on separate import of soy lecithin, it is assumed that it is extracted from soybeans in local oil crushing plants. Soybeans are also processed into full fat soybean flour, which can be used as an additive in animal feed. In this case, soybeans are hulled, heated and milled into a fine granulated flour.

<u>Results</u>
Figures 1 and 2 report the physical trade balances for soybeans, soy meals (= cakes), soy flour and soy oil. The trade in soy flour and oil has always been significantly lower than trade of soybeans and soy meals. Soybeans trade balances were under 500 000 tonnes annually before 1973 and later boosted to a level between 1 million and 1.5 million tonnes in the last two decades (figure 1). In 1981, the trade balances for soy meals became negative as a result of processing of the imported soybeans into meals that are re-exported. Until 1987, annual trade balances of soy oil and soy flour didn't exceed 6 500 tonnes; a maximum net import of 52 000 tonnes was reached in 1991. From 1987 on, only net exports of soy flour are reported.

Figure 1 – *Annual physical trade balances for soybeans and soy meals (1000 tonnes)*

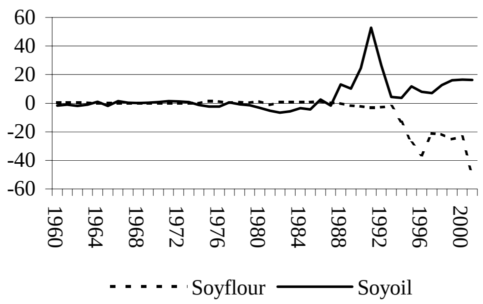
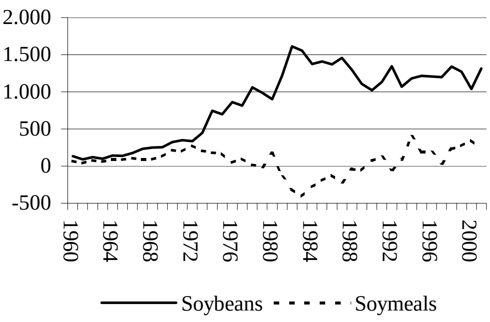


Figure 2 – *Annual* physical trade balances *for soy flour and soy oil (1000 tonnes)*



4.2.2.3.2. Other oilseeds

Whereas net imports of soybeans reach a maximum at 1.6 million tonnes in 1982 (figure 1), annual trade balances for other oilseeds never exceeded 800 000 tonnes (figure 3). In the early eighties a rise in net imports of rapeseeds, sunflower seeds and linseeds is noticed, whilst other oilseeds remain under the level of 60 000 tonnes.
Trade balances for soy meals were between –500 000 and +500 000 tonnes annually during the invested period whereas trade balances for oilcakes of other oilseeds (figure 4) were restricted between +100 000 tonnes and –50 000 tonnes annually until 1983. Hereafter, net imports of copra oilcake rose slightly up to 150 000 tonnes in 1991. For oilcakes of rapeseeds, a strongly fluctuating net export is reported after 1983 with an extreme net export of 330 000 tonnes in 1991. The latter indicates a fluctuating use of oilcakes from the imported rapeseeds for export on the one hand and for animal feed production on the other hand.

Figure 3 – *Average annual physical balances per decade of trade of oilseeds, other than soybean (1000 tonnes)*

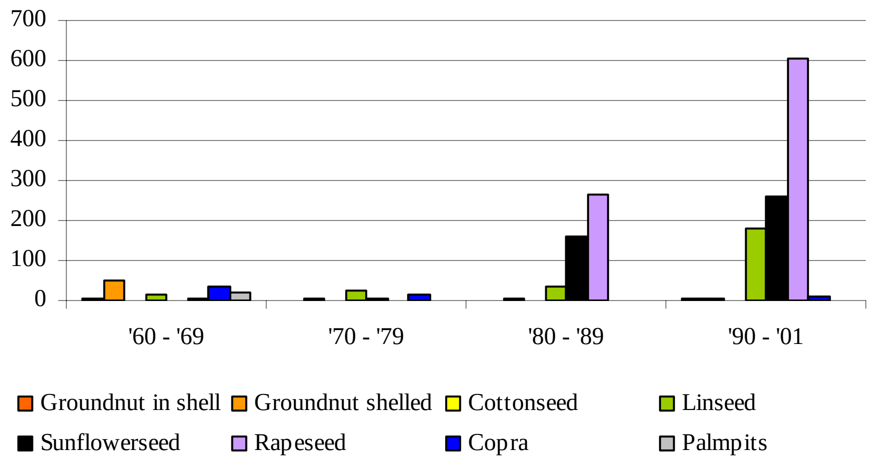
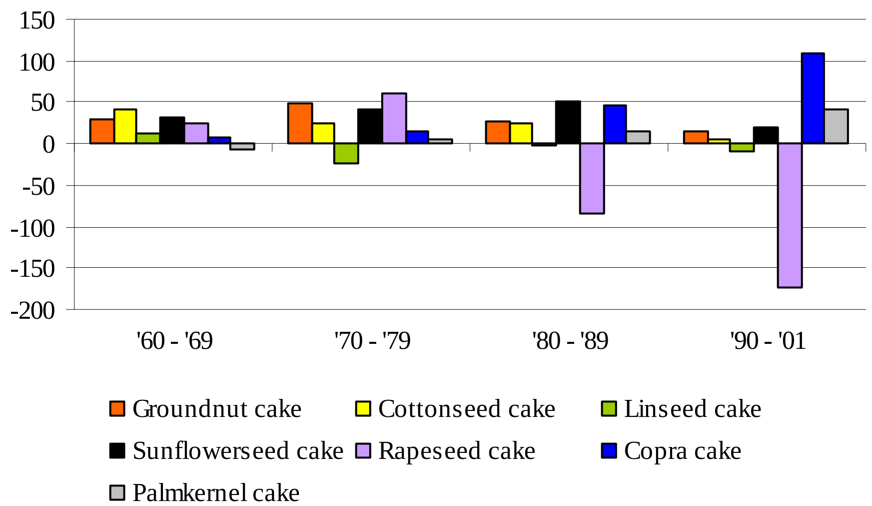


Figure 4 – *Average annual physical trade balances of oilcakes from oilseeds, other than soybean (1000 tonnes)*



Although linseed and rapeseed are also produced in Belgium, the importance of this domestic production is relatively negligible with regards to the imports (figures 5 and 6).

Figure 5 – *Annual domestic production and annual imports of **linseeds** (1000 tonnes)*

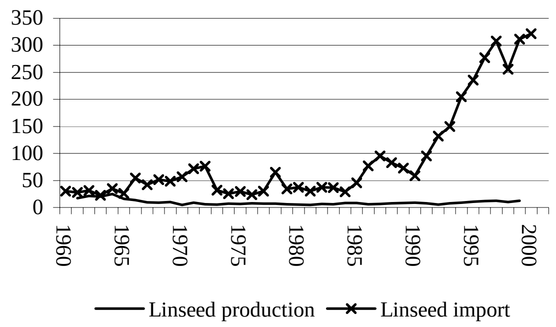
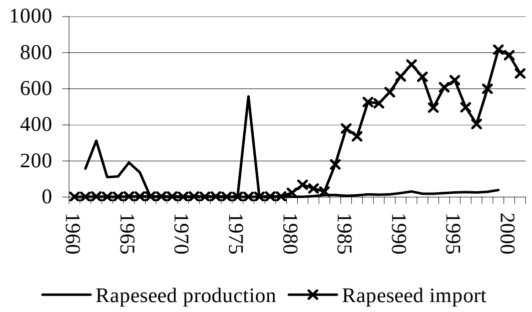


Figure 6 – *Annual domestic production and annual imports of **rapeseeds** (1000 tonnes)*

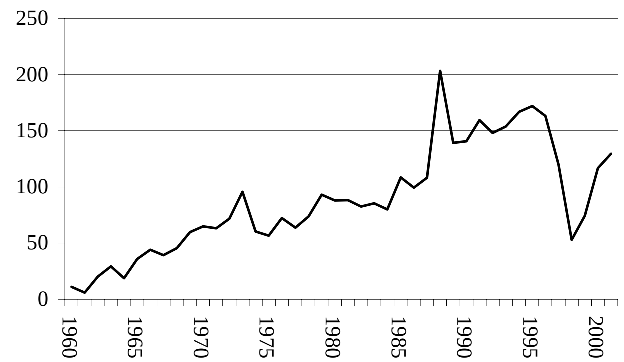


4.2.2.3.3. Other protein rich crops – Alfalfa and Peas

Next to oilseeds, other protein-rich crops are highly valued as a fodder crop commodity in the livestock sector. Since meat and bone meals have been banned by the EU since 1994 (EC, 2001), these crops have become more and more important. Figure 7 depicts the annual trade balances for alfalfa. Net imports have steadily increased from 10 000 tonnes in 1960 to 100 000 tonnes in 1987. The net imports have doubled in 1988 but were afterwards around 150 000 tonnes annually. Lower trade balances (50 000 tonnes) are noticed in 1998 and 1999. However, this decline is not due to lower imports but to sudden exports raises, particularly to Libya.

Problems arose with the analysis of trade figures for fodder peas in the Statistics on Foreign Trade of Belgium. The category '*fodder peas*' is only present from 1980 until 1987. In this period, imported quantities were between 100 and 2000 tonnes. Before and after this period, figures from the category '*dried peas not designed for sowing purposes'* are reported. Within this category, trade balances were negative before 1967, reached up to 60 000 tonnes annually between 1967 and 1980 and up to 500 000 tonnes annually after 1987. These figures contrast with De Jaegher (2004) who states that annual net imports of fodder peas should be around 7 000 tonnes in the last decade. As the genuine quantity of dried peas intended for the Belgian livestock sector can not be revealed with these figures, they will further be banned from the analysis of inputs for animal fodder.

Figure 7 – *Annual physical trade balances of alfalfa (1000 tonnes)*



4.2.2.3.4. Starch crops

Of all starch crops imported, corn is the most important, with an average trade balance between 800 000 and 1 500 000 tonnes annually (figure 9). Since the early 1970s, net imports of wheat, barley and cassava have been between 200 000 and 800 000 tonnes annually. Since 1993 net imports of wheat have doubled from 600 000 tonnes to 1 200 000 tonnes annually. As trade balances for rye, oat, sorghum and millet were practically always below 200 000 tonnes annually, they are not depicted in figure 9. It should be stressed however, that corn, wheat, barley, rye and oat are also produced inside Belgium. Figure 10 provides an overview of the historical evolution of imports and domestic production of corn and highlights the dominance of corn imports throughout the invested period. In 1995 however, this situation changed drastically as imports gradually dropped to 500 000 tonnes, whereas production increased almost tenfold in the same period also to 500 000 tonnes. The main reason for this pattern change is the decree on manure reduction adopted by the Flemish government in 1991, which encourages domestic production of corn, since it is a crop with a high nitrogen uptake (De Jaegher, 2004). Domestic production figures of wheat, barley, rye and oat were not available at the FAO database.

Figure 9 – *Annual physical trade balances for starch crops (1000 tonnes)*

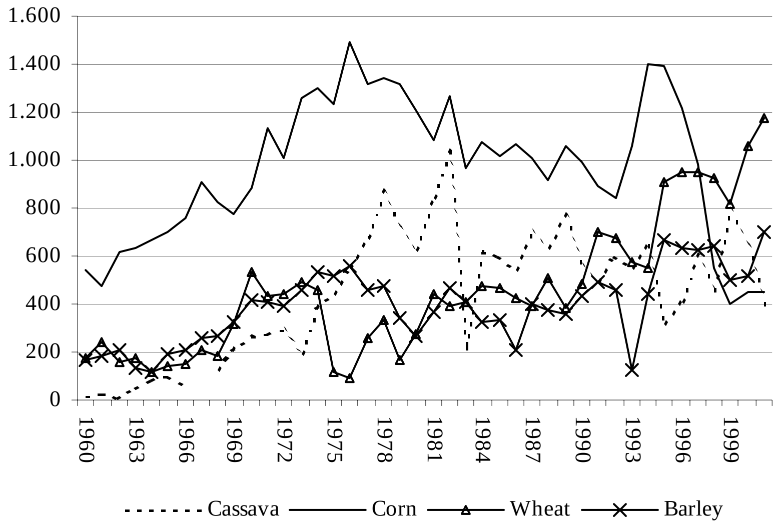
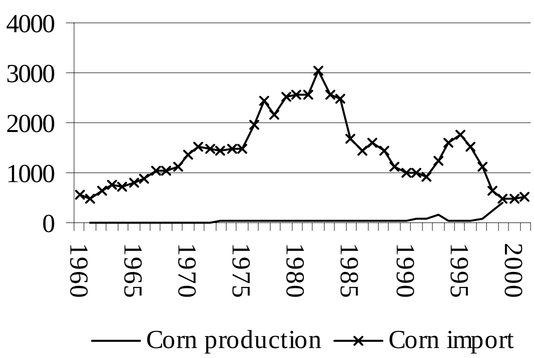


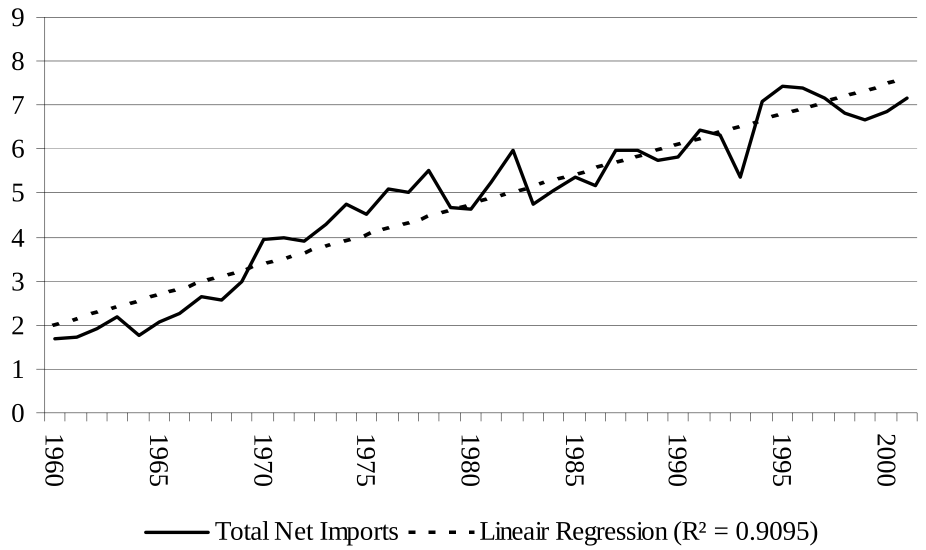
Figure 10 – *Annual imports and domestic production of corn in Belgium (1000 tonnes)*



4.2.2.3.5. Aggregation of results

In order to assess the imported material requirement of the Belgian livestock sector, the results of figures 1 – 9 have been aggregated in figure 11. Although some variation occurs, a nearly linear increase in net import of fodder crop commodities is observed. Net imports were 1.68 million tonnes in 1960 and rose up to 7.17 million tonnes in 2001. Linear regression yields a trend line with an average annual increase of 140 000 tonnes ($R^2 = 0.9095$).

Figure 11 – *Total net imported material requirement for the Belgian livestock sector (million tonnes)*



4.2.2.4. *Conclusion*

The net flows of 10 protein and 8 starch fodder crops to the Belgian livestock sector have been examined in a historical perspective. It was found that flows of soybeans are currently predominant with recent annual net import fluctuating between 1 – 1.5 tonnes annually, followed by rapeseed with current annual net imports of 600 000 tonnes. In general, oilseed cakes (rich in proteins) have relative lower physical trade balances. Oil crushing plants inside Belgium make oilcake exports possible whereas oilseeds are almost exclusively imported. Among starch crops, annual corn net imports were most important before 1995. Ever since, net wheat imports have increased up to 1.2 million tonnes annually, whereas corn net imports decreased to around 500 000 tonnes in 2001. The latter is caused by increased corn cultivation in Belgium as a result of the Flemish manure decree which encourages cultivation of crops with a high nitrogen uptake. Aggregation of net imports of the 18 agricultural crops revealed that total net imported material requirement for the Belgian livestock sector is still increasing. Net imports were 1.68 million tonnes in 1960 and amounted to 7.17 million tonnes in 2001. Total net imported material increases almost linearly with 140 000 tonnes annually.

4.2.3. Total land requirement for commodity production abroad for the Belgian livestock sector

The assessment of commodity flows to the Belgian livestock sector, enables calculation of total land requirement for production of these commodities. This eventually yields a time series of the foreign agricultural land requirement for the Belgian livestock sector. A first assessment will be made per crop, afterwards these data will be aggregated to yield the total land requirement abroad of the Belgian livestock sector.

4.2.3.1. Methodology

The recalculation of the physical flow data to land requirement is easily done by dividing net imports (in kg) of the commodities by their agricultural yield (kg/ha). Yield data have been obtained from the statistical division of the Food and Agriculture Organisation (FAO)[8]. Crop yields vary greatly from country to country and even inside countries, depending on the intensity of production and climatic and soil characteristics of the production region. These differences are also observed in time, with crop yields generally improving in time. For this chapter, the annual world yield of the studied crops has been used for land requirement calculations.

As mentioned in chapter 3.2.2. eight of the studied crops are being produced in Belgium as well: peas, corn, linseed, rapeseed, wheat, barley, rye and oat. Therefore, it is not sure whether the net imports – calculated by subtracting export from import figures – are correctly determined. Nevertheless, as imports of these crops are substantially higher than domestic production (figures 5, 6 and 10 in 4.2.2.3.), it will further be assumed that domestic production is not exported and that export figures for these commodities account for transit of imports to other (EU) countries. Therefore, total land requirement (TLR) for primary crops used in the livestock sector, will be calculated as:

$$\text{TLR} = \frac{\textit{Net imports crop}}{\textit{Crop yield}}$$

<u>Oilseeds</u>
Since imports of both oilseeds and their oil pressing cakes are accounted for, a conversion needs to be performed of the import figures of the oilcakes. Table 3 provides the average percentages of oilcake that is derived from different oilseeds (or copra).

[8] FAOSTAT Agricultural data – http://faostat.fao.org, Last updated February 2004

Oilseed	**Oilcake from seeds**	
Soybeans	79 %	(*)
Groundnut	55 % (from shelled nuts)	(**)
Cotton	45 %	(***)
Linseed	40 %	(+)
Sunflower	37 %	(+)
Rapeseed	56 %	(+)
Copra	35 %	(++)
Palm kernels	50 %	(∇)

Table 3 – *Percentage of oilcakes obtained from different oilseeds. Sources: (*) Mounts & Pryde, 1983; Semon* et al., *1997; Van Gelder & Dros, 2004 (**) USDA, 2000; (***) Blasi & Drouilard, 2002; (+) Schmidt, 1999; (++) Duke, 1983; (∇) Aspar (2000).*

An adjustment to the oilseed figures will however be performed by assuming that only 94 % of all oilseeds processed (pressed) finally end up in the livestock sector. The cakes of the remaining 6 % are designed for protein extraction for human consumption (Van Gelder & Dros, 2004; personal conversation with the Vandemoortele – Cargill Izegem commercial director).
The total land requirement (TLR) for oilseeds and their derived products will thus be calculated as follows:

$$TLR = \frac{\left[Net\ imports\ seeds + \frac{Net\ import\ oilcake}{\%\ cake\ in\ seeds} * 100 \right]}{Seed\ \ yield} * 0{,}94$$

For <u>soybeans</u>, not only seeds and oilcakes are imported for application in animal fodder. Soy flour is obtained by drying and grinding soy meals. The percentage of soy flour obtained from soybeans is 65 % (Semon *et al*., 1997). Both net imports of flour and meals (oilcake) will thus be converted to the weight of beans where they are derived from.

For <u>groundnuts</u>, figures were found for both shelled and in-shell nuts. Therefore a weight conversion factor for in-shell nuts was applied (UN, 1997) after which total weight of in-shell groundnuts was calculated: Groundnuts in-shell (kg) = Shelled groundnuts (kg) * 1,4286

Afterwards seed yield figures of in-shell groundnuts were applied to calculate the TLR for groundnuts.

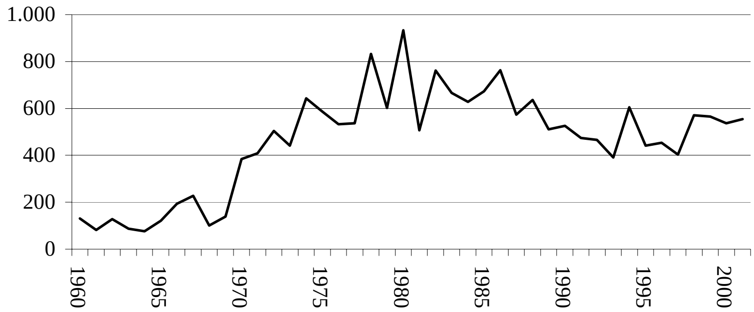
<u>Cereals</u>
As was the case with oilseeds, some amount of the starch crops is not used for animal feed. Namely, wheat, rye and barley are also used in human nutrition and industrial processing (starch industries). Eurostat provides cereal balances for 1999/2000 from which the share of animal feed derived from cereal imports and domestic production can be determined (EC, 2002). Although these ratios will most likely have evolved over time, following shares for animal feed will be assumed for the analysis: wheat: 50 %, barley: 58 %, rye: 18 %. No cereal balance for oat was found; a 100 % use for animal feed will be assumed. Net imports of wheat, barley and rye were multiplied by these percentages before calculating land requirement to produce these crops.

4.2.3.2. *Results*

4.2.3.2.1. Soya

The aggregated land requirement of soybeans, -flour and –meals for soybean cultivation intended for the Belgian livestock sector is depicted in figure 12.

Figure 12 – *Total annual land requirement (1000 ha) for soybean cultivation intended for the Belgian livestock sector*

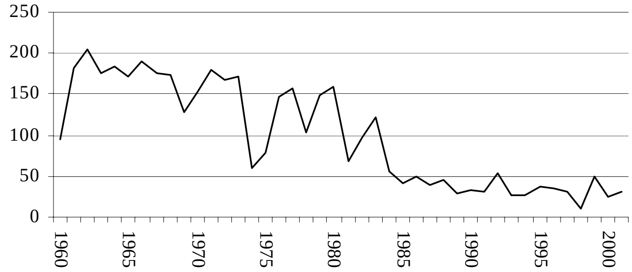


Land requirement for soybeans was below 200 000 ha before 1970, but tripled in only 3 years after. Following strong fluctuations between 1974 and 1986, land requirement gradually lowered and was fluctuating less extreme around 500 000 ha since 1989. These fluctuations and lowering are more related to fluctuating but improving yields of soybean crops than to variation in imported quantities (see figure 1 in 4.2.2.3.). Whereas yields for soybeans were 1.6 tonnes per ha in 1960, it was over 2.6 tonnes per ha in 2001.

4.2.3.2.2. Groundnuts

Unlike soybeans, fluctuations in annual land requirement for groundnut cultivation results from fluctuations in net imported quantities and are less related to yield variation. Net imported quantities of both groundnuts and their oilcakes decreased over time (figures 3 and 4). The world yield improved steadily from 0,85 tonnes per ha in 1960 to 1,45 tonnes per ha in 2001. Although lower than for soybeans, the total annual land requirement for groundnuts was between 100 000 and 200 000 ha until 1984 but stayed below 50 000 ha ever since (figure 13). Fluctuating markets due to varying production/transport costs, seemingly decreased the demand of groundnut cultivation area for animal fodder in Belgium.

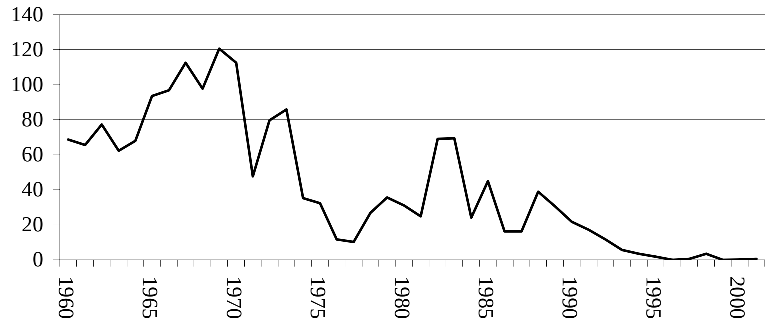
Figure 13 – *Total annual land requirement (1000 ha) for groundnut cultivation intended for the Belgian livestock sector*



4.2.3.2.3. Seed Cotton

Seed cotton meals as a commodity for animal fodder production in Belgium has been more important before 1973 than nowadays. Annual land requirement abroad for seed cotton production has been over 60 000 ha before 1973 but decreased afterwards significantly. Between 1973 and 1995, annual land requirement fluctuated between 20 000 and 40 000 ha with one peak of 70 000 ha in 1982-83. Since 1995, annual land requirement for seed cotton production abroad has become almost insignificant (figure 14).

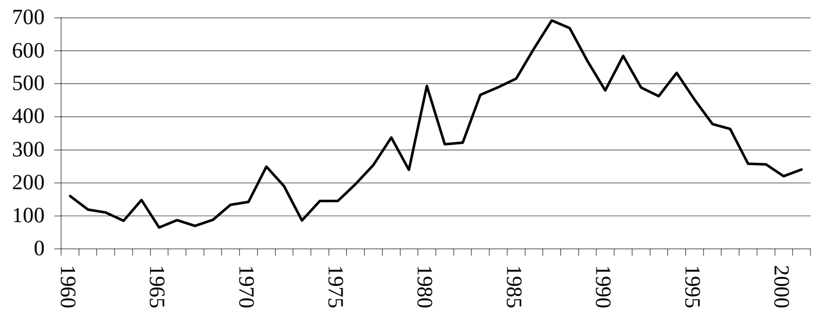
Figure 14 – *Total annual land requirement (1000 ha) for seed cotton cultivation intended for the Belgian livestock sector*



4.2.3.2.4. Linseed

Although net imported quantities of both linseed and linseed oilcakes are more or less in the same magnitude of order as for other oilseeds (figures 3 and 4), total land requirement for linseed cultivation exceeds most of the land requirement for other oilseeds (except for soybeans). Relatively low yields (400 kg/ha in 1960; 760 kg/ha in 2001) have caused relatively higher land requirements. Until 1973, annual land requirement was below 300 000 ha, afterwards it amounted to 700 000 ha in 1987. Later, annual land requirement for linseed production diminished, and is now between 200 000 and 300 000 ha (figure 15).

Figure 15 – *Total annual land requirement (1000 ha) for linseed cultivation intended for the Belgian livestock sector*

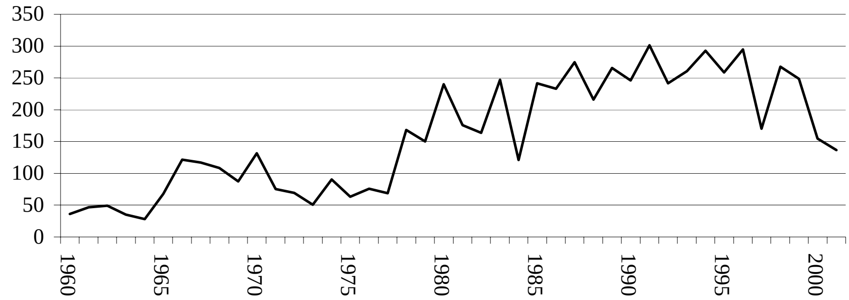


The evolution of land requirement for linseed production is to a certain extent comparable to the evolution of land requirement for soybean production, although the maximum for soybeans was reached earlier than for linseed production and current land requirement for soybean production is still higher than for linseed production (between 500 000 and 600 000 ha annually).

4.2.3.2.5. Sunflower seed

Sunflower seed cultivation is one of the more important oilseed productions with annual land requirement below 150 000 ha before 1978 but with (strongly fluctuating) annual land requirements between 150 000 and 300 000 ha afterwards (figure 16).

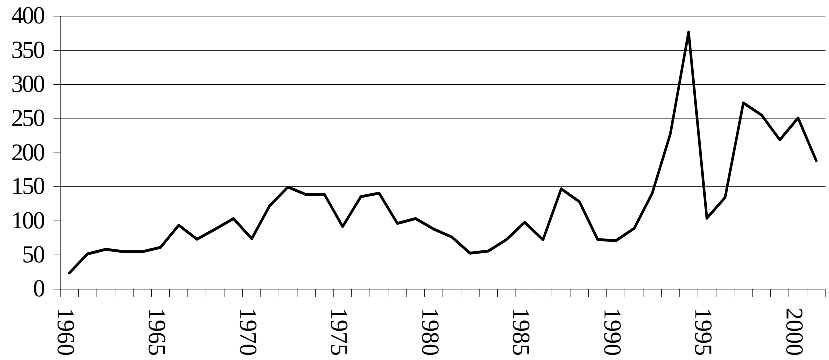
Figure 16 – *Total annual land requirement (1000 ha) for sunflower seed cultivation intended for the Belgian livestock sector*



4.2.3.2.6. Rapeseed

Unlike with other oilseeds, an increase in annual land requirement for rapeseed production is not observed before 1993 and has been below 150 000 ha annually. Afterwards, a peak of 380 000 ha was reported in 1994. Currently, around 200 000 ha is annually required for rapeseed production abroad intended for the Belgian livestock sector (figure 17).

Figure 17 – *Total annual land requirement (1000 ha) for rapeseed cultivation intended for the Belgian livestock sector*

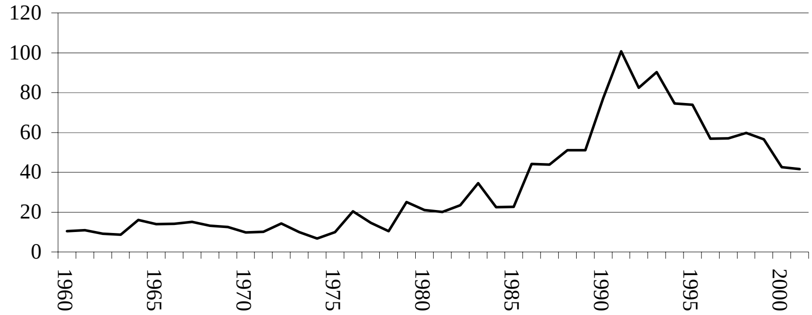


4.2.3.2.7. Coconut

Yield figures for copra (dried flesh of the coconut) were sought instead of yield figures for coconuts, as only net import of both copra and copra cakes has been reported in 3.2.2. Before 1986, land requirement for coconut production intended for the Belgian livestock sector was below 40 000 ha annually, which is relatively unimportant in comparison to other oilseeds.

Afterwards annual land requirement increased with a maximum of 100 000 ha in 1991. After 1991 annual land requirement gradually lowered and currently reaches the level of 40 000 ha (figure 18).

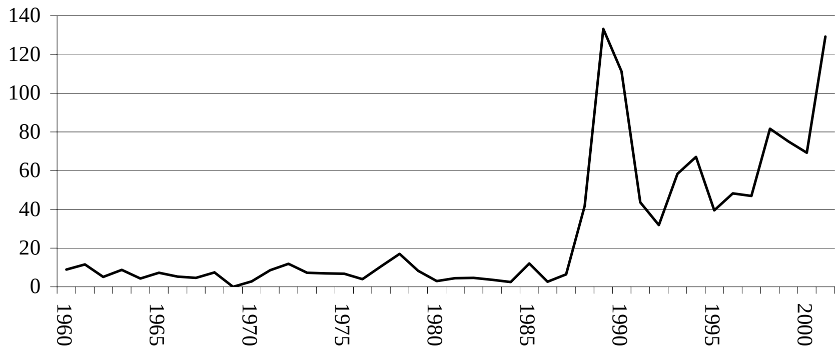
Figure 18 – *Total annual land requirement (1000 ha) for coconut cultivation intended for copra production for the Belgian livestock sector*



4.2.3.2.8. Oil Palm

Until 1988, oil palm kernels were nearly insignificant for the Belgian livestock sector with an annual land requirement of less than 20 000 ha. In 1989 the land requirement peaked at 130 000 ha. Nevertheless inputs in the Belgian livestock sector, derived from oil palm and coconut (see 4.2.3.2.7.) are relatively less important than inputs from other oilseeds. After 1992, annual land requirement for oil palm fluctuated strongly (again 30 000 ha in 1992). In 2001 however, again 130 000 ha was reported (figure 19).

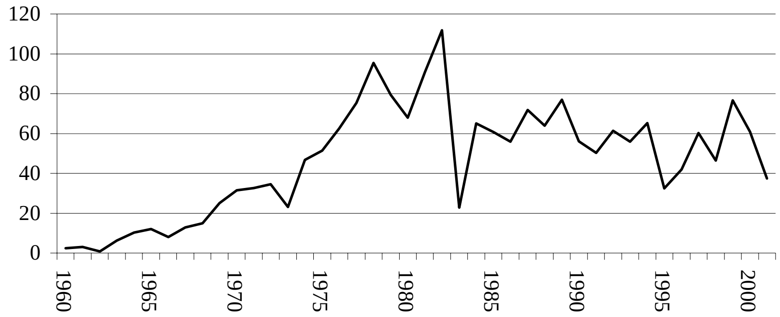
Figure 19 – *Total annual land requirement (1000 ha) for oil palm cultivation intended for palm kernel production for the Belgian livestock sector*



4.2.3.2.9. Cassava

Initially, land requirement for cassava cultivation was almost nil but the area increased steadily to 100 000 ha in 1978. Later, a maximum land requirement of 110 000 ha (1982), as well as a low point of 23 000 ha (1983) is observed. After 1983, annual land requirements for cassava fluctuated between 40 000 and 80 000 ha (figure 20).

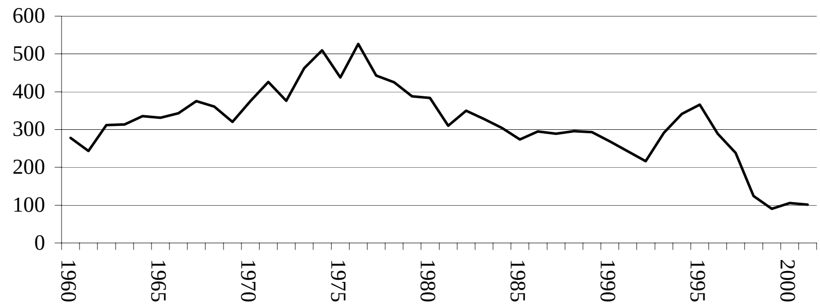
Figure 20 – *Total annual land requirement (1000 ha) for cassava cultivation intended for the Belgian livestock sector*



4.2.3.2.10. Corn

Land requirement abroad for corn cultivation for animal production has always been relatively important. From 1962 until 1989, it has been higher than 300 000 ha annually, with a maximum in 1976 of 530 000 ha. Afterwards land requirement decreased to the current level of approximately 100 000 ha (figure 21). The latter is caused by the adoption by the Flemish Government of the decree on manure reduction, which revaluated corn as a crop with high nitrogen uptake (De Jaegher, 2004). Consequently, corn is currently more and more cultivated inside Belgium (see also 4.2.2.3.5. and figure 10).

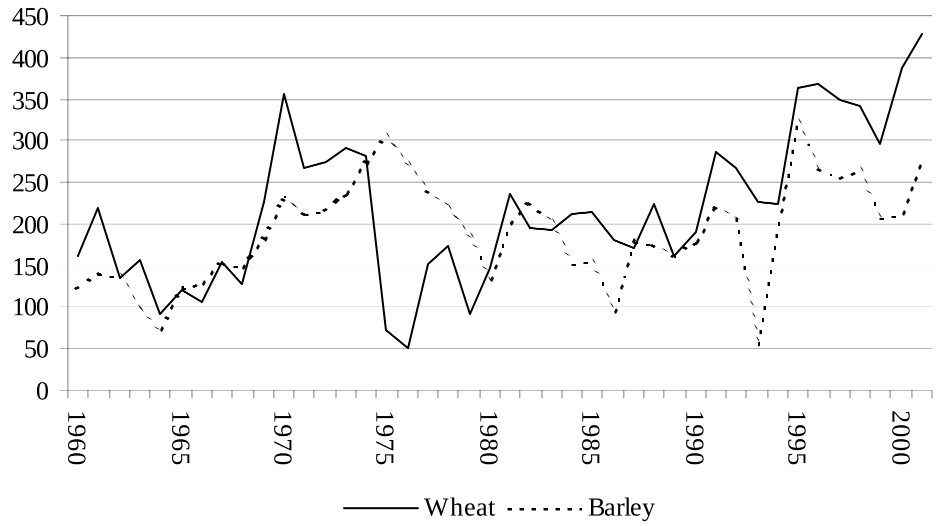
Figure 21 – *Total annual land requirement (1000 ha) for corn cultivation intended for the Belgian livestock sector*



4.2.3.2.11. Wheat and barley

Although variability in annual land requirement for wheat and barley production is high, it is fair to say that there has been an increase since 1980 from around 150 000 ha for both crops to a current level of 400 000 ha for wheat and 300 000 ha for barley (figure 22). Annual land requirement for both crops evolved quite similar.

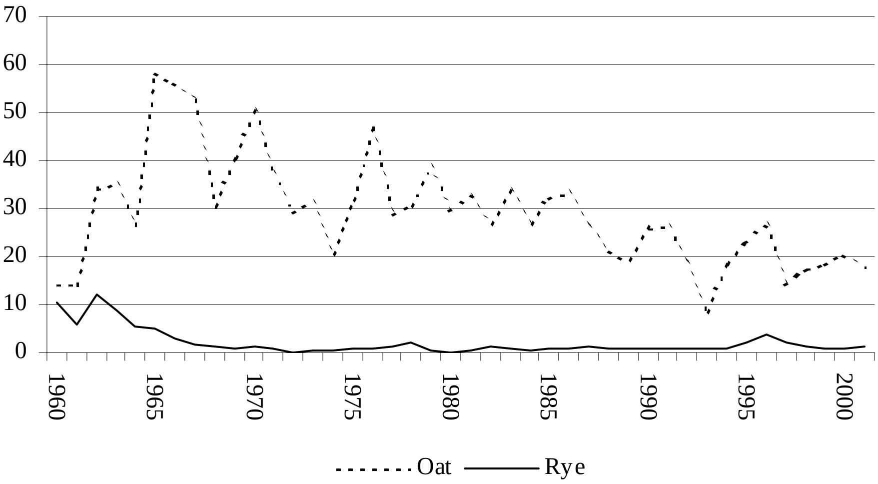
Figure 22 – *Total annual land requirement (1000 ha) for wheat and barley cultivation intended for the Belgian livestock sector*



4.2.3.2.12. Rye and oat

As already mentioned in chapter 4.2.2., rye and oat are (together with millet, see below) among the least important starch crops for the Belgian livestock sector. The land annual requirement for rye production never exceeded 4000 ha since 1966. Annual land requirement for oat gradually halved over time from around 40 000 ha in the early 1960s to 20 000 ha in 2000 (figure 23).

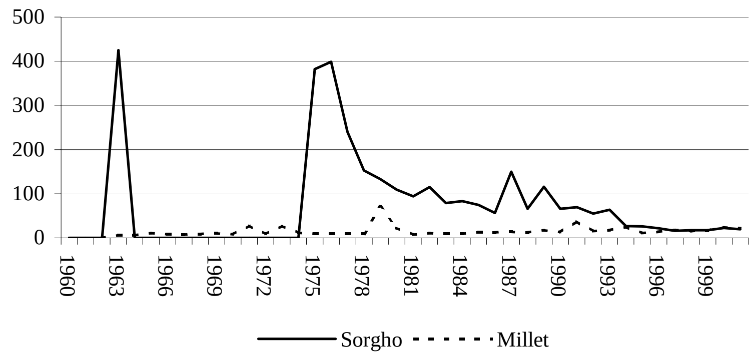
Figure 23 – *Total annual land requirement (1000 ha) for oat and rye cultivation intended for the Belgian livestock sector*



4.2.3.2.13. Sorghum and Millet

Although being also 2 cereals with relatively minor importance with regards to corn, wheat and barley, annual land requirement for sorghum and millet is assessed separately from oat and rye as sorghum and millet are cereals that require tropical climate conditions, and consequently have been produced abroad. Sorghum and millet are cultivated in almost every country of tropical Africa (Raemaekers *et al*., 2001). Whereas land requirement for millet never exceeded 50 000 ha annually (except in 1979 with 70 000 ha), land requirement for sorghum was at a maximum in 1976 with 400 000 ha. Afterwards, sorghum land requirement dropped drastically to a level of 150 000 ha in 1978 and 20 000 today. Before 1975, no land requirement was reported for sorghum, except in 1963 when a sudden land requirement of 420 000 ha was observed (figure 24).

Figure 24 – *Total annual land requirement (1000 ha) for sorghum and millet cultivation intended for the Belgian livestock sector*

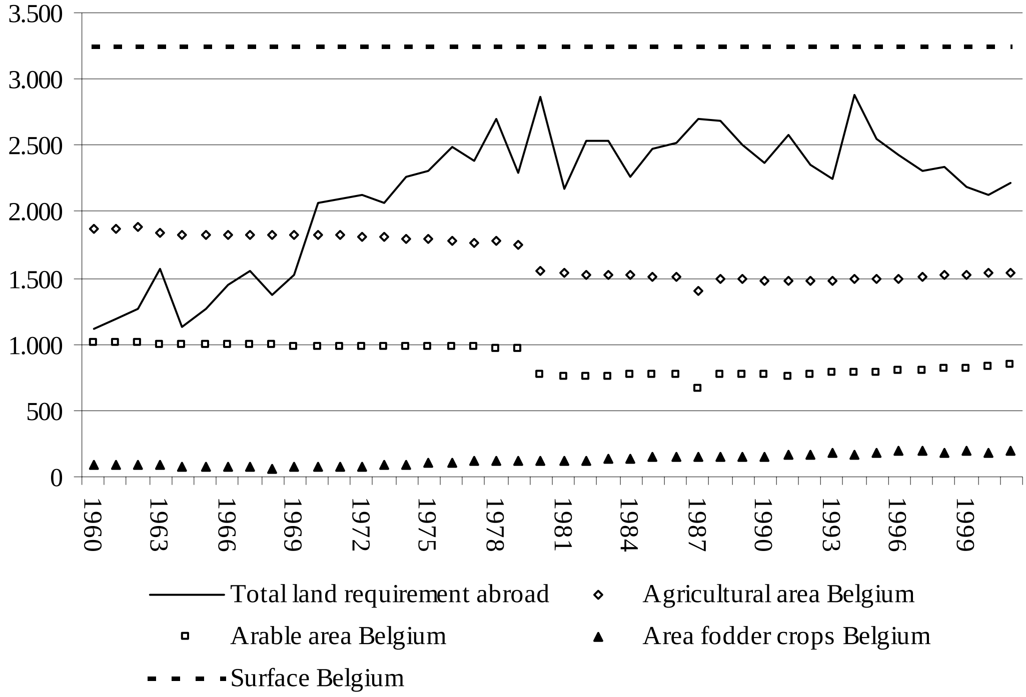


4.2.3.2.14. Alfalfa

It has been found unfeasible to obtain adequate figures on yields for alfalfa harvest. Duke (1981) reports yields varying between 5 and 75 tonnes per hectare. As most of the imports originate in France, yield figures were sought specifically for this country. Alfalfa yields however, not only depend on climatic and soil variables but also on the number of cuttings per year (mostly between 8 and 12; Duke, 1981) and the applied varieties (Martin, 2002). Even if the lowest reported yield is applied, annual land requirement never exceeded 30 000 ha, indicating that alfalfa doesn't add considerable quantities to the total land requirement for the Belgian livestock sector. Therefore, alfalfa will be banned from the analysis.

4.2.3.2.15. Aggregation of results

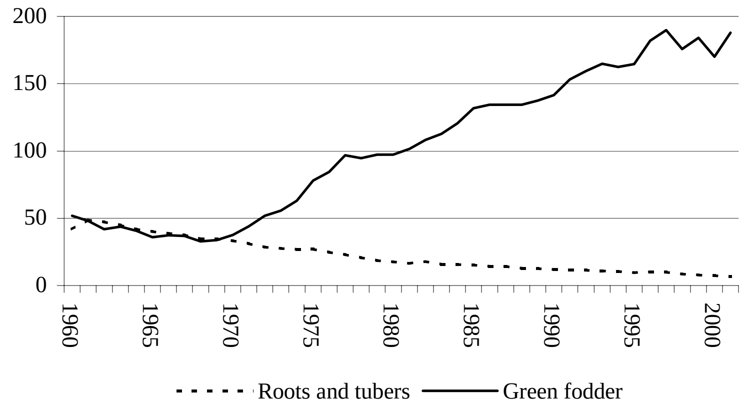
Figure 25 - *Total annual aggregated land requirement (1000 ha) cultivated abroad for the Belgian livestock sector, compared to Belgium's total country surface, annual agricultural area, annual arable area and annual area for fodder crop production (all in 1000 ha).*



The total annual land requirement abroad (figure 25) for commodity production for the Belgian livestock sector is the sum of all land requirements as reported in 4.2.3.2.1 – 14. The domestic annual agricultural area for Belgium consists of arable land, area for permanent crops, permanent pasture and forests and woodland[9]. Figure 26 gives an idea of domestic fodder crop production since 1960[10]. A striking contrast is noticed between area used for roots and tubers (mainly fodder beets) and area used for green fodder (mainly corn, wheat and barley). Whereas production area for roots and tubers gradually decreased from 50 000 ha in 1960 to some 7 000 ha today, area for green fodder increased from 50 000 ha to around 180 000 ha in the same period. The category 'area fodder crops Belgium' in figure 20 is the aggregated result of both data series in figure 21. Figure 25 illustrates that since 1975 the agricultural area exploited abroad for fodder crop production for the Belgian livestock sector (around 2,5 million ha) exceeds domestic arable area by almost 150 %. Even the domestic agricultural area has since 1975 been exceeded by 75 %. The domestic area for fodder crop production in the studied period is between 5 and 10 % of the area cultivated abroad for fodder crop production.

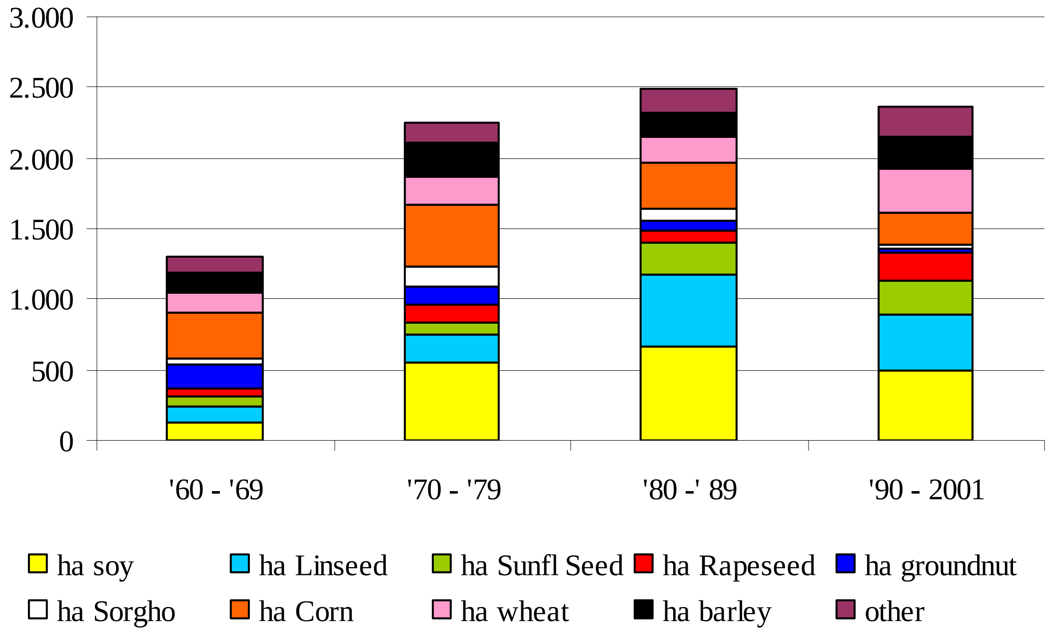
[9] Source: FAOSTAT data, 2004, http://faostat.fao.org
[10] Source: National Institute of Statistics (NIS), Récensement agricole et horticole. Résultats définitifs 1960 - 2001

Figure 26 – *Annual area for fodder crop production in Belgium (1000 ha)*



To give a convenient idea on the partition over different crops of the land area cultivated abroad for the Belgian livestock sector, per decade results are presented in figure 27. Although area for soybean cultivation takes the largest relative share in the last three decades, the largest relative share of land abroad in the sixties was taken by corn. The largest corn area abroad for the Belgian livestock sector was required in the seventies. It is clear that the cultivation area for oilseeds (mainly soy, groundnut, rapeseed, linseed and sunflower seed; everything below sorghum in figure 27) takes the largest share throughout the four decades studied. Area for linseed production abroad has been remarkably large since 1980.

Figure 27 - *Per decade land requirement (1000 ha) for all crops cultivated abroad intended for the Belgian livestock sector and Belgium's annual agricultural and arable area.*



4.2.3.3. Conclusions

Despite an annual increase of 140 000 tonnes in material net import of fodder crops for the Belgian livestock sector, Belgium's total annual land requirement (LR) abroad to produce these crops has almost constantly been around 2.5 million hectares since 1975. This phenomenon is explained by continued increase in average world yield of fodder crops. The total annual land requirement abroad for fodder crop production exceeds Belgium's arable land by 150 %. The domestic area for fodder crop production in the studied period is between 5 and 10 % of the area cultivated abroad with fodder crops.

After analysis of LR for the different studied crops, it was found that soy currently takes the lead with around 500 000 ha annually. Between 1975 an 1985 up to 800 000 ha was required. Land requirement abroad for wheat currently comes at the second place with 400 000 ha annually. Corn LR abroad used to be around 300 000 ha, but since 1999 fell back to some 100 000 ha. Linseed, sunflower and barley LR abroad is currently around 250 000 ha. Land requirement for some crops has been more important in former decades (groundnut and cotton seed in 60s – 70s) while LR for other crops was insignificant before but currently seems to gain importance, although absolute amounts remain modest (e.g. oil palm).

4.2.4. Per country land requirement for the Belgian livestock sector

4.2.4.1. Introduction

As ecological debt in the present research is considered as a debt between countries, regardless of the stakeholders involved in these countries, an assessment will be made of the size of agricultural area cultivated in specific countries for commodity production for the Belgian livestock sector. This chapter provides a methodology for, and the results of the allocation of total land requirement as described in 4.2.3. Per country land requirements yield an idea on the 'footprint' of the Belgian livestock sector in different countries worldwide (see further in 4.3.5.).

4.2.4.2. Methodology

The Statistics on Foreign Trade of Belgium not only report total import of a certain commodity, but also specify the country from which it was imported. As this study focuses on fodder crop production for the Belgian livestock sector, exports of a certain commodity should be subtracted from the total import of that commodity from a certain country. It is however difficult to assess which part from which country is exported again. Therefore, it is assumed that for a certain commodity, total export is composed of the same portions as the imports from all countries involved. In other words, it is assumed that the same commodities from all countries have been bulked and mixed before exportation.

Taking this assumption into consideration, first the above-mentioned portions were calculated by dividing the import figures (kg) from all countries for a certain commodity by the total import (kg) of that commodity. These portions were afterwards multiplied by the physical trade balances (= net imports, see 3.2.2.) for all commodities, yielding material flows from specific countries. These net imports from different countries were then divided by the country specific yields for a certain commodity, resulting in the per country land requirement for all commodities.

$$LR_{A,x} = \frac{f_{A,x}}{Y_{A,x}}\left[imp_x - \exp_x\right]$$

In which:
$LR_{A,x}$ = land requirement for crop x in country A
$f_{A,x}$ = portion of import of crop x from country A in total import of crop x
$Y_{A,x}$ = yield of crop x in country A
$imp_x - exp_x$ = physical trade balance of crop x from all countries

Oilseeds

For oilseeds, calculations are more complicated. The above-mentioned assumption for exports are not valid for oilcakes. As inside Belgium oilcakes are not only produced from imported oilseeds but are also imported themselves, it is assumed that export of oilcakes originates from processed oilseeds. Therefore, the calculation of the per country land requirement for oilseeds will be the aggregated result of the area derived from imported oilseeds (calculated using the general method described above) and the area derived from oilcakes. For the land requirement in country A for oilcrop x this calculation is:

$$LR_{A,oilcrop(x)} = LR_{A,oilseeds(x)} + \frac{1}{Y_{A,x}}\alpha\left[imp_{oilcakes(x)} - \exp_{oilcakes(x)}\ f_{A,oilseeds(x)}\right]$$

In which:
$LR_{A,oilcrop(x)}$ = land requirement for oilcrop x in country A
$LR_{A,oilseeds(x)}$ = land requirement derived from oilseeds of crop x in country A
$Y_{x,A}$ = Yield of oilcrop x in country A
α = factor for oilseeds applied in the livestock sector (0,94)
$imp_{oilcakes(x)}$ = import (kg) of oilcake from oilcrop x from country A
$exp_{oilcakes(x)}$ = export (kg) of oilcake from oilcrop x from country A
$f_{oilseeds(x)}$ = portion of import of oilseeds x from country A in total import of oilseeds x

Imports from EU

The Statistics on Foreign Trade of Belgium mention for every imported crop quantities that have been imported from inside the European Union (EU). From 1979 until 1981 for example, more soybeans (kg) have been imported from the EU (mainly Netherlands), than from any other country. Nevertheless, within the EU, soybeans are only grown in Italy and the European soybeans have a production share of only 1 % worldwide (Van Gelder & Dros, 2004). This means that the soybeans haven't been produced in the EU but originate elsewhere. This chapter only deals with direct imports from the country of origin. Inevitably, results of per country land requirement will as a consequence be underestimated, but with regards to recognition of ecological debt, overestimations should be avoided. Other crops from which the production inside the EU is inexistent or very limited, are: groundnut, cotton, coconut palm, oilpalm, cassava, sorghum and millet.

4.2.4.3. Results

Generally, it has been found that since 1960 commodities for the Belgian livestock sector have been produced in a broad range of countries on 5 continents[11]. As not all countries have exported livestock fodder commodities in the same quantities to Belgium and as imports from a certain country were not always consecutive in time, not all countries have been taken up in the analysis. Only if (i) the land requirement for a certain crop in a certain country contributed on an average time level to at least 10 % of the total land requirement for that crop and (ii) the imports from this country endured for at least ten years, the added land requirement of that crop to the total land requirement from that country has been further utilized in this study.

4.2.4.3.1. Overview of all countries

Aggregating land requirements in one country for different fodder crops, yields the per country land requirement for the Belgian livestock sector. Using this method, 16 countries have been identified in which these fodder crops have been produced or are still being produced (Table 4):

Country	**Average annual land requirement (ha)**
Argentina	416 844
France	214 365
USA	196 524
Brazil	155 668
Canada	69 674
Sudan	22 204
Thailand	15 120
Indonesia	14 945
Nigeria	14 943
Malaysia	14 266
Philippines	11 813
Paraguay	11 809
Germany	9 894
UK	7 716
Russia	6 537
China	1 420

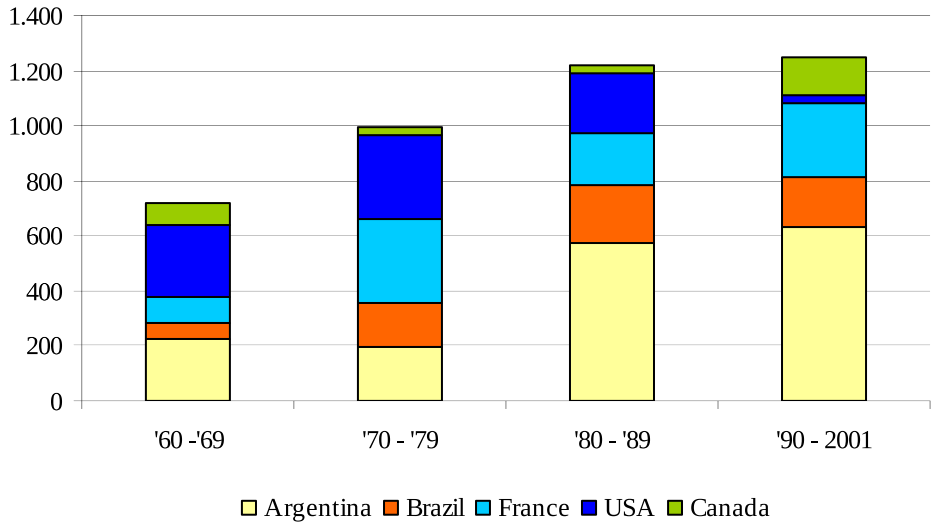
Table 4 – *Sixteen main countries in which a substantial land area is required for the Belgian livestock sector and the average annual land requirements from these countries (1960 – 2001).*

Since time series for these 16 countries are difficult to visualise, the results are being reported per country in figure 28 for the main five countries: Argentina, Brazil, France, USA, and Canada. Throughout time, a relative shift in land requirement from northern countries (USA, Canada and France) to Latin American countries is remarkable. Whereas in the sixties land requirement in both Argentina and Brazil was below half of total land requirement in the 5 analysed countries, the Latin American share increased to more than 60 % since 1980. The share from the USA gradually diminished over time. The last two decades depicted in figure 28 suggest a shift in land requirement from the USA to France and Canada. In absolute terms,

[11] Remote areas are no objection for the import of certain fodder commodities. e.g.: From 1998 until 2001 up to 30 000 tonnes of copra have been imported from Vanautu, an island in the Pacific ocean.

land requirement in Argentina tripled after 1980 from an average 200 000 ha to 600 000 ha annually.

Figure 28 – *Per decade average land requirement(1000 ha) in top-5 countries for commodity production for the Belgian livestock sector*

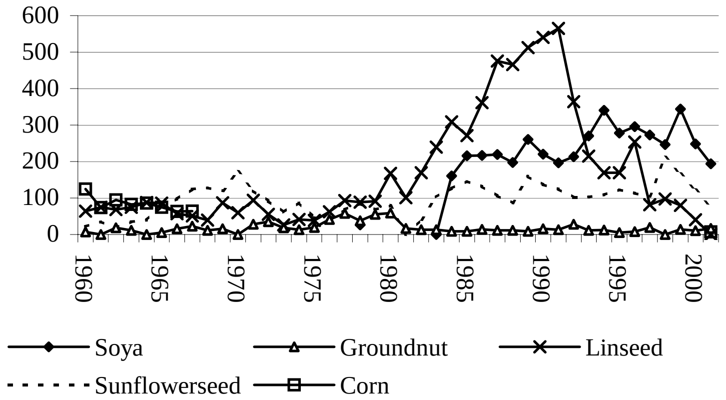


4.2.4.3.2. Analysis of land requirement in the five main countries

Argentina

Although some corn imports from Argentina are reported from 1960 until 1967, the most important crops in Argentina cultivated for the Belgian livestock sector are oilseeds (figure 29). From 1979 until 1993 more hectares were used for linseed cultivation than for any other crop. Annual land requirement for soybean production exceeded 200 000 ha since 1985 and is nowadays the most important Argentinean fodder crop cultivated for the Belgian livestock sector.

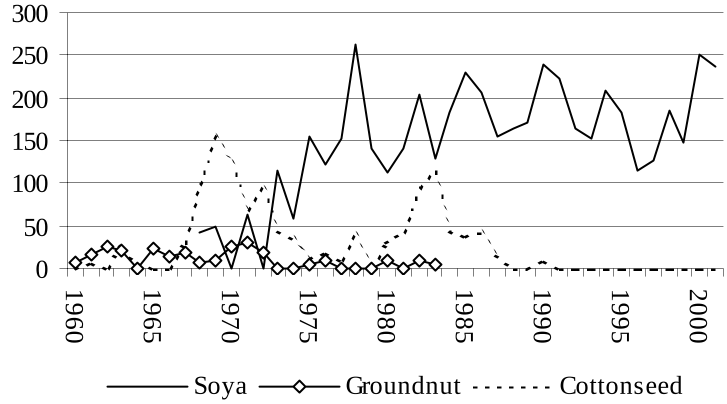
Figure 29 – *Annual land requirement in Argentina (1000 ha) for fodder crop production for the Belgian livestock sector*



Brazil

Like Argentina, land used in Brazil for fodder crop production for the Belgian livestock sector is mainly cultivated with oilseeds (figure 30). The importance of soybean cultivation is nevertheless relatively greater in Brazil, although in absolute terms the results for soy do not differ much from Argentina. Between 100 000 and 250 000 ha have been cultivated annually with soybeans intended for the Belgian livestock sector. Since 1988 soybean cultivation area is actually the only significant land required in Brazil for the Belgian livestock sector.

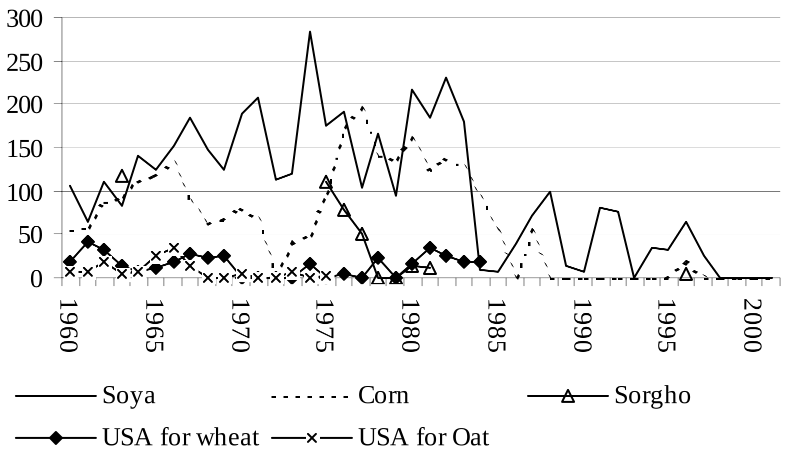
Figure 30 – *Annual land requirement in Brazil (1000 ha) for fodder crop production for the Belgian livestock sector*



USA

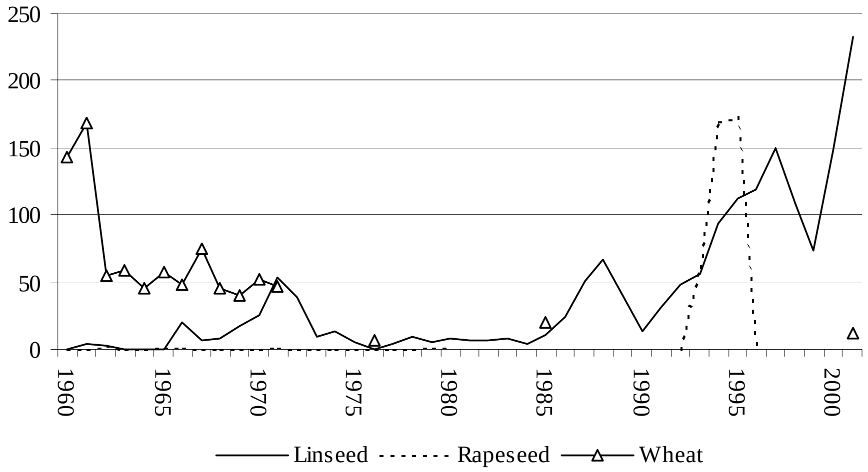
Fodder crops from the USA generally were more important before 1984 than afterwards (figure 31). Since 1997 no significant fodder commodities have been imported from the USA. After 1983 land requirement for any crop didn't exceed 100 000 ha. Unlike the Latin American countries discussed above, arable land in the USA was cultivated with some cereals. Corn was the most important cereal up to 1988; from 1975 until 1981 a sudden sorghum production is reported. Modest wheat production for the Belgian livestock sector occurred until 1984, land requirement for oat ceased in 1975.

Figure 31 - *Annual land requirement in the USA (1000 ha) for fodder crop production for the Belgian livestock sector*



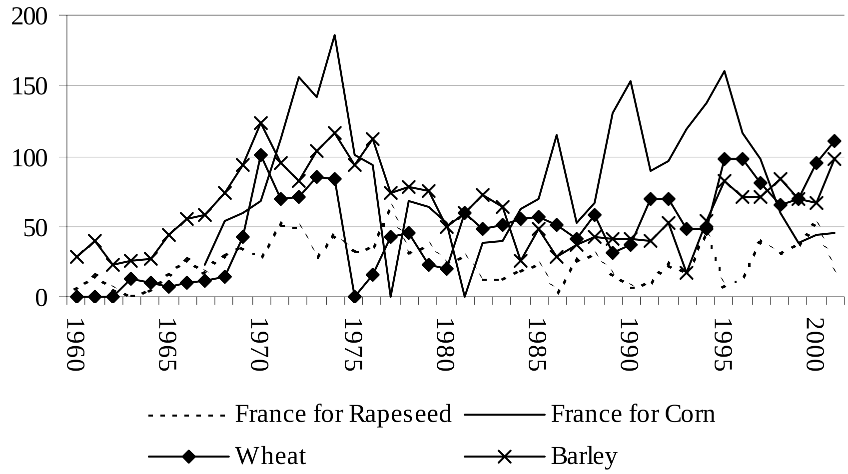
Canada
Of the five countries analysed more in detail in this chapter, Canada contributes the least to the land requirement of the Belgian livestock sector. Nevertheless, figure 32 illustrates that wheat cultivation for Belgium's animal feed occurred in Canada up to 1971. Nowadays, linseed cultivation area is the only relevant land required in Canada for the Belgian livestock sector.

Figure 32 - *Annual land requirement in Canada (1000 ha) for fodder crop production for the Belgian livestock sector*



France
As a neighbouring country to Belgium, France has always been an important supplier of fodder crops to the Belgian livestock sector. Whereas annual land requirement in the USA for corn production for the Belgian livestock sector fluctuates between 0 and 300 000 ha, a huge fluctuation is also noticed in France, but annual land requirement for corn production never exceeds 200 000 ha (figure 33). Corn land requirement in France increased since 1981, whereas a regression in land requirement for corn production since 1977 is observed in the USA (below 50 000 ha annually since 1985). Annual land requirement in France for barley and wheat production for Belgium's livestock sector evolved similar. Currently, land requirement for these cereals (around 100 000 ha) seems to be more important than land requirement for corn (reasons for which are explained in 4.2.3.2.10.). Annual land requirement in France for rapeseed production for the Belgian livestock sector always remained below 50 000 ha.

Figure 33 - *Annual land requirement in France (1000 ha) for fodder crop production for the Belgian livestock sector*



4.2.4.3. *Conclusion*

In this chapter, total land requirement for fodder crop production abroad for the Belgian livestock sector (see 4.2.3.) has been further analysed as to assess the land requirement per country. It has been found that fodder crops for the Belgian livestock sector are or have been mainly produced in Argentina, Brazil, France, USA and Canada. Within these 5 countries, a shift was observed in LR from Latin American countries (Brazil and Argentina). The Latin American share in LR for fodder increased in absolute terms over time, but also relatively compared to the whole of LR in the 5 countries (two thirds in the last decade). Although until 1990 annual LR in the USA for the Belgian livestock sector has been substantial, in the last decade it vanished almost completely.

LR for soy was prevalent in the USA until 1983. Currently LR for soy is most important in Argentina, Brazil and Paraguay. Until 1989 corn LR was most important in the USA and to a lesser extent in Argentina. Nowadays, although corn imports have fallen back, corn LR is mainly found in France. Arable land cultivated with linseed for export to Belgium occurs mainly in Canada and Argentina.

4.3. Ecological debt of the Belgian livestock sector

4.3.1. Introduction

In chapter 4.2., a detailed analysis of the land requirement for the Belgian livestock sector since 1960 has been performed. This chapter sheds light on the ecological debt caused by this part of Belgium socio-economic system, applying data from the previous chapter. First, this module is brought in line with the content of ecological debt as was studied in the core research (chapter 1). Then the different components of the general stipulative definition established in 1.3.3.2. will be applied to the agricultural sector in general. Where feasible, the data established in 4.2. will be used to assess the ecological debt of the Belgian livestock sector.

4.3.2. The concept of Ecological Debt in relation to the agricultural sector

4.3.2.1. *Definition as a starting point*

The core research has yielded a general stipulative definition of ecological debt. The definition is stipulative since ecological debt is a new concept which had no univocal meaning before. The general stipulative or 'operational' definition of ecological debt of country A has been brought forward as:

(1) the ecological damage caused over time by country A in other countries or in an area under jurisdiction of another country through its production and consumption patterns; and/or
(2) the ecological damage caused over time by country A to ecosystems beyond national jurisdiction through its consumption and production patterns; and/or
(3) the exploitation or use of ecosystems and ecosystem goods and services over time by country A at the expense of the equitable rights to these ecosystems and ecosystem goods and services by other countries or individuals."[12]

As literally stated in the core research, "the point of stipulation is to avoid ambiguity and vagueness of terms used within a context and for a purpose. Within a specific context and for specific purposes, existing definitions of ecological debt may be adequate, while in other contexts and for other purposes, definitions are not adequate or elements out of existing definitions may need further stipulation". Although the present modular research doesn't directly seek to formulate one or more operational definitions of the concept, the definition will be analysed as to see if further stipulation is necessary when applying the definition to the agricultural sector in general or the Belgian livestock sector in particular.

The first two parts of the definition have 'ecological damage' as key words. The distinction between both parts is found at where ecological damage occurs. Ecosystems (or areas) beyond national jurisdiction are also referred to as 'global commons' or 'extraterritorial space'. In fact these areas are the 'high seas' (all seas/oceans outside the Exclusive Economical Zones of sovereign states) and 'space' (Lavrysen & Maes, 2000). If the agricultural sector is considered not to include fishery, it is fair to state that part (2) of the definition will be irrelevant in making the concept of ecological debt operational for the present modular research.

4.3.2.2. *Refinement of the definition*

Together with part (3) of the general stipulative definition and taking the delineation of the present modular research as set out in 3.1.1. into account, an applied working definition for the modular research agriculture/food supply can be formulated as:

"The ecological debt of Belgium caused by its livestock sector consists of

(1) the ecological damage caused over time by Belgium through the production in other countries or in an area under jurisdiction of another country of agricultural commodities intended to feed the Belgian livestock; and/or

[12] The process of establishment of this definition can be consulted in detail in the core research (chapter 1.3.)

(2) the exploitation of arable land over time by Belgium for fodder crop production at the expense of the equitable access to this land by other countries, communities or individuals."

Since the present research aims at quantifying Belgium's ecological debt, there is a need for measurement of both parts of this definition. The core research presents four possible ways of measuring physical aspects of ecological debt (see core research, 1.4.):

1. System of indicators (environmental cause and effect chains or DPSIR model)
2. Ecological footprint
3. Environmental space
4. Material flow analysis

With regards to part (1) of the working definition for this module, the first method will be most appropriate. 'Ecological footprint' and 'environmental space' both deal with the problem of limitations to the earth's carrying capacity for human production and consumption patterns and are therefore more suitable for measuring part (2) of the working definition. As mentioned in the core research, material flow analysis (MFA) is not a direct measure of environmental damage as such, but provides necessary information in addition to financial trade balances when tracing the locations on which Belgian consumption and production patterns have impact.

Material flow analyses have been performed in 4.2., in which there has not only been shed light on the physical trade balances of fodder crops or derived products, but also on the land requirement to provide this material flow. The analysis yielded a clear image of the amount of land required in a certain country to produce certain fodder crops for the Belgian livestock sector. The data obtained in 4.2. serve as an onset to assess the two components of ecological debt of Belgium caused by its livestock sector.

4.3.3. Ecological damage as part of ecological debt of the Belgian livestock sector

4.3.3.1. Introduction: classification of ecological damage

Agricultural activities as a part of a global socio-economic system causes alterations of the environment. The core research (1.3.4.1.) offers a classification of environmental problems by type of interference with the environment: *pollution*, *depletion* and *degradation*. These terms will be applied to a system of indicators of environmental damage in 4.3.3.2. Another classification is based on spatial dimensions of environmental damage (see 1.3.4.2.). Cörvers & Slot (1998) distinguish 5 spatial levels: *global*, *continental*, *fluvial*, *regional* and *local*. With regard to the loss in CO_2 sequestration capacity and the emission of greenhouse gases, a global scale is most appropriate. Leaching or run off of fertilizers or pesticides to rivers are fluvial environmental problems. All other ecological damage described in 4.3.3.2. should be assessed on a regional scale.

In order to describe the ecological damage caused by agricultural activities abroad of fodder crops for the Belgian livestock sector, both 'spatial' and 'type of interference' categories will be integrated in a system of indicators. A much applied instrument of environmental analysis is the DPSIR model. It describes environmental cause and effect chains assuming that interference with the environment as a result of human activities is characterized by successive phenomena. The different components of the DPSIR model are: *driving force, pressure*, *state, impact* and *response* (see 1.4.1. for explanation of terms).

***4.3.3.2**. Ecological damage as a result of export-oriented fodder crop production*

Next to the DPSIR model as an international framework to assess environmental damage, Shah (2000) presents also the Framework for the Development of Environment Statistics (FDES) in which information categories are related to the components of the environment. The distinguished components are: *flora*, *fauna*, *atmosphere*, *water*, *soil* and *human settlements*. Table 5 provides an overview of environmental damage as a result of intensive (fodder) crop production in various agro-ecological areas. A cause and effect chain approach (DPSIR) has been applied to describe the damage to the above-mentioned components of the environment. Flora and fauna have been united, as to be equivalent to the much used ‘biodiversity’. ‘Human settlements’ has been abandoned as a component of environment since the impact indicators in table 5 describe impact on human settlements as well. Table 5 has been compiled using information from various authors: Bellini (2001), Branford & Ferris (2000), Butler (2001), Cordeiro (2000), Kimbrell (2003), Lee (2001), Papendick *et al*. (1986), Raina (2002), Riva (2002), Rubinstein *et al*. (2001), and Soil Association (2001).

In the core research (1.4.1.), a weakness of the DPSIR model was already highlighted: “it suggests a linear relationship between human activities and environment, while in reality most environmental problems have highly complex cause and effect relations”. The attempt of fitting agriculture-environment interaction in the DPSIR model also brought about following additional problems:

> (i). One driving force may be responsible for many pressures on the environment. Similarly, a single environmental pressure may provoke diverse changes in the state of the environment. Each of these changes of the state can have several impacts, etc. A more pyramidal approach would yield cause and effect chains that correspond more to reality. The *problem tree* approach from the logical framework might serve as an example (EC, 2004).
>
> (ii). Changes in the state can contribute to pressures in other environmental components. E.g. soil erosion (state change) causes unproductive agricultural soils but similarly boosts the run-off of pollutants to surface water (pressure). The agriculture-environment interaction should better be assessed cyclically rather than linearly.

Keeping these remarks in mind, some agriculture-environment interactions presented in table 5 are discussed more in detail below.

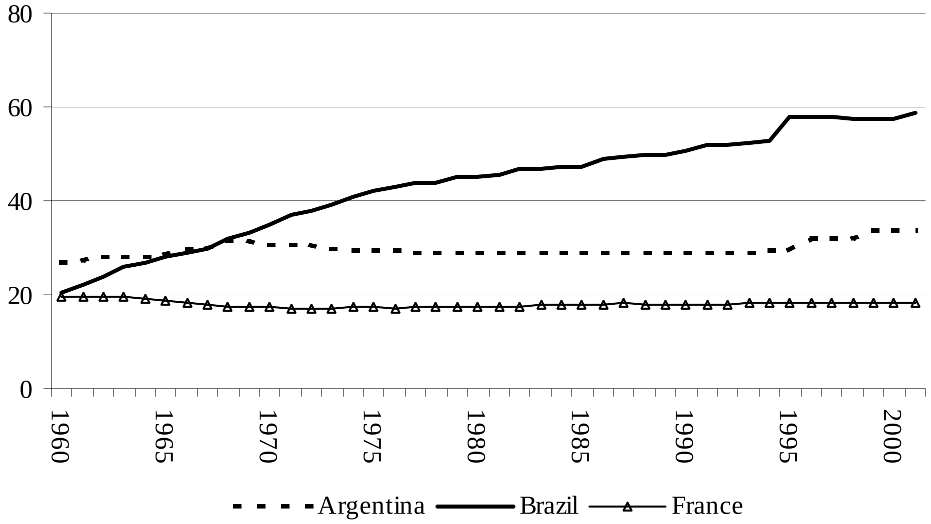
	FAUNA & FLORA	WATER	ATMOSPHERE	SOIL
DF	– Expansion of land requirement for export of fodder crops – Pursuance of production at lowest (economic) cost	– Expansion of fodder crop production in agro-ecologically unsuitable areas – Pursuance of production at lowest (economic) cost	– Expansion of land requirement for export of fodder crops – Poor agricultural waste management	– Expansion of land requirement for export of fodder crops – Expansion of fodder crop production in agro-ecologically unsuitable areas
P	– Deforestation – Monocultures – GMOs – Abundant pesticide and herbicide application – Spread of modified genes	– GMOs/high yielding varieties – Abundant fertilizer application → run off to surface water – Abundant pesticide and herbicide application → run off to surface water – Over irrigation	– Deforestation by slash and burn systems – Burning of crop residues	– Deforestation and/or clearance of land – Intensive cultivation on rainforest soils – Soil-water affecting processes (irrigation/drainage) – Use of heavy agricultural machinery
S	– Loss of plant and animal species – Herbicide tolerance in weeds → spread of uncontrollable weeds – Introduction of alien plant and animal species	– Eutrophication of surface water – Parched aquifers – Poisoning of surface water	– Loss of carbon sequestration capacity – Increased CO_2 emission – Loss of rainfall regulation capacity of tropical forests	– Erosion – Soil nutrient depletion – Salinization – Desertification – Soil compaction
I	– Loss of genetic resources for nutritious and/or medicinal plants – Loss of 'bush meat' reserves – Substitution of original crops and traditional farming methods → decline in quality and quantity of local food supply	– Diseases within local communities – Drinking water wells unusable – Unproductive agricultural areas ↓ – Compelled migration of local inhabitants	– Climate change → climatic disasters	– Unproductive agricultural soils – Change in landscape ↓ – Compelled migration of local inhabitants
R	– Animal production on a continental scale – UN Convention on Biodiversity (1992) – EU ban on GMOs	– Animal production on a continental scale – UN 'Water Convention' (1997)	– Animal production on a continental scale – Kyoto Protocol (1992)	– Animal production on a continental scale – UN International Convention to Combat Desertification (1996)

Table 5 – *Assessment of ecological damage as a result of export-oriented fodder crop production, applying the DPSIR model to 4 components of the environment.*
***DF**: Driving Forces, **P**: Pressures, **S**: State, **I**: Impacts, **R**: Responses.*

Deforestation and monocultures as a pressure on the environment

Deforestation is mentioned in table 5 as a pressure on fauna & flora, atmosphere and soils. Figure 34 illustrates the evolution of arable land in France, Brazil and Argentina, three of the main countries that produce fodder crops for the Belgian livestock sector. Throughout the studied period, arable area was steady in Argentina and France, whereas in Brazil it increased from approximately 20 million ha in 1960 to around 60 million ha in 2001. This means a clearance of around 1 million ha annually. Rubenstein *et al*. (2001) estimate that 20-30 percent of the world's forest areas have already been converted into agricultural area. The clearance of rainforest often combines the economical benefit of making arable area available with the fulfilment of world's demand for timber wood.

Figure 34 – *Evolution of arable area in Argentina, Brazil and France (million hectares)*[13]



Deforestation causes loss or even extinction of certain plant and animal species. This not only disturbs the vulnerable ecological cycles of the rainforest but also hampers the use of genetic plant resources by local communities for nutrition and/or medicinal application.

Rainforest soils are characterized by close nutrient cycles and a high degree of acidity (Butler, 2001). Largely cleared forest areas are therefore vulnerable to leaching of soil nutrients. A monoculture of a certain crop is productive for a few years, but afterwards requires increasing fertilizer input. As soils erode more rapidly under monoculture, these fertilizers will be washed out of the soils, reaching groundwater or run-off to rivers or other water resources. This illustrates that a change in state (soil erosion) can enhance pressure on other environmental components (water, see arrow in table 5). Deforestation also has an effect on climate change as the loss of vast forest areas diminishes the carbon sequestration capacity of the rainforest. Moreover, where slash and burn techniques are used to clear the rainforest land and where poor waste management results in incinerating crop residues, substantial amounts of CO_2 are being emitted in the atmosphere.

Monoculture, i.e. the cultivation of one single crop over a vast area, inevitably brings about pests and diseases which are no longer controlled by natural antagonists. Their natural environment vanished as a result of clearing the cultivation area. As a result, abundant

[13] Source: FAO: http://faostat.fao.org/

quantities of pesticides are being applied to the crop. Run off to surface waters cause pollution of drinking water of local communities.

Another – often overlooked - impact of monocultures is the substitution of original crops and traditional farming methods (Branford & Ferris, 2000; Raina, 2002). In stead of making use of the present local gene pool of the rainforest, farmers become dependent on imports of food crops from elsewhere.

Water management

Monoculture crops are often cultivated in areas that are agro-ecologically unsuitable because of dry, acid or swampy soils. Irrigation/drainage then is performed as to adjust moisture content of the soils. When these soil-water affecting processes result in parching of aquifers, rising of groundwater tables or supply of minerals from other areas, salinization or desertification is likely to occur. This leads in a few years to areas in which agricultural production is no longer possible. In Brazil, 30 % of irrigated areas suffer under salinity (Cordeiro, 2000).

Genetically Modified Organisms (GMOs)

GMOs have been developed by – mostly multinational – companies for several reasons. Yield improvement has been of minor importance in comparison to genetic modification towards resistance/tolerance against certain pests or diseases. Broad spectrum herbicides are very effective against a wide range of weeds, but also destroy the crop in which the weeds occur. Genetic modification therefore often aims at introducing resistance/tolerance against these herbicides[14]. Consequently herbicides are being abundantly applied to the monoculture crops. Run-off to surface water causes poisoning of water resources for local communities (see arrow in table 5). In Brazil, 220 000 people die each year as a result of pesticide poisoning. The Brazilian National System for Toxico-Pharmaceutical Information (SINITOX) estimates the total number of cases of pesticides intoxications at 3 639 300 in 2000 (Bickel & Dros, 2003).

Further, massive herbicide application causes genetic erosion within the area of the monoculture crops. This not only affects biodiversity of local (medicinal or nutritious) plants but also insects and other animals that depend on them. Another hazard can be found in the spreading of modified genes to wild relatives of the crop. This induces herbicide resistance in these wild relatives – some of which are weeds. This leads initially to an increase in herbicide application but eventually herbicides with other physiological properties will have to be introduced, thus increasing pressure on the environment.

Plants are also being genetically modified to induce resistance/tolerance to certain pests and diseases. Bt-crops[15] are a well known example of crops resistant/tolerant to caterpillars and insect grubs. The constant exposure to the Bt toxins is likely to increase resistance in the pest/disease organisms, which still makes pesticide application necessary. Moreover, the toxins can kill beneficial organisms also (e.g. certain butterflies).

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[14] E.g. (i) Monsanto's Round-Up ready crops are resistant to the broad spectrum herbicide Round-Up (glyphosate as active principle); (ii) Aventis modified crops as to make them resistant to Liberty (gluphosinate)

[15] The genome of Bt-crops has been inserted with a gene from the soil bacteria *Bacillus thuringiensis*. It induces the production of toxins lethal to insects by the modified plant.

4.3.3.3. *Interim conclusions*

In chapter 4.3.3.2. the DPSIR framework has been applied to four components of the environment in order to describe ecological damage as a result of export oriented fodder crop production. Doing so, problems occur when cause and effect chains go beyond the borders of different environmental components. The linear nature of the DPSIR framework is a constraint to an adequate description of cyclic interactions between agricultural activities and the environment.

Classifying ecological damage only according to the type of interference with the environment (pollution, degradation and depletion) offers little information on the causes nor the consequences of the damage, but is nevertheless useful when applied in a broader DPSIR framework. The same goes for distinguishing between different spatial scales of ecological damage.

All literature consulted on environmental damage as a cause of intensive/industrial agriculture makes little or no distinction between

(i) the *country* in which production takes place: As described above, deforestation has a tremendous effect on rainforest soils. Elsewhere these effects might be more moderate;
(ii) the *magnitude and intensity* of production: large areas of monoculture crops with high fertilizer and pesticide input are likely to have more detrimental effects on the environment than dispersed small-scale producers. The impact with regard to substitution of original crops and traditional farming methods is nevertheless alike;
(iii) the cultivated *crop*: depending on crop or variety, other types of fertilizer and pesticide input and post harvest treatments are required.

Therefore, in order to assess part 1 of the refined definition of ecological debt for the Belgian livestock sector, ecological damage should be assessed according to the three dimensions described above. If all ecological damage can be valorised, aggregation of all damage would yield the whole of part 1 of ecological debt of the Belgian livestock sector.

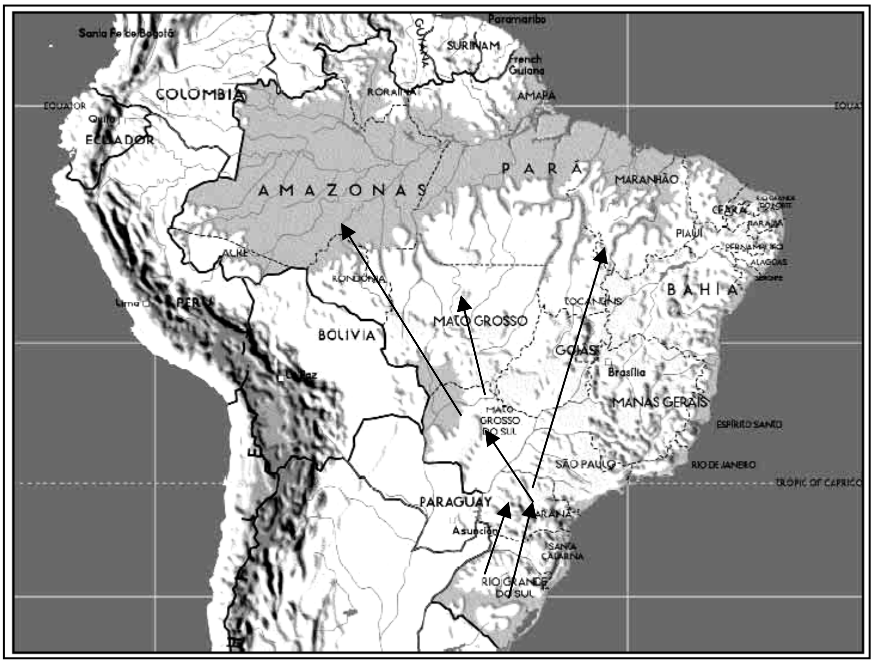
4.3.4. Case study: Ecological Debt of Belgium to Brazil, aspect ‘ecological damage’

As for Belgium soy is the predominant imported crop in the last two decades (figure 27), a modest case study of ecological debt as a result of ecological damage caused by soybean cultivation abroad is performed. Although land requirement for soy production in both Argentina and Brazil are reported in more or less equal amounts (figures 29 and 30), Brazil was chosen as ‘creditor’ country since soy acreage cultivated was larger (16 million ha in 2001) than in Argentina (11 million ha in 2001). Nevertheless, Argentina has a larger growth in production quantity in 2001 (+143 % since 1996) than Brazil (+75 % since 1996) (Van Gelder & Dros, 2004).

4.3.4.1. *Overview of the Brazilian soybean sector*

Still behind the USA (43 % of global soybean production), Brazil is currently the second soybean producing country in the world with a market share of 23 %. The above-mentioned recent rise in production over the last eight years has resulted mainly in a strong growth of soybean exports (+322 %). A large part (58 %) of the total Brazilian soybean supply is being crushed inside Brazil. In 2001, the most important export markets for Brazilian soybeans were the European Union (59 %) and China (Van Gelder & Dros, 2004). Although (cooperatives of) family farms contribute to the total Brazilian soybean production, Van Gelder & Dros (2004) state that most production inside Brazil is performed by very large agricultural enterprises like *Andre Maggi*, *Camilas cooperative* and *Itamarati*. These companies produce soy on farms with an area between 100 and 1 000 ha, often over 1 000 ha (Cordeiro, 2000).

Figure 35 – *Brazilian federal states and soybean expansion areas (Cordeiro, 2000)*



The Brazilian soy cultivation started around 1960 in the southern states Rio Grande do Sul, Santa Catarina and Paraná. Due to several crises in the protein crop sector in other countries on the one hand, and a rise in demand for protein fodder commodities on the other hand, soy cultivation rapidly expanded after 1973. Subsidized by the government, soy became the predominant export product of Brazil in the following 15 years. The cultivation area rapidly moved northward to the states of Mato Grosso do Sul and is currently expanding in the scrub savannahs (cerrados) and rainforest areas of Mato Grosso, Uruçui (Southern Piauí) and Amazonas (Figure 35) (Coppens, 2003).

In 1996 Roundup Ready soy was introduced in the United States and Argentina. Although structural adjustment programs from the World Bank encourage the export oriented expansion of soy in Brazil, import of genetically modified soy was prohibited by the Brazilian government in 1997. Initially this meant a trade advantage for Brazil as EU consumers are sceptical towards GMOs. It is estimated however, that as a result of smuggling through the Argentinean border, already 15 % averagely – up to 70 % locally – of soy plants are in fact genetically modified (Copppens, 2003).

Since ecological damage as a result of agriculture depends on the ecological features of the region in which cultivation takes place, current evolution and ecological impact of the expansion of soybean cultivation in three different Brazilian regions is discussed below (Bickel & Dros, 2003).

A. Uruçui (Southern Piauí – Northeast Brazil)

Soybean cultivation started on a commercial scale in Uruçui in 1988. In the whole district 50 large producers cultivate 80 000 ha of soy, compared to only 10 000 ha cultivated by 400 smallholders. Since 1995, annual increase of soy acreage was between 30 % and 113 %. Cheap land, flat upland areas suited for large-scale mechanisation, subsidies and tax exemptions enhance expansion of soybean cultivation in the district of Uruçui. Poor acid soils and transport constraints to the expansion are mitigated by the high input of fertilizer and lime and the prioritisation of the Brazilian government to infrastructure improvement.

The 'cerrados' of Piauí are considered to be the savannah type with the highest biodiversity in the world. The *Código florestal* (= forest law) requires that 20 % of all landholdings in these cerrados have to be protected and an additional 10 % should be left uncultivated for environmental compensation. This law is often not respected. Apart from ecological damage as a result of clearing the native cerrado vegetation and soybean cultivation, damage is also caused by huge requirement of fuel wood for the Bunge soybean crushing plant (400 m^3 = 20 – 25 ha of cerrado wood per day). Smallholders in the area are encouraged by the Brazilian government to develop eucalyptus plantations as a resource for the Bunge factory. This cultivation and its concomitant ecological damage should therefore also be taken into account when assessing the ecological damage caused by soybean cultivation in Brazil.

B. Mato Grosso (Central West Brazil)

The original vegetation of the state of Mato Grosso consists of Amazon forest (50 million ha) and 'chapadões' (flat cerrado highlands – 40 million ha). The central western cerrados were long considered unsuitable for soybean cultivation but soy varieties have been adapted to tropical conditions by EMBRAPA, a Brazilian agricultural research centre. Today Mato Grosso is the largest soybean producing state in Brazil, containing one-fourth of Brazil's total of 18.5 million ha planted with soy. In the last eight years, soybean area has almost doubled to 4.5 million ha. In 2003, Cargill[16] opened a US$ 20 million soy terminal in Santarem - a harbour town along the Amazon river - to alleviate transport constraints to the region.

Some areas in Mato Grosso where soybean cultivation is expanding are biodiversity hotspots and thus recommended as priority area for conservation. Of total 90 million ha, only 1.8 million ha were protected in 1997. Fourteen percent of the forest area has been lost since 1970. Soybean area expanded with 770 000 ha, being 70 % of total expanded agricultural area. In some cases, soybean producers have penetrated into protected areas or indigenous reserves, like the Xingú National Park, with resulting deforestation and pesticide contamination of local water resources. The jeopardy of pesticide application in large-scale agriculture has been explained in 3.3.3.2. In Mato Grosso however, pesticides are disseminated over much larger areas than intended as a result of spraying by aircraft.

[16] Cargill is the sole multinational company that crushes soybeans inside Belgium – see 4.3.4.2.

C. Humaitá (Southern Amazonas)

The state of Amazonas extends over 150 million ha, of which 97 percent is still covered with original vegetation - mainly tropical forest. Soybean cultivation in this area is very recent. First cultivation took place in 1994. Between 1996 and 1998, there was a boom involving some 46 soybean farmers. Area cultivated with soy amounted to 15 000 ha in that period.

Next to already described impact of deforestation on biodiversity, another hazard lies within the rainfall regulation function of the Amazon forest. Tropical rains originate from evaporation from and transpiration of tropical forest vegetation. The Amazon forest regulates rainfall that is important for agriculture in the North as well as in the central west and southeast of Brazil. Given the size of the country, it is fair to state that deforestation can cause an ecological problem on a continental scale (see 4.3.3.1.). The process of often irregular land occupation and forest clearing is stimulated by public investments in transport infrastructure. Further, correcting tropical soil acidity with lime puts a pressure on biodiversity additional to deforestation and pesticide application, as vegetation types vary according to soil acidity.

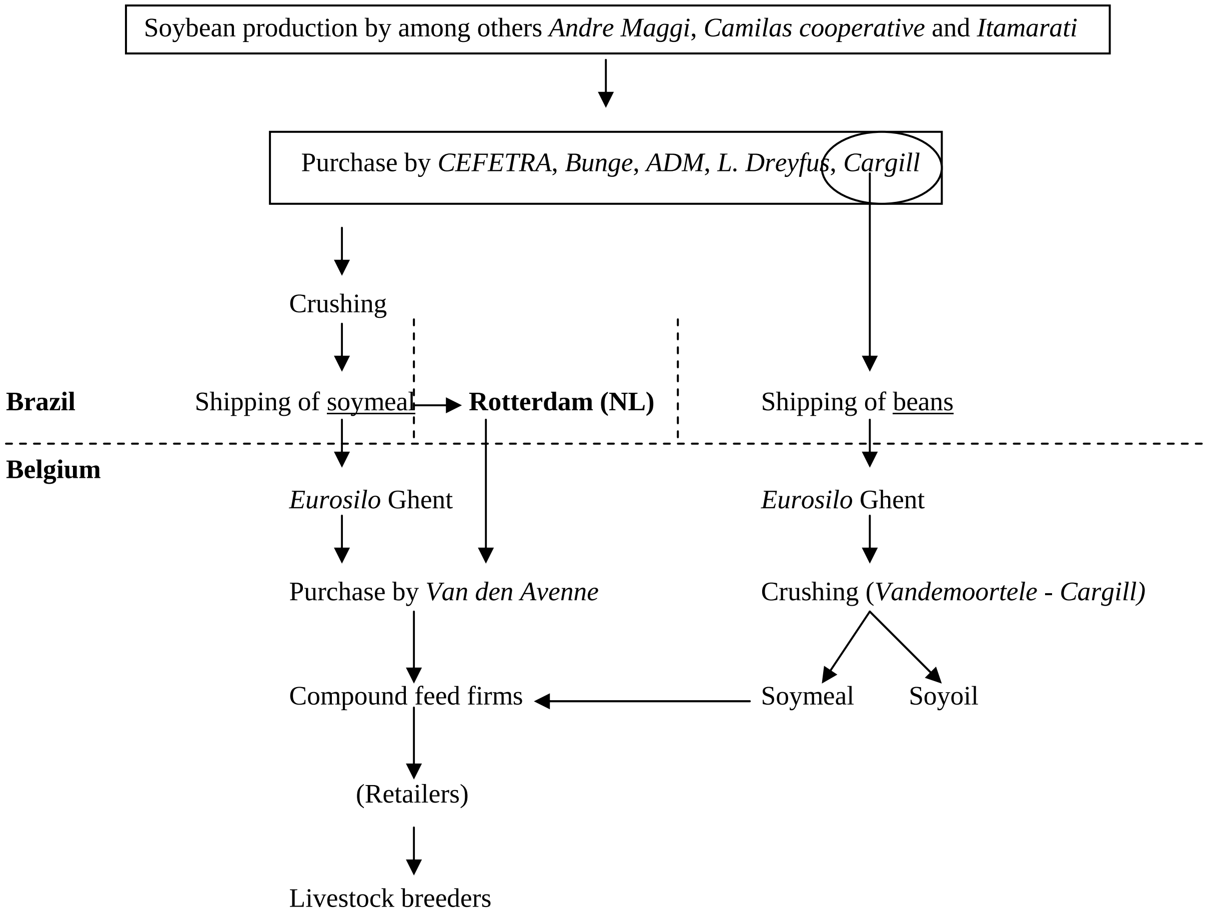
4.3.4.2. *The integration of the Brazilian soybean sector in the Belgian economy*

Soybeans are imported in Belgium as raw beans or enter the Belgian economy as soymeal (= soy oil pressing cake) or as soy flour (see chapter 4.2.). Import to the EU from Brazil (and Argentina) is performed mainly through the ports of Ghent (Belgium) and Rotterdam (Netherlands).

Inside Belgium two main players can be distinguished on the soybean market. One is the fodder commodity wholesaler *Van den Avenne* from Izegem. This company purchases mainly already processed soya (meals, flour) from five multinational companies: CEFETRA, Cargill, Bunge, ADM and Dreyfus. *CEFETRA* is a cooperative of 9 Dutch compound feed producing companies; *Bunge* and *ADM* are privately-owned American commodity trading and processing multinationals; *Cargill* is an American privately-owned company and is the largest commodity trader in the world. Finally, *Louis Dreyfus* is a French privately-owned company. Four of these five companies (CEFETRA excepted) dominate the world market of agricultural commodities (Van Gelder & Dros, 2004). If shipped, (processed) soy enters at the seaport of Ghent where it is collected at *Eurosilo* company, the former *Ghent Grain Terminal*. From there, soy commodities are transported by truck to retail traders in the whole country, or are exported to other European countries (personal conversation with Mr. Frank Bruyneel, employee of Van den Avenne company).

Cargill is the second main player on the soy market inside Belgium. It does not only supply to wholesalers like Van den Avenne, but also has its own crushing plant in Izegem Belgium. In Belgium, this company is better known as *Vandemoortele* which was taken over by Cargill in 1998 (Durez, 1998). Cargill mainly imports soybeans to be crushed inside Belgium. Processed soybeans are then transported to retailers inside Belgium or are exported. Figure 36 illustrates the soy supply and distribution chain between Brazil and Belgium.

Figure 36 – *Soybean production, processing and distribution chain between Brazil and Belgium (main stakeholders and main chains)*



Capital is provided to these companies through direct loans or through international banking syndicates. Many of these banks are operating in Belgium also, but following overview is limited to Belgian banks only (Van Gelder & Dros, 2004):

In March 1999 *ADM* secured a US$ 1 750 million revolving credit facility. *KBC* bank was participating in the lending syndicate. In February 2001 *Bunge* received a € 400 million revolving credit facility from a lending facility in which *Dexia* participated for € 40 million. Another lending syndicate facilitated a US$ 750 million loan to Bunge. Both *Fortis* bank and *KBC* bank participated in this syndicate. In February 2002 Bunge Asset Funding secured a one-year US$ 180 million revolving credit from an international banking syndicate in which *Fortis* bank participated. *Fortis* bank also participates for US$ 10 million in a US$ 420 million revolving credit facility, secured by Bunge in March 2002. Finally, *KBC* bank participates in a US$ 600 million revolving credit facility, secured by Bunge in July 2002. Although *Cargill* has invested in the Belgian economy through the take-over of Vandemoortele oilseed crushing company, no loans have been provided by Belgium banks to this firm. *Louis Dreyfus* also is not provided with capital from Belgian banks. Data on financial support of *CEFETRA* have not been found.

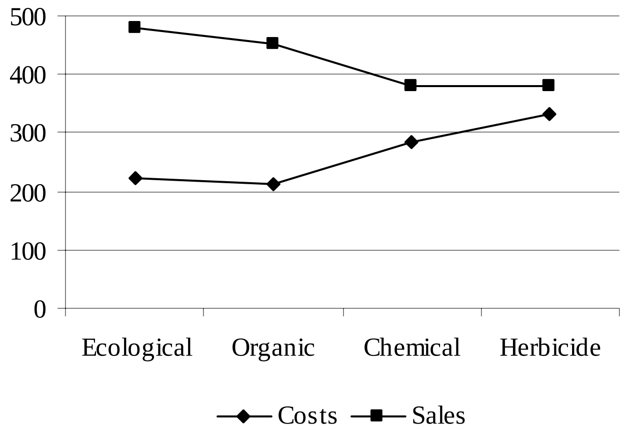
***4.3.4.3.** Ecological debt of Belgium towards Brazil as a result of fodder crop production for the Belgian livestock sector*

Ortega *et al*. (2001) compares four technological options for soybean cultivation in Brazil:

1. The traditional *ecological* method, applied by mostly family operated farms that cultivate areas of around 30 ha. The cultivation is characterized by high manure input (limited fertilizer application), manual weed control, biological pest control and manual harvest techniques.
2. The *organic* modern enterprise; a new rural system now appearing and adopted in medium and big size farms. The farms are run by families or enterprises and cultivate land areas of around 300 ha. Cultivation techniques are similar to the ecological method, however more mechanisation in weed control and harvest is applied.
3. The *chemical* method which corresponds to the ‘green revolution’ model, promoted in the 70’s. Here cultivation area is also around 300 ha per farm, but cultivation practises vary significantly from the organic or ecological methods. Fertilizers, herbicides and pesticides are applied abundantly. Harvest and seedbed preparation is performed mechanically. As enterprises applying these methods usually do not obey the ‘forest law’ (see 4.3.4.1.) and are far less dependent on forest ecoservices for production, deforestation occurs to a larger extent compared to the ecological or organic soybean cultivation method.
4. The *herbicide* method is also referred to as the ‘no tillage’ model. It can be seen as the result of the introduction of the ‘new green revolution’ in the last decade. This model originally envisaged the massive introduction of biotechnology in modern agriculture, but due to law restrictions on the application of GMOs, this has been banned gradually. The method implies an enterprise system with a cultivation area of 3 000 ha or more. In contradiction to the former three methods, no seedbed preparation is performed here. Herbicides are applied to clear fields from weeds. Other cultivation characteristics are comparable to the chemical method.

The chemical and herbicide method occur mostly in the states of Mato Grosso. As a consequence, the expansion of these cultivation methods puts a high pressure on the Amazone forest ecosystem.

Figure 37 – *Cost and sales comparison (US$/ha/year) between four soybean cultivation methods*



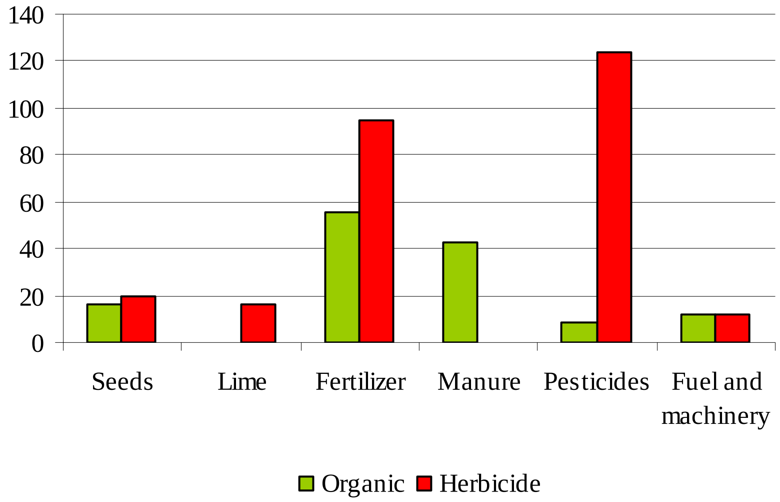
Although profits (sales – costs) per surface unit are maximized with the ecological method (figure 37), per farm annual net income will nevertheless be greater with the herbicide method (US$ 142 742) than with the ecological method (US$ 8 415). The herbicide method farms gain profit from the application of huge land surfaces (3 000 ha and more), compared to the ecological method (30 ha).

Ortega *et al*. (2001) calculated the environmental load rate (ELR) of the four methods as the sum of the emergy[17] values of applied non renewable resources and the purchased resources divided by the emergy value of applied renewable resources. From this calculation a clear distinction can be made between the ecological (ELR: 1.19) and the organic (ELR: 1.40) method on the one hand, and the chemical (ELR: 3.40) and herbicide (ELR: 3.70) method on the other hand.

In what follows the organic method will further be compared to the herbicide method. The organic method was chosen as it puts far less pressure on the environment when compared to the chemical or herbicide method and yet is applied on a cultivation area of around 300 ha. The herbicide method was chosen on the other hand because of its recent expansion in northern Brazil.

Although economic costs (US$/ha/year) are more or less equal for seeds and fuel and machinery, costs are differing significantly between the two methods for the input of lime ($CaCO_3$), fertilizer, manure and pesticides. Whereas with the organic method soy can be produced on agricultural suited soils in southern Brazil, the herbicide method requires a US$ 16 lime application per ha per year, as to correct acidity in tropical soils. Fertilizer input with the herbicide method (US$ 94.4 per ha per year) almost doubles the value for the organic method (US$ 55.2 per ha per year). The organic method can be sustained through the input of US$ 43 manure per ha per year, which is derived from nearby livestock production. The largest difference is observed in pesticide input which is almost 15 times higher in the organic method compared to the herbicide method. In the latter case, four fifths of pesticide budget is spent to herbicides (figure 38).

Figure 38 – *Economic cost comparison (US$/ha/year) of two soybean cultivation methods in Brazil*



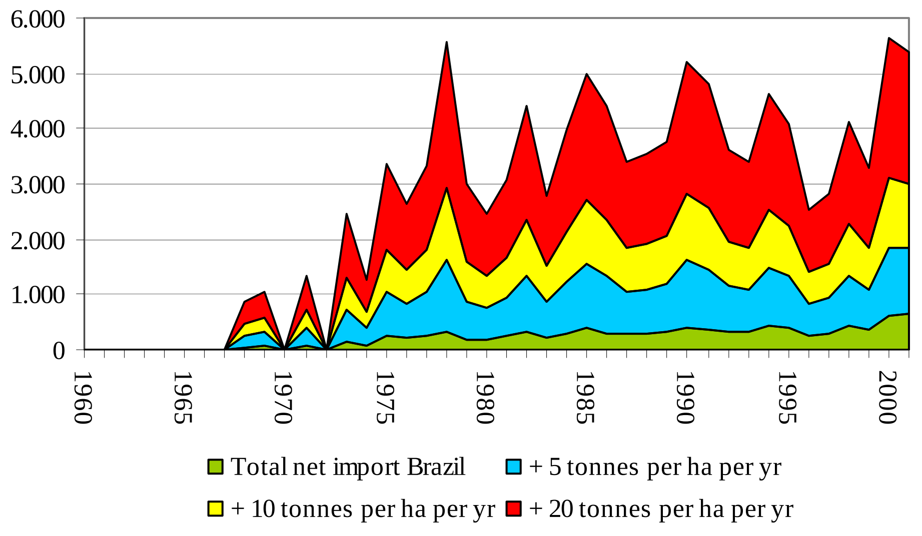
[17] Emergy = Necessary Joules (J) of solar energy to produce a product or a service (Ortega *et al*., 2001)

<u>Soil loss</u>

Figures on soil loss due to soybean cultivation vary considerably. Ortega *et al*. (2001) report soil losses of 1 ton per ha per year for the ecological and the organic cultivation method, 12.5 tonnes for the chemical method and 1.5 tonnes for the herbicide method. The soil loss is much higher with the chemical method as mechanical soil ploughing and harrowing occurs in sensitive areas whereas no tillage is applied with the herbicide method. Ortega (2004) states that the chemical method can result in maximum soil losses of 40 – 60 tonnes per ha per year. Cordeiro (2000) mentions soil losses of 20 tonnes per ha per year in southern Brazil (because of more soybean fields on slopes). Soil losses are variable because they depend on declivity of the soil and the exposure to rainfall (which is much higher in tropical regions). UNDP (1998) reports an annual soil loss of 2 – 10 tonnes per ha on 0 – 2 % slopes and 10 –18 tonnes per ha on 2 – 6 % slopes for zero tillage (i.e. herbicide method) in Brazil. For the chemical method however, soil losses of 3.5 to 5.5 tonnes per ha are mentioned.

Since no information has been found on the cultivation method, nor the latitude of the cultivation area or the declivity of the soils cultivated with soy for the Belgian livestock sector, it is impossible to put forward an average soil loss per ha as a result of it. However, as large producers and multinational traders dominate the soy supply chain to the Belgian market (figure 36), it will be assumed that the chemical or herbicide method is commonly applied. Figure 39 depicts the soil losses in Brazil caused by net imported soybeans and the beans from which net imported soy meals were derived. The soil loss already doubles the net imported amounts of soybeans with a soil loss of only 5 tonnes per ha per year.

Figure 39 – *Total net import of Belgium of Brazilian soybeans (1 000 tonnes) and additional soil losses in case of 5, 10 and 20 tonnes soil loss per ha per year*



<u>Quantification of ecological debt</u>

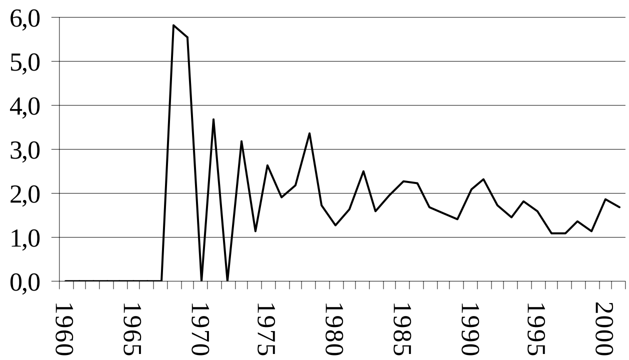
In 4.3.3.3. it was stated that ecological debt as a result of ecological damage caused abroad should be assessed according to the cultivated crop, the magnitude and intensity and the country of production. In the present case study it was observed that even within a given country (Brazil), ecological damage has a high variability depending on the region of agricultural production within this country. Moreover, data on the magnitude and intensity of production are scarce. Production and trade of soybean cultivated for the Belgian livestock sector is dominated by multinational companies which indicates that these soybeans are

produced according to the above described chemical or herbicide method. As no information has been found on the financial value of environmental externalities that are not incorporated in the sales price of these methods, quantification of this part of ecological debt is impossible. However, Ortega *et al*. (2001) report the value of forest biological control of the ecological method (25 US$ = € 20.57[18] per ha per year) based on annual cost of pesticides per ha of other options. Applying this to the soy area cultivated in Brazil for the Belgian livestock sector yields: € 3 038 415 in 1999; € 5 172 245 in 2000 and € 4 880 274 in 2001.

These amounts are only one part of the Belgian ecological debt. Additional debt consists of cultivation of other crops in Brazil and other countries and of the inequitable use of arable area abroad (see 4.3.5.).

To conclude, it should be kept in mind that the share of land requirement for soybean cultivation in Brazil intended for export to Belgium currently is only around 1.5 percent of total soybean area harvested in Brazil (figure 40). Mitigation of environmental pressure on Brazilian ecosystems due to soybean production should therefore be achieved by all countries importing soy. In 2001 the EU imported 45 % of all South American soybeans; China 35 % (Van Gelder & Dros, 2004).

Figure 40 – *Evolution of share (%) of land requirement for soybean production for the Belgian livestock sector in total Brazilian area cultivated with soy*.



4.3.5. Inequitable use of arable land as part of ecological debt of the Belgian livestock sector

This chapter deals with the second part of ecological debt as refined in 4.2.2.2.: "*the exploitation of arable land over time by Belgium for fodder crop production at the expense of the equitable access to this land by other countries, communities or individuals*". As was mentioned in 4.2.2.2., two indicators that were described in the core research can be applied in order to assess this part of ecological debt: 'environmental space' and 'ecological footprint'. First the 'ecological footprint' indicator for Belgium will be examined in brief. Further on, the significance of these indicators for the Belgian livestock sector is examined.

[18] US$ 1 = € 0.8229. Source: Universal Currency Converter 28/06/2004, www.xe.com/ucc/

4.3.5.1. *Belgium's Ecological Footprint*

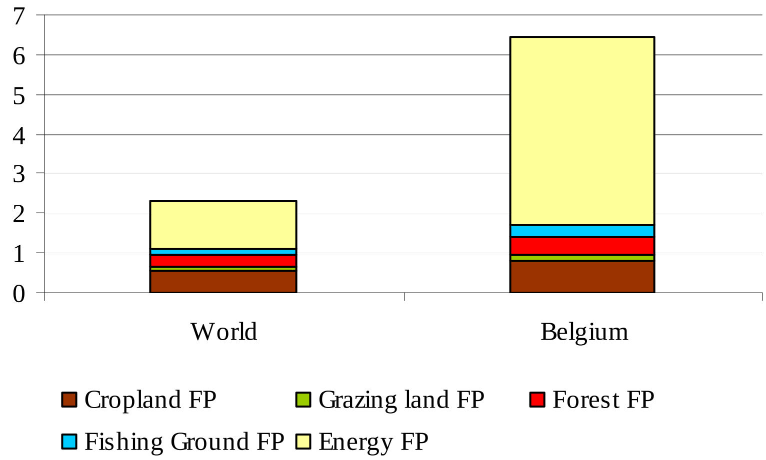
The concept of the ecological footprint has been discussed in the core research (1.4.3.). Here it is applied for the calculation of footprints and ecological debt in the case of fodder crops.

Loh (2002) subdivides ecosystem areas into 5 components. Each country has an ecological footprint that consists of:

1. *Cropland* footprint: area required to produce all crops consumed in a country (for human and animal consumption).
2. *Grazing land* footprint: area required to feed all animals of which products are consumed in a country but which are not crop-fed.
3. *Forest* footprint: area required to produce the forest products a nation consumes
4. *Fishing ground* footprint: area (of water) required to produce the fish and seafood products a country consumes.
5. *Energy* footprint: area required to sustain a country's energy consumption. It exists of 4 components: (i) the footprint of *fossil fuel* combustion, which is the area of forest that would be required to absorb the resulting CO_2 emissions (minus ocean absorption); (ii) the footprint of *biomass fuel*, which is the area of forest needed to grow this biomass; (iii) *nuclear power* footprint, for which energy generated is transformed into fossil fuel equivalents for which footprints can be calculated; and (iv) the footprint of *hydropower*, which is the area occupied by hydroelectric dams and reservoirs.

Figure 41 compares the per capita footprint of the world with the per capita footprint of Belgium for each of the above described five components in 1999. Total per capita footprint of the world is 2.3 ha whereas total per capita footprint of Belgium is around 6.5 ha. It makes clear that Belgium takes around 3 times the world average of earth's footprint area for its consumption patterns. The difference between Belgium and the world's average occurs mainly at the energy footprint (1.21 ha per capita for world's average; 4.75 ha per capita for Belgium).

Figure 41 – *Per capita cropland, grazing land, forest area, fishing ground and energy footprint (ha) of Belgium compared with the world's average in 1999. Source: Loh (2000).*



In what follows, attention will be given solely to the cropland footprint (0.53 ha per capita for the world; 0.83 ha per capita for Belgium). Cropland namely produces fodder crops for which the ecological debt assessment of the Belgian livestock sector was conducted. Gerbens-Leenes *et al*. (2002) found that land requirement for food of Dutch households mainly consists of production area for margarine, minced meat, sausages, cheese, fats for frying and coffee. In other words, land requirement for fodder crops is taking a large part of total cropland footprint, as 5 out of 6 of these products are derived from animal production. Hille (1997) agrees that aggregate consumption of animal foods most tends to push land consumption upwards.

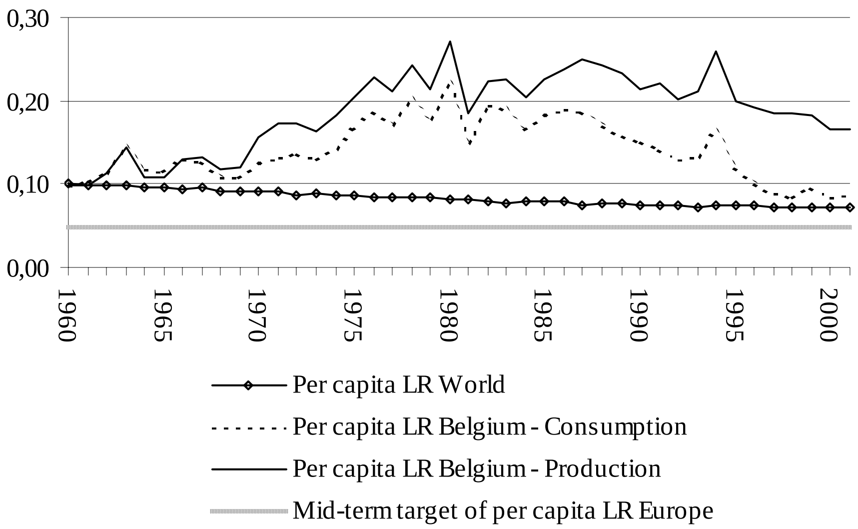
4.3.5.2. *Seizure of the Belgian livestock sector on world's arable area*

Figure 25 in 4.2.3.2.15. revealed that total land requirement of Belgium for fodder crops is around 250 % of the available domestic arable land. However, this amount as such doesn't indicate equitable access to fodder cropland by other countries or farmers within these countries. Therefore, based on the egalitarian equity principle (see 1.3.4.3.), a per capita land requirement (LR) approach was chosen. Figure 42 depicts:

- Annual per capita[19] LR of Belgium for fodder crop production. It consists of total land requirement for fodder crops abroad (see figure 25) and of fodder crop area inside Belgium[20]
- Annual per capita LR of Belgium for fodder crop consumption. Since animal products derived from livestock production is partly exported, the per capita land use of Belgium for fodder crop production is transformed into land requirement for fodder crops that finally end up with Belgian consumers. This was done by dividing the annual per capita land requirement by the annual degree of self-sufficiency for diary and meat products[21].
- Annual per capita[22] LR of the world for fodder crops[23].
- A mid term target level for per capita LR for the European Union (0.047 ha) (Spangenberg, 1995). See details below.

[19] Source of population data : UN (2003). World Population Prospects. The 2002 revision population database, http://esa.un.org/unpp
[20] Source: National Institute of Statistics (NIS), Récensement agricole et horticole. Résultats définitifs 1960 – 2001. Fodder crop area in Belgium can be divided into green fodder and tubers (see figure 26 in 3.2.3.2.15.).
[21] Source: LEI (1995)
[22] Source of population data : UN (2003). World Population Prospects. The 2002 revision population database, http://esa.un.org/unpp
[23] Source: FAOSTAT data (2004). http://faostat.fao.org/. Figures of world cropland area were obtained for aggregated harvested area of all fodder crops for which land requirement outside Belgium was calculated

Figure 42 – *Annual per capita land requirement (LR) for fodder crop production of Belgium, annual per capita LR for fodder crop consumption of Belgium, annual per capita LR for fodder crop production in the world, and a mid-term target level for EU land requirement of fodder crop production.*



Some conclusions from figure 42:

1. Annual per capita LR for fodder crops for Belgium has doubled world's per capita LR for fodder crops between 1975 and 1995. A slight decline is noticed after 1995.
2. Since 1975, annual per capita LR for fodder crops for Belgium has been around four times the mid target level of 0.047 ha for the EU as established by the Wuppertal institute (Spangenberg, 1995).
3. Throughout the years, a widening gap between per capita LR for fodder crop production and consumption is noticed. The increasing gap is caused by an increasing self-sufficiency rate for diary and meat products. As the self sufficiency rate is calculated as (domestic production) / (domestic production + imports – exports), the differences between the consumption and the production line can be attributed to an increased domestic production, decreased imports or increased exports of meat and dairy products. The true cause of the widening difference has however not been examined. It is nevertheless doubtful that total available quantities of meat and diary products (domestic production + imports – exports) has decreased over time. Therefore it is assumed that domestic production of meat and diary products increased as a result of improved fodder conversion ratios (kg meat or milk / kg fodder).

The question if ecological debt should be appropriated to our consumption or our production patterns nevertheless remains. The definition of ecological debt mentions both as they contribute both to the process of our wealth creation. This question will inevitably be risen when the concept of ecological debt would be brought at the negotiation table of agricultural policy makers. Assessing ecological debt only from the production side is tenable as for example the Kyoto-protocol for CO_2 emissions was based on national production of CO_2, regardless of who consumes the end product that results from these emissions. Furthermore, both the present research module and the energy/climate change research module have chosen to delimit ecological debt to the production side of the Belgian economy. Assessing ecological debt related to our consumption patterns requires a more thorough analysis of material flows inside and towards Belgium.

4.3.5.3. *Towards equitable land use for fodder crop production*

The Wuppertal mid-term target level for EU fodder crop area

The mid-term target level of 0.047 ha per capita for the European Union is only one sustainable future scenario of many available. It is however the only scenario which offers a preview on per capita land requirement for fodder crop production. The Wuppertal institute determines the year 2010 as mid term. The future scenario is based on following assumptions for future agriculture in general (Spangenberg, 1995):

1. Fodder crops for EU livestock feeding will be produced exclusively within the EU borders (continental scale).
2. 10 % of total area will be protected from human use and exploitation.
3. Agriculture will apply ecological farming methods (with a concomitant 10 % yield loss compared to conventional farming methods).
4. Only half of the per capita area used today can be used for luxury agricultural products (like certain tropical fruits).
5. Degraded agricultural land will no longer be used.
6. 3.2 % reduction in per capita utilisation of agricultural land for the production of biomass or other renewable energy resources.

The number of livestock required to meet demands for meat consumption is based on gross domestic meat production of 357 kg of meat per animal annually. Based on above-mentioned assumptions, calculations were performed which yielded a 0.047 ha per capita for fodder crop production by 2010 on a EU scale (Spangenberg, 1995).

Alternative strategies

Hille (1997) criticises the continental scale for assessing land requirement for fodder crop production. Average land productivity is better inside EU than the world average. Crops intended for export might then be grown on less productive land so that the inequality of world-wide access to arable land would be no longer a concern of absolute land surfaces but of distribution in arable land quality (productivity). Further, Hille (1997) puts forward an indicator for sustainable arable land use; the ratio between imported arable land surface to the EU, and the arable land surface cultivated inside the EU. A mid-term achievement of 1 for this ratio would already be satisfactory, whereas Spangenberg (1995) states that the ratio should be 0 on the mid term - albeit only for fodder crops. Nevertheless, both authors agree that self-sufficiency on a continental scale would reduce pressure on environment since energy and material requirement for transport and intermediate storage of food would be reduced.

This implies that proteins will have to be available from within Europe. The main reason of importing massive amounts of soy today is that it contains a high concentration of high quality proteins. The ban on animal meal as a protein source for livestock production provoked a rise in soybean imports. Soybeans can however – due to climatic requirements – not be cultivated on a large scale in Europe. Replacing soybeans (and other protein crops produced in tropical regions) by other protein rich crops is therefore essential in achieving self-sufficiency in fodder crops on a continental scale. Although production related agricultural subsidies under the Common Agricultural Policy of the EU (see 4.1.2.3.) are being reduced, incentives should be given to European farmers to produce more protein-rich crops. VODO (2002) and Coppens (2003) mention lupines, peas, beans and/or pastures in which alfalfa or red clover are integrated (mixed cropping) as possible alternatives. In August 2003, the Flemish regional government agreed upon a subsidy for the production of plant protein resources. The Agenda 2000 reform of CAP (see 4.1.2.3.) however supports production of oil- (and thus protein-) rich crops, but to the same extent as grain production (€ 63 per ton). As a result, European farmers tend to prefer grain production above oilseed crop production, since cost-effectiveness is lower with the latter (Coppens, 2003).

Hitherto, strategies for a more equitable land use for fodder crop production assumed a constant and persistent EU demand for fodder crops. This means - on a consumer's level – a high demand for meat and diary products. Gerbens-Leenes *et al*. (2002) however argue that an affluent (i.e. rich in meat) diet requires more than three times as much arable land as a vegetarian diet. Land requirement for a hypothetical diet on wheat would even be six times less than that for an existing affluent diet with meat (Gerbens-Leenes & Nonhebel, 2002). White (2000) analysed the distribution of food consumption of the world. Without going into details, it is shown that consumption of animal calories exhibits a greater degree of inequality than consumption of either total or vegetable calories. The world-wide degree of inequality in environmental impact of agricultural production is in fact 2.5 times the inequality in the distribution of food (White, 2000). Nonhebel (2004) assessed the value of livestock production as a 'rest-stream upgrading system'. With rest-streams, by-products of human food production is meant. It was found that a food production system in which meat in the diet is replaced by vegetable proteins has the lowest land requirement, but the difference with the system where rest-streams are fed to livestock is small. Seidl (2000) states that world-wide calorie availability depends on the substitutability between land and other inputs dedicated to livestock feed on the one hand, and land area to produce plants for human consumption on the other hand.

All authors nevertheless agree with the viewpoint of Gerbens-Leenes & Nonhebel (2002) that social and cultural requirements of food claim large parts of the available land resources. The effect of changes in food consumption patterns on land requirements will even be greater than the growth in world population.

4.4. Conclusions

The Belgian livestock sector is highly dependent on foreign produced fodder crops. Belgium together with the Netherlands can be considered as 'gates' to the European Union for fodder crops. The international dependence of the Belgian livestock sector is rooted in a Common Agricultural Policy (CAP) of the EU, which Belgium helped establish in the late 1950s. From the very beginning the CAP brought some undesired effects along. While farmers' income remained relatively low, overproduction of animal products occurred due to a price-support policy adopted by the CAP. Although this direct price support to EU farmers is currently being cut down and overproduction has been reduced as a result, material flows of raw fodder commodities from developing countries (South) to Belgium (and the EU in general) is still increasing. International financial institutions (World Bank and IMF), together with international trade agreements of the World Trade Organisation (WTO) enhance the current agricultural trade relations between South and North, in which environmental pressure of (fodder) crop production is persistently shifted to the South.

In this study, the fodder crop flows from all foreign countries towards Belgium were analysed. Further, total land surfaces to produce these crops were calculated. An assessment was also made of the area that is intended for export production to the Belgian livestock sector in several countries. The latter can be regarded as one (but important) part of the ecological footprint of Belgium. All of this has been performed as to assess the ecological debt of Belgium as a result of its livestock sector. For this purpose, the definition of ecological debt as established in the core research has been refined. It consists of two parts; one that accounts for ecological damage and another that accounts for inequitable distribution of arable land use as a result of fodder crop production abroad for the Belgian livestock sector.

It was found that fodder crop net flows toward the Belgian livestock sector quadrupled since 1960 and are still increasing with around 140 000 tonnes annually. Currently, soybeans and wheat imports are predominant. Total land requirement (LR) abroad to produce fodder crops for the Belgian livestock sector has since 1975 been around 2.5 million ha, which is some 250 % of total available arable land in Belgium. Main countries of production of fodder crops for Belgium are Argentina, Brazil, France, USA and Canada. Within these five countries, the Latin American share (Brazil and Argentina) in LR for fodder crops increased in absolute terms over time, but also relatively compared to the whole of LR in the 5 countries (two thirds in the last decade). Although until 1990 LR in the USA has been substantial, in the last decade it vanished almost completely.

Cultivating vast areas of fodder crops abroad inevitably brings about ecological damage, of which the impact is not affecting the Belgian consumer. It was found that monocultures of fodder crops in general mainly cause pollution of surface waters by massive pesticide and fertilizer application. They also provoke a chain of other negative interferences with the environment where deforestation occurs or GMOs are applied. Attempts were made to fit interferences with four environmental components (fauna and flora, soils, water and atmosphere) as a result of agricultural production in general into a system of indicators: the DPSIR framework. The DPSIR framework was evaluated as valuable for this purpose, but the assumption of linear cause and effect chains is an obstacle for an assessment of ecological damage as a result of agriculture. Furthermore, this assessment is very complex since it depends on the country of production, the nature of the crop and applied cultivation methods; which all vary to a great extent. A modest case study of soybean production in Brazil for the Belgian livestock sector, could not yield an adequate ecological damage measure per surface unit.

Another part of ecological debt is the issue of equitable distribution of world-wide arable land. Belgium exceeds the world per capita LR for fodder crops with a factor two. A per capita mid-term target level (0.047 ha, Wuppertal institute, Germany) for fodder crop production area is exceeded with a factor four. In the latter case, it is assumed that self-sufficiency for fodder crops on a continental scale, using ecological farming methods, is the most sustainable future scenario. Because of these assumptions, this target level is only one of many future scenarios reported. Further research is needed to obtain one or more well-defined sustainability target levels for fodder crop land distribution. Anyhow, land requirement for fodder crops and equity in arable land distribution is related to Belgian (or European) food consumption patterns. An affluent (meat rich) diet requires at least 3 times as much cultivation area as a vegetarian diet.

As a result of the CAP, sustainable agricultural policies should be implemented at the European level. Current trade regimes between South and North sustain current ecological damage in the South and the global inequity in arable land use. Next to internalising costs of ecological damage in world market prices of fodder commodities, a change in Belgian and European consumption patterns is an important element in reducing Belgium's ecological debt as a result of its livestock production. Besides implementation in relevant domestic policies, both elements should be brought at the negotiation table of the WTO or the CAP by the Belgian government. A universal commitment as the Kyoto protocol for climate change so far is inexistent for agricultural issues. The UN water convention (1997) and the UN International Convention to Combat Desertification (1996) so far did not tackle the root causes of this part of ecological debt.

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