Resilience of the European food system to calamities

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Resilience of the European food system to calamities

Report for the Steering Committee Technology Assessment of the Ministry of Agriculture, Nature and Food Quality, The Netherlands

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Foreword

Food security was a global issue during World War II. Since then, the problem has been largely confined to developing countries. However, in 2006 food security was back on the global agenda. A host of factors led to a sharp rise in food prices. These included increased meat consumption in Asia, crop failures in Australia following drought, increasing levels of production of energy crops in North and South America replacing food crops, and - almost inevitably - speculation. Global food stocks shrank to uncomfortably low levels.

Such a dangerous situation can appear again. Low food stocks pose a major risk to the food system making it more vulnerable to calamities. If production suddenly falls following a severe drought, flooding, outbreak of a plant or animal disease, or volcanic eruption, food security may be at risk, even in Europe.

The Steering Committee for Technology Assessment is an independent advisory committee to the Dutch Minister of Agriculture, Nature and Food Quality. We have been concerned for some years about the resilience of the global food system to calamities. It was our fear that ongoing globalization of the world food system would lead to greater regional specialization and thereby concentration and increase of risk. We decided to focus on food security in Europe and commissioned Plant Research International of Wageningen University and Research Centre to carry out a risk analysis.

The findings of this report are both valuable and surprising. They suggest that globalization would neither further promote regional specialization to a significant degree, nor the commensurate concentration and increase of risk. The European food system is not expected to become less resilient to calamities until at least 2020. The only vulnerable area of significance appears to be the import of soybeans for fodder and vegetable oil, almost exclusively from South America. But even a total collapse of that import, while causing heavy price shocks, would not jeopardise the nutritional needs of the European population.

The report does raise additional questions. What would happen after two simultaneous calamities, such as a collapse of soybean imports *and* a heavy drought in Europe? What might be the impact on developing countries? What will happen after 2020 when global changes in diet may have developed further, energy and phosphate prices have increased, production of biomass for energy has grown, and climate change has continued? How will the resilience of the world food system to calamities develop under such conditions? These questions will be the focus of a follow-up project.

The present report makes important reading for agricultural researchers as well as policymakers in government, the farming community, the food industry and development NGOs.

We thank the PRI team for their skilful work, their critical attitude and interactive approach, and for the many fruitful discussions we had during the project. We also thank those experts mentioned in Annex 2 for their contributions. We look forward to the follow-up project.

Culemborg, November 2008

Wouter van der Weijden
Chair,
Steering Committee for Technology Assessment

Abbreviations and acronyms

AI	Avian Influenza
BSE	Bovine spongiform encephalopathy
BT	Blue tongue
CAP	Common Agricultural Policy
CSF	Classical Swine Fever
DDGS	Distiller's dried grain soluble
EC	European Commission
EEA	European Environment Agency
ENAPRI	European Network of Agricultural and Rural Policy Research Institutes
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FAPRI	Food and Agricultural Policy Research Institute
GTAP	Global Trade Analysis Project
FMD	Foot and mouth disease
GHG	Greenhouse Gases
GMO	Genetically modified organisms
HNV	High Nature Value
IFPRI	International Food Policy Research Institute
IGC	International Grains Council
IIASA	International Institute for Applied Systems Analysis
MBM	Meat and Bone Meal
Mtoe	Mega ton oil equivalent
PDO	protected designation of origin
PGI	protected geographical indication
RASFF	Rapid Alert System for Food and Feed
RSM	Rapeseed meal
SBM	Soybean meal
SFM	Sunflower seed meal
SRES	Special Report on Emission Scenarios
UAA	Utilized Agricultural Area
USDA	United States Department of Agriculture
WFP	World Food Programme
WTO	World Trade Organization

Executive summary

Food security is an issue of growing concern. With an increasing world population, changing diets and growing demand for energy crops, agricultural productivity will have to increase, probably even at rates exceeding those experienced so far. This might lead to a tightened supply-demand balance for agricultural commodities, in which fluctuations due to climatic, economic and political factors have a magnified impact on food prices and availability. Increased variability in food production is likely to harm vulnerable groups and countries with insufficient buffering capabilities, but also currently wealthy nations with 'full control' over their economies and resource base may be severely affected directly or indirectly. In addition, the global food system may become less resilient to natural and man-made calamities.

This study has analyzed the impact of possible calamities on the food security of Europe (EU-27) up to 2020 in a context of evolving globalization. It is hypothesized that Europe might be at risk at least for some basic food commodities if further globalization would lead to geographical specialization, and even more so under a scenario of trade liberalization, or with biofuel targets in place putting an additional demand for food crops.

Current situation
Europe is today largely self-sufficient in all basic food items, including the net export of various commodities. Two major exceptions are soybean, which is almost fully imported, and vegetable oils, which are imported for about 32% (2005) of total consumption. The current consumption patterns allow for a relative buffer in the sense that about 60% of the EU cereal consumption is used as feed, and meat consumption could be halved without harming dietary needs. Moreover, much food that appears as 'consumption' is actually not eaten, but wasted.

Baseline and liberalization projections towards 2020
Reviewed studies on long-term effects (2020) of various policy scenarios indicate that agricultural trade patterns in the world will not show great changes compared to the present. Present exporting countries will largely retain their positions and so will importing countries. The food situation of the EU-27 is projected to remain virtually unchanged towards 2020, also under trade liberalization. Total food demand will hardly change as population remains unchanged and expected dietary changes towards more luxurious food items will have minimal impact on total food demand. The net export of meat items would diminish somewhat, due to fiercer international competition, and the soybean import would remain at present levels, because meat production will level off. Moreover, Europe has a surplus production capacity as yields per hectare can be further increased, in addition to the extensive suitable soils that are still available for cultivation, though at the expense of nature.

The findings suggest that the European food system is rather robust in terms of food availability, with surplus domestic production, and strong purchasing power to acquire food on the international market. The exposure to increased international trade does not appear to pose additional risk to the EU, as its dependence on foreign supplies will not change much.

Until 2020, the EU agricultural sector as a whole is expected to continue its path towards lower employment, and decreasing agricultural land use, while increasing agricultural productivity. Particularly in the free trade scenario, these processes lead to concentration of production in North-western Europe, where institutional and infrastructural conditions are favorable. Land will increasingly become available due to increase in land abandonment and in crop productivity, while total production will level off. This leaves more room for natural habitats and/or cultivation of crops for feed and energy.

Climate change
Climate change will not affect this pattern dramatically up to 2020. It is likely to favour the production conditions in Northern Europe because of increased temperatures, while Southern Europe will face increasing drought, which coincides with the concentration of production areas occurring under a liberalization scenario. The effects of climate change are likely to become increasingly important in the long term, hence beyond the scope of this study (2020).

This does however, not exclude more extreme climatic events, such as hot and dry spells and flooding, from happening before 2020. This is likely to have a larger impact on acute food availability than the overall long-term climate changes, with a horizon beyond 2020.

Biofuels

Concerns about global warming, rising world fuel prices and growing demand for energy are considered by policy as the key factors driving the increasing interest in renewable energy sources and in biofuels in particular. Additionally, the use of biofuels will make the EU less dependent on fossil oil imports and offer an alternative to farmers to sustain their farming operations in future. Relevant for this study are the by-products of bio-diesel (oil cakes) and of bio-ethanol (DDGS) obtained from production of food-based feedstock, as they are protein-rich and can be used as feed.

Recently an EU biofuel policy has been proposed for obligatory blending targets of 10% biofuels for the transport sector in 2020. Research on the impact of cultivation of energy crops and use of biofuels on climate change and biodiversity is still being conducted, as the ability of biofuels to make a significant contribution to energy security and to reduce GHG emissions is being questioned. Though this policy target is currently under debate, we have pursued our analysis based on the proposed targets. When all energy crops for biofuels would be cultivated in the EU, it would require some 24 million hectares. However, baseline projections suggest that imports will be required to meet the target, and that it is more likely that approximately 57% of the energy crops are to be produced in the EU claiming nearly 14 million hectares in addition to 3.3 million hectares in Asia and Brazil assuming palm oil and sugarcane as feedstock. Sufficient agricultural land is projected to become available towards the year 2020 only under a liberalization scenario when some 26 million hectares are expected to be released as compared to 2000, and could thus be used for alternative agrarian activities. Under a baseline scenario, about 10 million hectares only would be released.

If the demand for food by humans and for biofuels exceeds the increase in crop productivity, food prices will rise due to biofuel production. Economic analyses indeed indicate an increase in food prices under the proposed policies to range from 10 to 40%.

Reviewed studies showed that food and energy markets are interlinked. The oil prices put both a ceiling and a floor for prices in the food market. However, the main driver for biofuel production in the EU, USA and Canada is policy, including tax exemptions, investment subsidies and obligatory blending of biofuels. The influence of the mandatory blending is expected to be more significant on production of biofuels than the influence of the crude oil price. However, high energy prices, to a certain extent, will further enhance biofuel production and consumption in other regions, as it would become increasingly competitive.

Calamities

Recently, global price hikes of food commodities have revealed the tightening of supply and demand. It is important therefore also to assess the impact of calamities on the European food system, apart from overall trend developments. It is questioned for instance whether the advancing globalization implies an increased dependence and with that an increased risk of the European food system.

To this end, the occurrence of calamities and their impact on food availability was reviewed, including drought, plant and animal disease outbreaks, a nuclear catastrophe and a collapse of trade.

The drought in 2003 had a strong impact on the farmers concerned, but had little effect on the consumers, as reduction in production could be compensated for by purchases from the global market and the use of stocks. In case of animal disease outbreaks, consumers modify their diets and even reduce their meat consumption but dietary needs are not in jeopardy. The nuclear catastrophe in Chernobyl damaged agriculture in Ukraine but left the food system in Europe at large virtually untouched. The impact of single biophysical calamities on European food security appears to be limited therefore.

Collapse of EU soybean (meal) imports

Soybean is the only commodity that is almost fully imported by the EU and is an important source of feed. Hence, it represents a major trade risk to the European food system. A total collapse of soybean (meal) import was studied as a possible disruption of an important supply line.

The total decline of meat production due to a collapse in soybean is estimated to be as high as 25%, but European meat consumption is projected to decrease by roughly 10-15% only. More than half of the decline due to the collapse in soybean is expected to be compensated for by purchase of meat from the world market. The remaining decrease of meat availability in Europe will not threaten food security in general but it will seriously harm the meat production and processing industry and the feed industry.

As soybean meal is an ingredient in dairy feed as well, milk production may be affected but the extent to which this might happen has not been analyzed.

Immediate coping measures include the use of intervention and private stocks and the use of substitutes. However, EU stocks in soybean (meals) are low, and the EU would have severe difficulty in finding substitutes within its own borders. Therefore, it would call upon the world market for substitute sources of proteins and substitute meat. Because of the small volumes of alternative protein-rich crops being traded internationally relative to the amounts needed, substitution at the short term would be very limited.

There is some scope to mitigate adverse short-term effects by raising the stock levels of soybean in Europe. Large stocks are kept primarily in the USA, Argentina and Brazil, and global soybean 'stock to use ratios' exceeds 25%, while it is less then 3% in Europe. Higher stocks in the EU could reduce price shocks and smoothen any transition to other feed sources. With a monthly consumption equivalent to about 3.4 million tons of soybean, a stock of about 10 million tons could cover about 3 months' consumption providing time to secure other sources of proteins. A stock in the EU of 10 million tons would correspond with 10 to 15% of the global stock over the past four years.

Openness to trade could imply a source of risk, but also creates opportunities to better cope with calamities. Furthermore, to protect the European market from adverse effects of trade shocks, stocks of goods may offer a buffer as an immediate tool to deal with strong negative effects. High levels of commercial stocks tend to stabilize prices, but also to depress average prices somewhat. Strategically, there could be scope for policy measures to promote maintenance of higher levels of stocks, for example by offering tax rebates to private stockholders, or by government stockpiling. In both cases, stocks should be used for stabilization only, and not become subject of speculation or (political) debate, which brings more uncertainty into the market.

Europe could respond to a collapse in soybean (meal) imports by cultivating more protein-rich feed crops on its own territories. To this end an area of some 27 million hectares is required if this calamity would occur in the very near future and some 20 million hectares in 2020 due to productivity increase. At the very short term, this can only partly be met from formerly set-aside land and from less cultivation of other crops. However, under a liberalization scenario, sufficient agricultural land is projected to become available towards the year 2020 when some 26 million hectares less is expected to be used for agriculture. In contrast to the liberalization concept, policy incentives would have to be put in place to facilitate the preservation of this land for agriculture and to render cultivation of these crops economically viable. Obviously, these lands can be used for various purposes, including nature, and energy crops.

If land is used for biofuel crops, the pressure on land in the zero-soya-import scenario is likely to be augmented less, as the proteins are a by-product of biofuel production using 1st generation food-based technology. Under this scenario, the available oil meals and distiller's dried grain soluble (DDGS) produced in Europe could replace much of the current soybean imports. Further analysis on the synergy between biofuel crops and feed is needed to help properly evaluate the contributions of such dual-purpose crops, and to further elaborate the consequences for third countries. Some pitfalls should be analyzed in more detail, such as the land areas that will actually become available, costs involved to stimulate the cultivation of these crops in Europe, maximum amounts of oil meals that can be mixed in feed, the use of the oil to replace the shortfall in oil imports or production elsewhere in the world, etcetera.

The coping and response strategy of Europe to the collapse of soybean imports will have consequences for third countries. However, even for poor developing countries, the consequences are likely to be mild, as substitute feed crops are mainly produced in developed nations, such as the USA, Canada and Eastern European countries.

A collapse of EU soybean (meal) imports implies an increased availability of soybean on the world market, leading to reduced prices of feed.

If soybean production collapses in the major exporting countries, a fierce competition on the world market will particularly harm feed and soybean importing countries, primarily, the EU-27, China, Japan, Mexico, Indonesia and Thailand. Purchasing power and geopolitics will then likely decide on who are the winners and losers.

1. Introduction

Food security has recently resurfaced on the political agenda of developed countries, because of the tightened supply-demand balance of agricultural products that may again lead to an increased risk of the food system to calamities. Food prices have been increasing since 2006 and price hikes have been experienced over the past months raising concerns worldwide because of social unrest and increased hunger. It is questioned for instance whether the advancing globalization implies an increased dependence and with that an increased risk of the European food system.

The aim of this study is therefore to analyze the resilience of the European food system with regard to the availability of food, within the context of an ever-globalizing world. This introduction first describes briefly the global food system and the main processes, which determine the demand and supply for food and which have led to a tightened supply – demand balance. Subsequently the aims and research approach of this study are described followed by the report outline.

Background information

The global demand for food has changed due to growing population and economic growth. Higher incomes, urbanization and changing preferences are raising domestic consumer demand for high-value products in developing countries. The consumption of food budgets is shifting from the consumption of grains and other staple crops to vegetables, fruits, meat, dairy products and fish. As the global livestock production increases, more animals are fed with products that compete with food crops or are fed with fish, which could be used for human consumption as well. In addition to food and feed, the demand for bioenergy has abruptly increased during the past years because of policies for compulsory blending of transport fuel and subsidies for the production of biomass for energy.

With an increasing world population, changing diets and growing demand for energy crops, agricultural production will have to increase, which can be achieved either by increasing productivity or by expanding agricultural land. Increase in crop productivity is expected mainly in the less developed countries, as there is still a large gap between current and potential yield levels that can be closed. It has to be taken into consideration however, that natural resources (land and water) per head of the growing population will continue to decline, yield growth potential is more limited than in the past, and rising energy prices will affect the costs of further intensification (Bruinsma, 2003). Expansion of land is mainly expected in the tropical areas of Latin America and Africa, and will be at the expense of tropical rainforest and grassland.

Continuing anthropogenic global warming is not expected to have much impact on overall global food production, but the impact on production due to climate change will be unevenly distributed. Positive effects are mainly expected in the temperate zones, and the negative effects in the tropical and subtropical zones. Climate change is expected to increase the occurrence of extreme weather events, accelerate the spread of pests and diseases, make some areas too hot for staple crops and raise the sea level causing flooding and salinization.

Trade volumes across and between continents have grown rapidly over the past decades and are likely to increase further in response to a reduction in trade barriers and an increase in food and feed demand. The flow of food and feed from South America to China has for instance increased enormously over the past decade. From an economic perspective, trade liberalization has been stimulated strongly over the past decades to allow countries with comparative advantages to benefit from global trade. This perspective is actively pursued through international agreements and negotiations, though regional self-interests have contained the speed of liberalization. Liberalization stimulates large-scale production systems to benefit from economies of scale and might lead to regional concentration of agricultural production.

Fluctuations in supply and demand can possibly have their origin in climatic, economic, technical or political factors. The frequency and severity of droughts and floods are expected to rise with climate change. Simultaneous outbreaks of animal diseases in large-scale production units and regions, either through natural events or through bioterrorism may place a temporary but severe shock on the global food system, as will sudden dents in the supply-demand chain due to social unrest and war. Collapse of the internet jeopardising information exchange may curtail trade flows. A nuclear disaster may have unprecedented sudden, but even long-term implications on food availability.

The impact of calamities, on regions and people will depend on the robustness of the food system to respond to such calamities and the resilience of the system to recover. Stability of supply of food depends crucially on the flexibility with which shifts can be made to other sources of food or feed, distinguished either by type of product, or by origin. In the past food stocks have been used to prevent major famines. In Europe and the USA production volumes have been controlled through a wide range of agricultural policy measures, including set-aside policies and quotation. Variability in food production is likely to harm vulnerable groups and countries with insufficient buffering capabilities. But also, current wealthy nations with 'full control' over their economies and resource base may be severely affected directly or indirectly due to the tightening supply-demand balance.

Objectives, research approach and report outline

Given these developments and potential effects on the European food system, the objectives of this report are to:

- Analyse whether Europe will be subject to possible risks in terms of overall food availability or in some major food items, such as cereals, meat or soybean, resulting from calamities.
- Identify the transfer of possible adverse externalities on third countries when it will safeguard its food security.
- Identify measures to cope with the problems.

These outcomes will depend on the reactions of the global and European food systems to calamities, such as extreme events like drought and floods, epidemics, geopolitical instability, bioterrorism and so forth. The number of combinations or scenarios to analyse these effects can be numerous and have been rationally selected in order to test the hypotheses, which have been formulated for this research. These hypotheses and the outcome of this study in respect to these hypotheses are presented in Annex 1.

The study was conducted in two phases and has been based on thorough data search and additional information provided by consulted experts, listed in Annex 2. In phase I, the impact of possible calamities on the European food production was reviewed as the dependencies of Europe from food imports. To this end, an overview was made of global trends with regard to food security, and European production and demand was placed in this global context. A range of possible calamities and their impact on food security was identified. The findings of this study have been documented in an internal report (Bindraban *et al.*, in press) and the main findings have been recaptured in Chapter 2 of this report.

During phase 2, the impacts of calamities on European food security have been assessed under a baseline and liberalization scenario. An outline of the research issues addressed in phase II is presented in Figure 1.1. The hypotheses as presented Annex 1 have been integrated in this structure. The European food situation in 2005 is used as a starting point and depicted left in Figure 1.1. Projections towards 2020 were studied under a baseline and a globalization scenario, whereby some variables were derived from existing analyses. These include the political stability of the EU-27 suggesting no further expansion, population growth, climate change, the EU biofuel target and space for natural ecosystems. The arrow from the left to the right shows these developments from 2005 towards 2020. The occurrence and impact of extreme climatic events, epidemics and trade risks have been further elaborated, and are represented in the oval with continued line in the figure. Note that no specific attention has been given as to how, why and what caused a calamity, but the effects of the calamities on the food system have been looked into.

Based on the findings of the review study (Bindraban *et al.*, in press) it has been decided to specifically look into the impact of a complete shortfall of soybean imports to the meat production, because of the high dependency of the

EU on soybean imports. The impact of a collapse of the import of soybean has been estimated for the availability of meat. Coping measures have been reflected on, viewed from the trade perspective. For a possible response strategy, estimates have been made of the amounts of protein feed required and acreages needed in the EU, to substitute for the shortfall. The impact of biofuels on claims for land has been reflected upon in the view of these soybean shortfalls. The measures taken by the EU to secure its food availability, may worsen or soften the effects of the calamity themselves, and might have implications on the food security of third countries or biodiversity. The elaboration of the soybean case is depicted in the oval with dotted lines. Specific attention was paid to economic responses to shocks and the role of stocks, for calamities in general and in case of a collapse of soybean imports in particular.

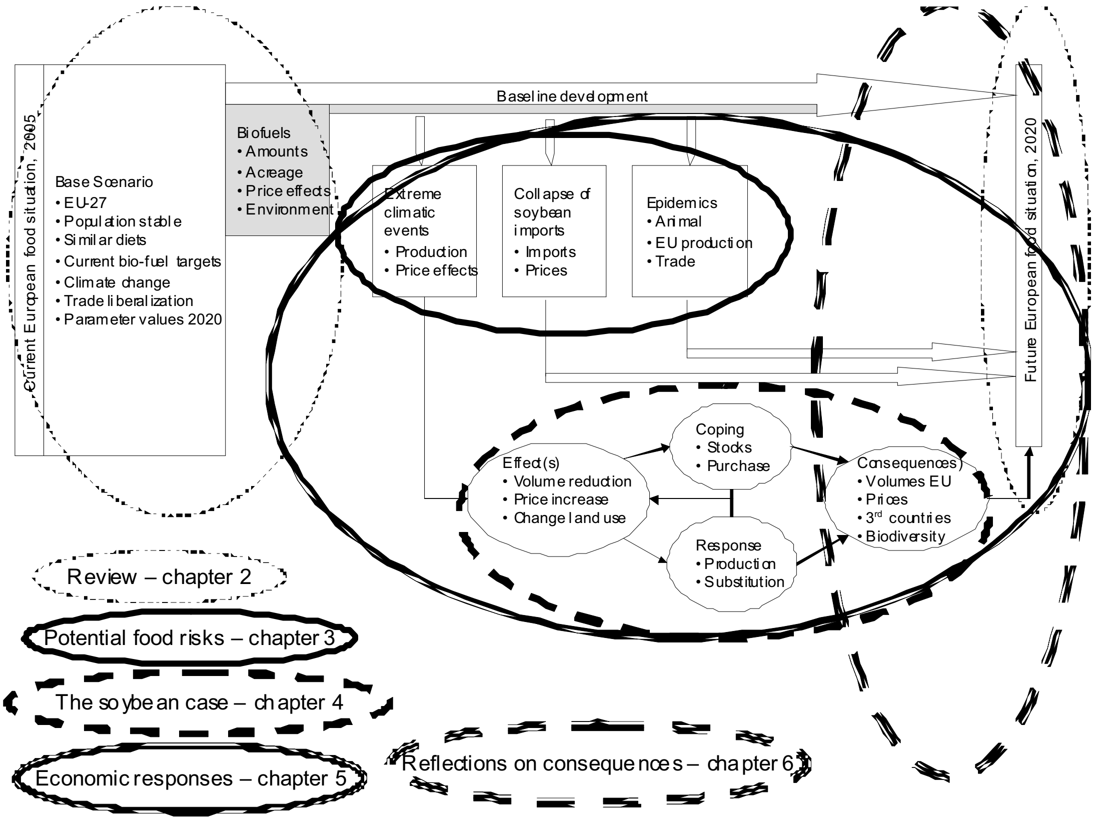


Figure 1.1. Overview of issues analyzed in phase II. Effects of calamities have been reflected on the baseline scenario (squares) along a procedure that allows identifying coping measures, strategic responses and consequences to food security of the EU and third countries (oval symbols).

The report has been structured according to the research structure as shown in Figure 1.1. The projections for the EU towards 2020 under a baseline and liberalization scenario are presented in Chapter 2. These are principally the main findings of the first phase. Selected potential food risks, such as extreme climatic events, epidemics and trade risks are discussed in Chapter 3. As an example of a trade risk, the collapse of soybean imports to the EU is studied and discussed in Chapter 4. The role of stocks as an instrument to soften the impact of a sudden decline in availability in a commodity is discussed in Chapter 5, with grain and soybean used as examples. In the discussion in Chapter 6, the main findings of this study are reflected on, followed by the main conclusions in Chapter 7.

2. Review of existing studies

This chapter presents an overview of factors that might affect the food security situation of the EU in the near future. Existing studies have been screened on trends in drivers and their likely projection for the future for the EU. Data of 2005 were used to describe the present situation of the EU and its vulnerability for calamities related to food security. These 2005-data serve as a benchmark for a projection towards 2020.

2.1 Modeling approaches

Production estimates explore possible options that are not necessarily time-bound. Some biophysical analyses that specifically look for instance into the impact of climate change on crop yield are time related (long term 20–100 years), but should be considered as explorations rather than predictions. Predictive analyses are generally based on economic principles and attempt to predict developments for the near future (short term 10–20 years). These models generally take past trends as a basis and assess future developments by imposing (econometric) empirical relationships of the past trends. Some model analyses try to comprehensively account for various possible future changes, such as climate change, demand for food, feed and for fuel, and trade liberalization. The approach in this case, in general, is to perform calculations of different thematic models sequentially in an attempt to account for the various aspects. Often, sophisticated interactions are lost and crude assumptions are introduced to account for certain aspects and processes, such as for the impact of climate change on yield in production-trade models. Fully integrating various (complex) models generally turn out to be too complex or tedious. In addition, the errors and uncertainties accumulate to the extent that the final quantitative accuracy of the analysis is reduced. Due to these limitations, it may be questioned whether comprehensive analyses that attempt to integrate a too large number of factors, provide better quantitative insight than stepwise and logical qualitative analyses based on partial quantitative studies.

2.2 Current food security of the EU

The current degree of self-sufficiency in the EU-27 is high and is likely to remain high in the near future. For the most basic food items, 95-100 to over 100% of European consumption is produced on its own territory (EC, 2007e). Extra-EU trade volumes generally do not exceed 10% of the production volumes, with net trade volumes below 5%. Of all cereals produced, about a quarter is consumed directly, and about 60% is destined to animal feed, which suggest some flexibility in overall food availability by modifying diets. Primarily processed foods and dairy products are exported. Europe imports about a quarter of its fruits and less then 10% of its vegetables, with total per capita supply doubling amounts strictly needed for an affluent diet. Soybean is a basic commodity to the oil and feed sector that is imported for almost 70% from Latin American countries and the remainder from the USA. 98% of soybean meal is imported from Latin America (ISTA Mielke, 2007). Europe is heavily dependent on imported vegetable oils and fats, amounting to 32% of its consumption, if oil production in the EU from imported soybean is included, this figure increases to nearly 43% for 2005 (ISTA Mielke, 2007).

An ever-decreasing share of the household income in Europe-15 is used for food, declining from 13.2% in 1995 to some 11.6% in 2005, though the differences between European countries and between income groups are large. The poorest first quintile of people in Portugal spend almost 30% of their income to over 12% in the Netherlands, while the richest quintile uses less than 14% in Portugal and a mere 7% in Luxembourg (Mildon, 2007). While Europeans on average are not likely to be affected by rising food prices, some groups, such as poor people in Southern and Eastern Europe seem most vulnerable and may experience the greatest impact of food shortages.

2.3 Trends and scenarios

Some selected key data for 2005 and their projections for 2020, are presented in Table 2.1.

Table 2.1. Selected key data for 2005 and baseline projections for EU-27 in 2020.

	2005	2020 baseline projection
EU- member states	27	27, no expansion
Population [1]	489 million	496 million EU-15:slowly increasing EU-12:slightly negative
Production potential	332 mio ha potentially suitable 2-4 times current requirements[4]	as 2005
Food self-sufficiency	Self-sufficient, but depends on imports of vegetable oil and protein feed (soy) [2]	Self-sufficient, but depends on imports of vegetable oil and protein feed (soy)[3]
Diet	Affluent diet: 11540 KJ/day.[4]	Affluent diet[4], though: Shifts in composition Consumers concern for food safety and ethics Increase in consumption of convenient meal solutions [5]
Food prices and consumption	Highest vulnerability - Poorest people South & East Europe	Highest vulnerability - Poorest people South & East Europe

- *affluent diet: an affluent diet is considered to be the upper limit of food consumption and will mostly be found in rich societies (WRR, 1995).*

Sources:
[1] *EC, 2007c*
[2] *EC, 2007e*
[3] *FAPRI, 2002*
[4] *own calculations (Bindraban et al., in press), based on WRR, 1995 and EC 2007e*
[5] *Nowicki et al., 2006a.*

Changes in climate due to global warming are projected to have an impact on food production on a global and European level. Biofuel policies in various countries have caused a shift from food and feed production towards fuel production. The impact of these trends, in particular for the EU, is presented briefly. It is followed by a short general description of economic predictions and the elaboration of two scenarios, a baseline and a liberalization scenario and their impact on trade balance and land use in the EU.

Agricultural production potential and effects of climate change

Biophysical production potential

To be able to compare production (estimates) to consumption without having to calculate the production of all individual food items, diets have been converted into grain-equivalent. The production potential of Europe exceeds the demand of food by more than a factor 2 to 4 depending on the production system applied (WRR, 1995). These levels are attained however when all suitable lands and available water is allocated to food production. The study does not suggest taking additional natural lands and forest into cultivation, but does reflect the available 'ground for choices' .

Climate change

Climate is changing, influenced by increased atmospheric concentrations of the three main greenhouse gases (GHG), carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

Along with the combustion of fossil fuels, land use change is a primary source of anthropogenic GHG emissions. Without drastic changes in the current production and consumption patterns, the trend in global emissions of greenhouse gases will continue. By 2100 global surface temperature is projected to warm by 1.1 to 6.4 ^{0}C, and global sea level to rise by 18 to 59 cm in relation to the 1990 levels (IPCC, 2007).

IIASA/FAO model

The Global Agro-ecological Assessment for Agriculture in the 21st Century, of IIASA/ FAO (Fischer *et al.*, 2001) is a study, which evaluates the biophysical limitations and production potential of major food and fibre crops.

According to this study, intensification of agriculture will be the most likely means to meet food needs for a world population of some 9 billion people in 2050. The study asserts that enough food can be produced on currently cultivated land if sustainable management and adequate inputs are applied. However, this will require substantial improvements of socioeconomic conditions in many developing countries to enable access to inputs and technology.

According to the results of IIASA/FAO, the projected climate change will result in mixed and geographically varying impacts on crop production. Developed countries substantially gain production potential, while many developing countries lose. In some 40 poor developing countries with a combined current population of 2 billion, including 450 million undernourished people, production losses due to climate change may drastically increase the number of undernourished, severely hindering progress against poverty and food insecurity.

The overall impact of climate change on the productivity of crops will be modest as positive and negative impacts will be in balance, but regional differences are expected to be large. Globally, a widespread decline in productivity is expected in particular in Sub Saharan Africa and Southern Europe, while improvements will occur in current temperate climates like Northern Europe, Canada and Latin America and the former Soviet Union (Bruinsma, 2003; Braun, 2007).

Climate change may reinforce intensification of agriculture in Northern and Western Europe and extensification in the Mediterranean and South-eastern parts of Europe (Cooper and Arblaster, 2007; Olesen, 2006). Agricultural production systems can be expected to gradually adapt to these changing conditions to mitigate climate impact.

It should be noted that the consequences of climate change include large uncertainties. In particular, a change in the thermohaline currents in the oceans is a possibility, which cannot be excluded, and would lead to a strong cooling of Western Europe. This could completely call for a reorientation of future scenarios for the long term, while developments for the coming two to three decades are not likely to be affected much.

For 2020, no major changes in climatic conditions are expected as most studies reveal changes for 2050 and beyond only. However, climate calamities, such as the drought in 2003, are current realities of unknown uncertainties and should already be taken into consideration.

Biofuels

Concerns about global warming, rising world fuel prices and growing demand for energy, are the key factors driving the increasing interests in renewable energy sources and in biofuels in particular. Additionally, the use of biofuels will make the EU less dependent on fossil oil imports and offer an alternative for farmers.

The new energy policy for Europe (EC, 2007d) includes:

- A binding 20% target for the overall share of renewable energy in 2020.
- A binding 10% target for the share of biofuels in petrol and diesel in each member state in 2020, to be accompanied by the introduction of a sustainability scheme for biofuels.

Conditions for the target for 2020 are that the feedstock has to be produced in a sustainable way and second-generation technology will have to be available.

The European obligatory target of 10% for biofuels for the transport sector in 2020, amounting to 31-43 Mtoe, will put a potential claim on 11-25 million hectares, depending on the crops used, their productivity, and availability of 2nd generation technology (EEA, 2006; MNP, 2007). Economic analyses indicate that only approximately 7% blending can be realized when taking market and technology development into account (EC, 2007d).

If the Biofuels Directive is not implemented, which means that there is no blending obligation, the production of biofuel crops (and the imports of biofuels) contributes up to 3.6% of total fuel consumption in 2020 (Nowicki *et al.*, 2006a).

The overall target for 20% of its total energy, to be derived from renewable sources, including solar and wind energy, amounts to 325-340 Mtoe. Biomass should account for two thirds of this target in the form of electricity, heat and biofuels, representing respectively 90, 90-95 and the 31-43 Mtoe (Table 2.2). Half of this total amount is estimated to be derived from waste flows, though it remains unclear whether the large contribution from waste is adequately estimated and can be attained, as it compares to an equivalent of over 80 million hectares of rapeseed. The remainder will be collected from forest areas and agriculture. Reports differ enormously with regard to the acreages needed for producing these amounts of energy. The study of the EEA (2006) suggests 90 Mtoe in the form of electricity, heat and biofuels to be derived from 16 million hectares. Other studies estimate almost 9 million hectares to produce only 19 Mtoe in the form of transport fuel. The high energy levels of the EEA imply land productivity levels that would exceed potential production level in Europe, for example over 25 tons total dry matter per hectare for producing electricity or heat and over 6 tons vegetable oils per hectare, etc. It remains unclear what the acreage of ‘energy production forest’ would be to meet the targets. Converted to agricultural acreages, a total amount of 180 Mtoe would put a claim on a total acreage ranging from almost 50 to over 160 million hectares. These figures and values should be looked into in more detail in future analyses.

Table 2.2. The share of renewable energy consumption for 2002 and the targets for 2010 and 2020 for the EU-25.

In Mtoe resp. (% primary energy consumption)	2002	2010	2020
Renewable energy sources	97 (5.8)	210 (12)	325-340 (20)
• of which bioenergy	69 (4.1)	149 (8.3)	210-230 (13)*
• electricity	20	55	90
• heat	48	75	90-95
• transport	1	19	31-43

* *includes 25Mtoe import*
Source: MNP, 2007.

In April 2008, the EEA released a statement of its scientific advisory body, which clearly brings a less optimistic message across, also referring to its own report on the potentials estimates: ‘The EEA has estimated the amount of available arable land for bioenergy production without harming the environment in the EU. In the view of the EEA Scientific Committee, the land required to meet the 10% target exceeds this available land area even if a considerable contribution of second-generation fuels is assumed. The consequences of the intensification of biofuel production are thus increasing pressures on soil, water and biodiversity'. The scientific advisory body therefore recommends 'suspending the 10% goal; carrying out a new, comprehensive scientific study on the environmental risks and benefits of biofuels; and setting a new and more moderate long-term target, if sustainability cannot be guaranteed' (EEA, 2008).

Banse *et al.* (2008) conclude that the influence of the mandatory blending is much more significant than the influence of the crude oil price. The EU biofuel directive (in all obligatory blending scenarios, Annex 4.2) has a strong impact on agriculture at global and European level. The long-term trend of declining real world prices of agricultural products will be slowed down or even reversed for the biofuel crops.

While an increasing body of studies is released that explicitly considers biofuels, still no unambiguous final conclusions can be derived as the matter is too complex, not transparent, and viewed from different objectives and priorities. In general, however, more and more institutions question the ability of biofuels to make a significant contribution to energy security and to reduce GHG emissions (.e.g. OECD, 2008). Much will depend on the decision of the EU to install obligatory targets or not.

Baseline and liberalization scenarios

The study 'Scenar 2020, scenario study on agriculture and the rural world' , conducted by Nowicki *et al.* (2006a) is a comprehensive study for Europe and served as base for the selection of scenarios.

Two scenarios have been identified: a baseline and liberalization scenario. The baseline scenario is based on the continuation of the trends in exogenous drivers and assumes the development of agricultural and rural policy according to current policy objectives, including the outcome of successful Doha Round negotiations.

Liberalization is a policy framework, implying that the current context of moving towards more open markets at the international level will be strengthened. In this scenario, all forms of market and trade policies and income support will be abolished in the EU and the rest of the world. Table 2.3 describes these scenarios.

Table 2.3. Main 2020- scenarios: baseline and liberalization, assumptions on policy related drivers.

Scenarios	CAP			*Biofuels*	*Enlarge-ment*	*WTO and other international agreements*	*Environmental policies on agriculture*
	Market policies	*Direct payments*	*Rural development polices*				
Baseline	Balanced market i.e. keeping public stocks at 1to 2% of domestic consumption	Financial discipline and 25% modulation	Taking into account the new financial perspectives	Continuation of EU Biofuels Strategy	EU-27	EU offer	Continuation of existing environmental legislation
Liberalization	No internal support policies	Removing direct agricultural payments	Rural development provisions decrease	No per hectare subsidies for biofuels	Baseline	Removing import tariffs	Partial withdrawal of environmental legislation

Based on Nowicki et al., 2006a.

Some key features related to agricultural production and trade under a baseline and a liberalization scenario for the EU in 2020, are presented in Table 2.4. Under both scenarios the EU is projected to keep its position in food self-sufficiency, though under the liberalization scenario net export volume will be smaller. The two scenarios differ in their projected impact on land use in the EU as is described in the following section.

To investigate the effect of trade liberalization on trade flows of different commodities on the world market, models from FAO (based on GTAP), FAPRI, IFPRI and ENAPRI have been consulted. Although the outcomes of these models for Europe are quite similar, there are some minor differences. The FAPRI and ENAPRI models focus only on trade volumes related to Europe. Both models expect an increase in meat imports as well as an increase in wheat exports coming from Europe. Furthermore, regarding soybeans, other oilseeds and vegetable oils, Europe's situation will not change significantly and will remain a net importer. The models from FAO and IFPRI focus on trade volumes on a global level. These models disagree with each other on the cereal commodities. According to FAO, Europe will become a net importer of cereals whereas the IFPRI model claims that although exports will decline, Europe will remain a net exporter of cereals. Table 2.4 summarizes the projections for 2020, based on the existing studies that were reviewed.

Table 2.4. Selected 'key-data' for 2005 and projection for 2020 for baseline and liberalization scenarios.

	2005	2020 baseline	2020 liberalization
Food self-sufficiency	Self-sufficient, but depending on imports of vegetable oil and protein feed (soy)	Self-sufficient, but depending on imports of vegetable oil and protein feed (soy)	As baseline
Trade volumes[1]	Overall – net exporting	Overall - hardly exporting	Quite similar to baseline, but increase in import and decrease in export

[1] *Sources: Conforti and Salvatici (FAO), 2004; FAPRI, 2002; Rosegrant et al. (IFPRI) 2001; Yu and Jensen (ENAPRI), 2005.*

Economic predictions

Trade models are rather consistent in projecting declining acreages in the EU for food production with continuation of a positive exporting trade balance. Though estimated trade volumes do differ significantly between models they suggest a reducing difference between production and consumption. The most extreme global liberalization scenario whereby both border and farm support are eliminated projects for 2020 that agricultural productivity and farm size will increase, total production of some commodities will be reduced, as will the agricultural area. The agricultural pattern within the EU will show a concentration of production in North-western Europe due to its competitive ability with other global regions and with other European countries. East European countries will hardly be able to participate in this competing scenario because of low degree of technology use, fragmented and small farming systems, poor infrastructure and the like, and South European countries will lag behind because of climate change (Nowicki *et al.*, 2006a). Especially the removal of farm support will harm small-scale farms in East European countries. Note that the competitiveness of Eastern European countries might improve in the longer term. Under the regionalization scenarios with border control and farm support, a more dispersed production pattern is expected.
A recent analysis (Hermans and Verhagen, 2008) considering Eurasia, shows that cereal production under trade liberalization will concentrate in North-western Europe and in Eurasian countries, like Ukraine, while Eastern European countries will make a small contribution only. These changes become more eminent beyond 2020. It should be noted that the models analyse rather extreme changes to occur under full liberalization due to the inherent characteristics in modelling approach, so that production might be less concentrated than expected. Moreover,

productivity increase has a dominating impact on the outcomes, which has been related to high technological improvements under a liberalizing condition.

The trade models are not consistent however with regard to the impact of liberalization on different global regions, particularly Africa. Differences result from different assumptions such as the competitive power of developing nations. The IMPACT model for instance, expects Africa to have a better competitive position on the world market after trade liberalization (Rosegrant *et al.*, 2001). The FAO model (Conforti and Salvataci, 2004) expects that relatively poor economies may have less comparative advantages to resort to if protection is reduced in agriculture, as they have fewer activities other then their present agricultural sectors. Therefore, Africa would benefit from trade liberalization according to IMPACT, but this would not be the case according to the FAO model.

Land use

Selected characteristics of land use in the EU-27 in 2000, and projections to 2020 under baseline and liberalization scenario are presented in Table 2.5 and Figure 2.1. Definitions of land use types and detailed information on land availability can be found in Annex 3.

Table 2.5. Land use in EU-27 in 2000 and projections to 2020 under baseline and liberalization scenario.

(mio ha)	2000	2020 baseline	2020 liberalization
Built-up area	19	19.4	19.4
UAA	203	193.5 Decrease of UAA: 9.5 (4.7%)	177.1 Decrease of UAA: 26 (12.8%) As baseline and • marginal areas and areas with unfavorable facilities and market conditions will be taken out of production • larger productivity increase than under baseline • overall production decrease
Production regions	Current situation	Concentration in NW-Europe • competitive advantage • existing infrastructure • climate change	As baseline but comparative advantages result in an even increased concentration in NW Europe due to removal of border support and income subsidies.
Natural vegetation & forest	Natural veg: 51 Forest: 140	Natural vegetation: 51 Forest: 142	Natural vegetation: 57 Forest: 143
Bioenergy Blending of biofuels	Actual blending in 2005:1.0%	Continuation of biofuel policy: 10% blending obligation If 57% produced in EU, approx. 14 mio ha needed [1]	No per hectare subsidies 3.7% blending

Source: Nowicki et al., 2006b.

[1] *for calculations see Annex 3*

Table 2.5 shows an expected increase in built-up area under all scenarios. The agricultural area of the EU-27 in 2000 reached 203 million hectares on a total land mass of 432 hectares. A much larger acreage of 332 million hectares is potentially suitable for agriculture, which suggests room for expansion whenever needed, further raising the potential production volumes that could be realised, however at the expense of natural lands and forest (WRR, 1995). The current acreage is actually expected to decline by 2020, to 194 million hectares under the baseline scenario and to 177 million hectares under the liberalization scenario, which corresponds respectively with a decrease in Utilized Agricultural Area (UAA) of 4.7% and 12.8%.

This decline is driven by the following factors:

- Increasing productivity and farm size, while total production of some commodities will be reduced.
- Increasing crop productivity at rates varying from 0.5-1.5% per year, depending on crops and regions (Nowicki *et al.*, 2006a). This productivity increase is larger under liberalization then baseline scenario (Hermans and Verhagen, 2008). As the gap between current yield levels and potential levels is still substantial, same amounts of food can potentially be produced on much less land. Under the baseline scenarios, overall production is expected to decrease (Nowicki *et al.*, 2006a).
- Demographic changes in rural area may increase land abandonment dramatically.
- Under the liberalization scenario, no Less Favored Area (LFA) compensation is implemented, which will increase abandonment of these areas.

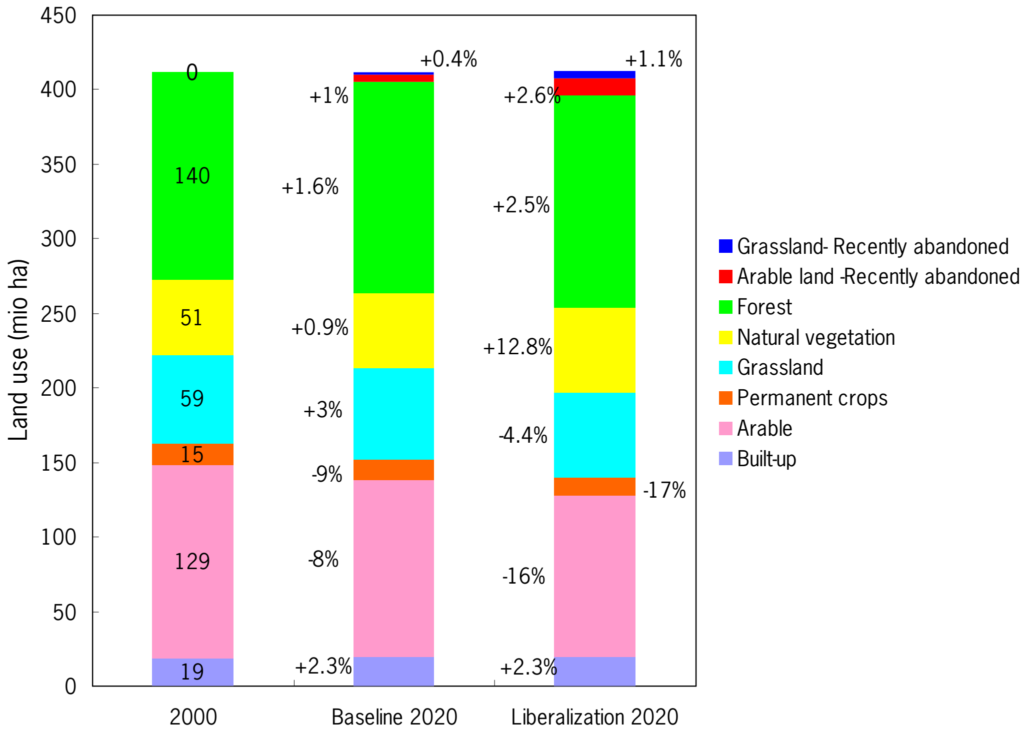


Figure 2.1. EU-27: land use in 2000 and projections for 2020 under baseline and liberalization scenarios Adapted from: Nowicki et al., 2006b.

Biodiversity

In a study by MNP (2007) biodiversity is expressed as 'the mean species abundance (MSA)' , based on Alkemade *et al.*, 2006. According to MNP, increasing consumption during the past 50 years has drastically changed ecosystems. Globally about 35% biodiversity has been lost, mainly in Europe, India and China (MNP, 2007). Loss of biodiversity occurs principally because of conversion of forests and grassland into agricultural land. Since further expansion of agricultural lands is expected in the tropics, pressure on biodiversity will increase especially in the tropics.

In Europe, nearly all productive land is cultivated, unless it has been used as built-up area. Nature can be found at marginal areas, which are less suitable for human use (Kleijn pers. communication).

It has been estimated that 50% of all species in Europe depend on agricultural habitats. Highest biodiversity coincides with low agricultural inputs, as is the case in semi-natural grasslands and unfertilised grassland. According to a study by EEA (2004), 15-25% of the European countryside qualifies as high nature value (HNV) farmland. The largest areas are found in Eastern and Southern Europe. The great majority of HNV farmland falls within the less favored areas (LFA).

The main threats to HNV farmland are two contrasting trends: intensification and abandonment. When natural and economic conditions allow, farming will intensify in order to increase yields and overall efficiency. With increase in land intensification, biodiversity decreases exponentially (Kleijn, pers. communication). In rural areas with extensive agriculture, the socio-economic conditions are generally unfavorable, and many of these areas are expected to be abandoned. The unmanaged areas are prone to natural succession of farmland to forest.

To protect biodiversity in agricultural areas it is possible to take measures in the following areas:

- Areas with high biodiversity as in extensive agricultural areas in the Alps.
- Areas bordering nature areas, as to create a more gradual change from nature areas to agricultural areas.
- To maintain a habitat of a specific animal as public support is high, for instance the black-tailed Godwit (in Dutch; grutto) in The Netherlands. (Kleijn, pers. comm.)

These measures are only possible with EU policies and subsidies, and therefore conservation of biodiversity is closely related with agricultural policy. Policy responses in the EU include site protection under the habitats and birds directives and environmental measures under the Common Agricultural Policy (CAP).

Under the Natura 2000 network, 18% of Europe's land is designated as protected areas, which will contribute to securing the health and diversity of its ecosystem. Under the Natura 2000 policy, all conversions from nature (forest and semi-natural vegetation) to other land uses are only allowed outside the Natura 2000 areas. It has to be noted that less than one third of HNV area is included in the Natura 2000 area (EEA, 2004).

In the baseline scenario, this policy will be in place, while as under the liberalization scenario there will be no strict application of the Natura 2000 policy (Nowicki *et al.*, 2006a).

Conservation of high nature value (HNV) farmland relies largely on measures under the so-called second pillar of the CAP, notably support to less favored areas and agro-environmental schemes. Current policy measures however seem to be insufficient to prevent further decline in HNV areas and thus to meet the challenge of the 2010 deadline for putting an end to loss of biodiversity (EEA, 2004).

According to the projected changes in land use in 2020, 6 million hectares are subjected to land abandonment under the baseline scenario, as compared to 2000. Under the liberalization scenario this figure is much higher, namely 16 million hectares, mainly because no LFA compensation is implemented. Under the baseline scenario, less land becomes available, but land, which comes available, might be destined for instance for cultivation of energy crops, leading to intensification of agriculture in LFA areas and thus threaten biodiversity.
The present high prices for agricultural products and the demand for energy crops stimulate farmers to intensify agriculture in HNV areas. Related to cultivation of feedstock EU policy can restrict the impact on biodiversity loss due to EU-policy. It will be very difficult to monitor the impact of increase for feedstock out of EU territory. The EU can however impose sustainability criteria for feedstock that is imported for the production of biofuels or for the biofuels themselves, as is currently under development in the Netherlands (Cramer, 2007) and other European countries.

Demand for bioenergy in the EU will most likely lead to less food produced in EU, and an increasing demand for biofuel imports. This means that elsewhere agricultural land has to expand. Most likely this will be in Brazil, Central Africa and Indonesia. These regions are also 'hotspots' for biodiversity (MNP, 2007). One of the main outcomes of the MNP study is that it will not be possible to both produce enough food and feedstock, without substantial decrease of biodiversity.

Climate change affects biodiversity as well as land use systems are adapting to changes in climate. Animals living in the agricultural habitats do not always succeed to change there lifecycles accordingly.

2.4 Conclusions

The studies on the long-term effects of various policy scenarios and climate developments show that agricultural trade patterns in the world will not show great changes compared to the present. Present exporters will remain in that position and so will import countries. Europe will remain mostly self-sufficient, with small exports of cereals, and large imports of soybeans. Climate changes will not affect this pattern dramatically, though developed countries will gain relative to developing countries. Africa will be worse off in most climatic scenarios, while the trade scenarios do not offer much hope for Africa either. Northern regions in particular may benefit from global warming. Within the EU, Southern regions will do a little worse. The impact of liberalization and climate change on agricultural production in the EU is shown in Figure 2.2. The EU agricultural sector as a whole will continue its path towards lower employment, and lower land use, particularly in the free trade scenarios. This leaves more room for natural vegetation or cultivation of energy crops.

The longer-term trends appear therefore not to pose additional exposure to risks connected to trade, as the EU's dependence on foreign supplies will not change much.

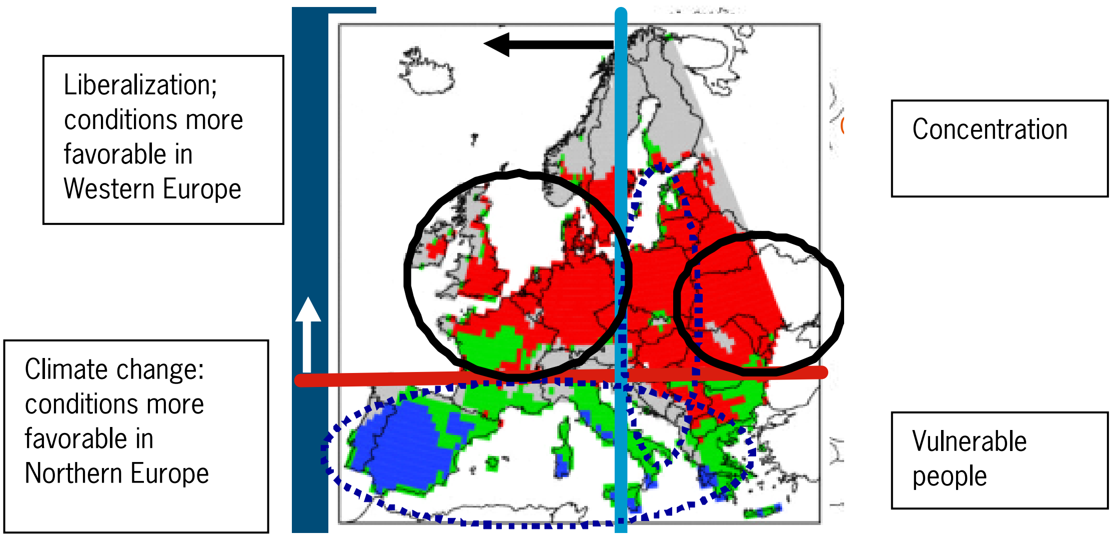


Figure 2.2. Impact of liberalization and climate change on agricultural production in the EU.

3. Potential food risks

The analyses, as reviewed in Chapter 2 project smooth and gradual developments into the future. The findings suggest that the European food system is rather robust in terms of food availability with surplus home production and strong purchasing power to acquire food on the international market.

A review of past calamities by Bindraban *et al.* (in press) showed that the impact of the Tsjernobyl nuclear catastrophe on overall food availability in Europe has hardly been noticed (Chernobyl Forum, 2003-2005). Similarly, extensive fire in Greece affected only 5% of the olive oil production that was compensated by a higher production in Spain (Zervas and Eleutheroxorinos, 2007). The impact of climate risks, outbreak of animal diseases and trade risks will be discussed more in depth in this chapter.

3.1 Climate risks

Impact of weather conditions on crop production.

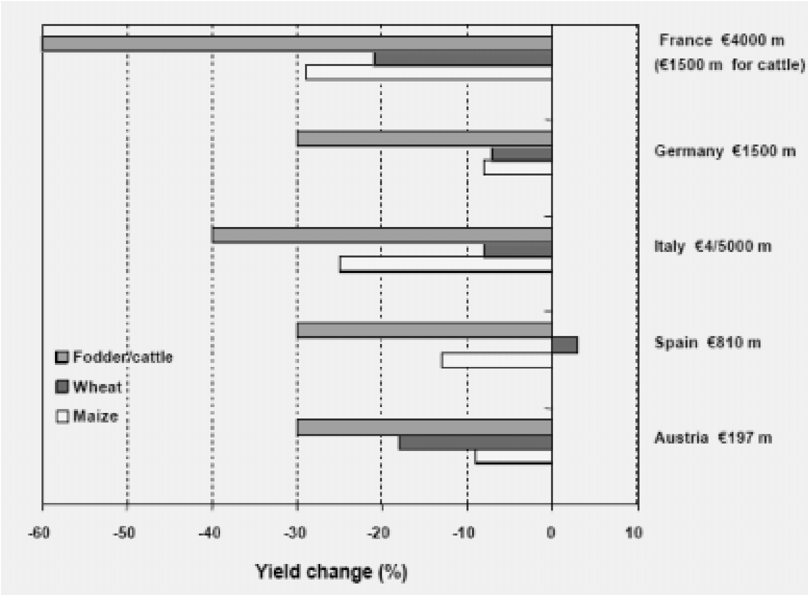
Adverse weather conditions (drought/flooding) have decreased global cereal production in the past year and led to increased prices. Agricultural production has always been prone to variability in weather conditions. The severity on plant and animal production depends much on the location and type of events. The ultimate impact on food availability to humans depends very much on the food system. Those depending directly on their own food production are immediately affected, which can lead to famine in drought prone areas for instance, while people with adequate purchasing power embedded in a complex food chain with global linkages in production, trade, processing and retail appear less vulnerable.

The increasing frequency of extreme climatic conditions due to climate change, such as hot and dry spells and of flooding, is likely to have a larger impact on acute food availability than the overall long-term changes and variability. While much research has been done on the long term overall effect, little is known about the impact of this increased frequency, especially when a number of consecutive years with extreme weather events would occur.

A clear and unexpected case has been the severe heat wave over large parts of Europe that started in June 2003 and continued through July until mid-August, raising summer temperatures by 3 to 5 ^{0}C from Northern Spain to the Czech Republic and from Germany to Italy. Extreme maximum temperatures from 35 to 40 ^{0}C were repeatedly recorded in July and to a larger extent in August. This heat wave has been found to be statistically an extremely unlikely event under current climate. It is however considered consistent with an increase in mean temperature and temperature variability. As such, the 2003 heat wave resembles simulations by regional climate models of summer temperatures in the latter part of the 21st century under the SRES Provincial Enterprise (A2) scenario (Olesen, 2006). (SRES: Special Report on Emission Scenarios)

The heat wave was associated with annual precipitation deficits up to 300 mm, and this drought was a major contributor to losses in agricultural production. This reduced agricultural production and increased production cost resulted in an estimated damage of 13 billion euro's (Olesen, 2006). The main sectors hit by the extreme weather conditions were green fodder supply, the arable sector, the livestock sector and the forestry sector.

Winter crops suffered from the effects of a harsh winter and late spring frost. The heat wave started as early as June and caused crops to develop in advance by 10 to 20 days, anticipating ripening and maturity stages. The higher temperatures increased crop's water consumption, which in combination with the dry spell resulted in acute depletion of the soil water reservoirs available to the crops. Both the quantity and the quality of the harvest decreased particularly in Central and southern European areas.



- Winter crops affected by harsh winter and late spring frost
- Heat wave from early June till mid August
- Crops enter 10 to 20 days earlier in ripening and maturity stage
- Increase in crop water consumption
- Soil water reservoirs depleted

Figure 3.1. Summer heat wave 2003: effects on EU agriculture.
Source: COPA-COGECA, 2003 and Olesen and Bindi (no year).

The impact of these extreme climatic conditions, with large variations per region, was the biggest in the green fodder supply, the arable sector and the livestock sector (Figure 3.1). EU-15 cereal production in 2003 reached 186 million tons: a reduction of 24 million tons (11.4%) compared to 210 million tons in 2002. The low harvest was topped up by more than 6 million tons imports (under the mandatory quotas) and more than 10 million tons from carry over stocks (COPA-COGECA, 2003). Also rapeseed yield, decreased and, was 6.6% lower than the average at about 2.9 t/ha instead of 3.1 and sunflower yield dropped by some 25%.

All pastures were affected by excessive lack of moisture. Largest reduction occurred in biomass produced in southern countries and the southern half of France. The fodder deficit varied from 30% (Germany, Austria and Spain) to 40% (Italy) and 60% in France. The lack of green forage resulted in early slaughtering of part of the herd of beef cattle.

The shortage of green forage was not limited to summer months but was felt all through winter and until fodder stock could be renewed. The dairy sector was confronted with a decrease in milk production. Milk quality was affected by a decreasing level of milk protein and increasing fat content. Moreover, the heat caused health problems, which continued into the winter.

The poultry sector in France and Spain was hit severely; both due to loss of animals and on top of that a loss in productivity. In Spain, the poultry flock was reduced between 15 and 20% and productivity decreased by 25-30%.

The hot and dry conditions led to forest fires, which destroyed 647 thousand ha of forest mainly in Portugal, Spain, France and Italy (COPA-COGECA, 2003). Many major rivers were at record low levels, resulting in disruption of irrigation.

3.2 Animal diseases

The importance of livestock and poultry trade to producers and consumers around the world increased in the last part of the 20th century (Figure 3.2). Producers in major exporting countries grew to rely on trade as significant outlet for their products, and consumers in the importing countries relied increasingly on trade for a significant contribution to their diets.

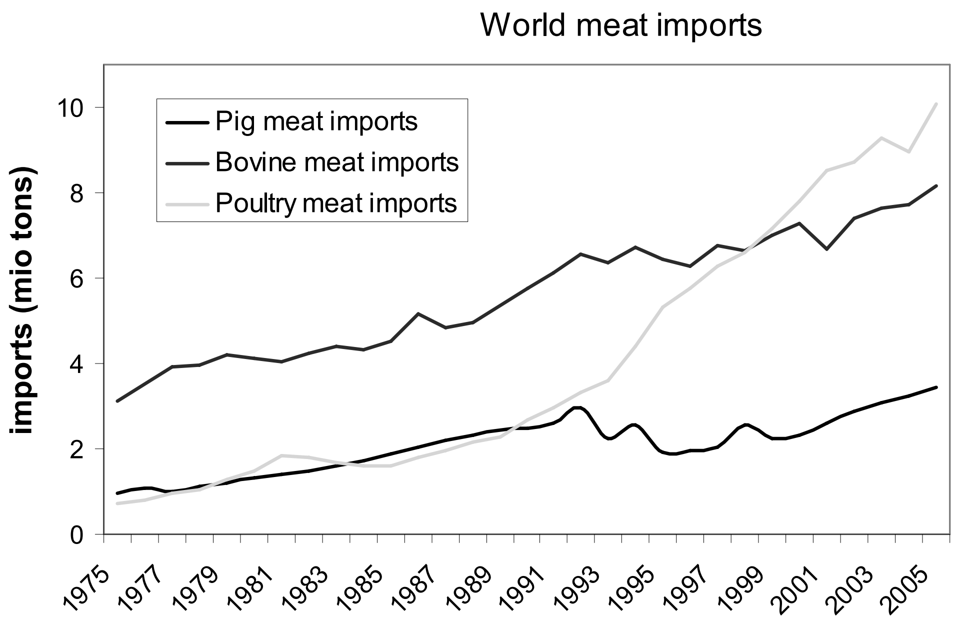


Figure 3.2. *World meat imports (mio tons) 1975-2005.*
Source: FAOSTAT, 2008.

In the last decade, however, a spate of animal disease outbreaks has repeatedly disrupted livestock and poultry meat trade and created uncertainty about future trade disruptions. Avian influenza (AI), bovine spongiform encephalopathy (BSE) and foot-and-mouth disease (FMD) have had large impacts on livestock and poultry trade. The spread of AI has the potential to cause the first major disruption for the world poultry sector, with significant negative impacts on the feed cereals and oilseeds/oil meal markets. Trade disruptions may result in losses for livestock industries, but also affect food industries and consumers in the importing countries, when the meat affected by the ban could not be replaced by either domestic producers or other exporting countries or when consumers reduced purchases because of fears for their health.

Transmission of disease occurs amongst others through trade and migration of people with their animals. Outbreaks of Classical Swine Fever (CSF) in Western Europe can be caused by transport from Eastern to Western Europe. Wild boars in Eastern Europe bear the virus and transmit it to pigs held in extensive farming systems. Through transport from eastern to Western Europe the disease is transmitted, for instance with the pig dung. The question is not if an outbreak will happen (about every 15 years), but when it will happen. Based on experiences with former outbreaks a control strategy is in place (Maassen, pers. comm.).

Vaccines against Classical Swine Fever and Foot and Mouth Disease are available, so that vaccination could be part of the control strategy. Stamping-out will still be applied for infected and contact herds, but widespread pre-emptive culling will not be enforced anymore, as emergency vaccination will be used to prevent spread of the disease. Due to vaccination, a sudden drop in meat production is prevented. Previously, meat of vaccinated animals could not be traded, but at present, some countries have talks on bi-lateral agreements with regard to allowing meat from vaccinated animals to be traded. Without trade agreements, meat exports will remain within borders, creating a surplus of meat on the domestic market, which causes the price of meat to drop drastically in a country. With bi-lateral agreements, the economic impact of the disease is restricted as trade is less distorted (Bergevoet, pers. comm.).

As the above shows, Classical Swine Fever is a known disease. The incubation time allows time to take action and the disease cannot be transferred to people. Outbreaks of diseases which can be passed to humans such as Avian Influenza, for which no vaccination is available, can have a spin off on the whole infrastructure and lead to disturbance of daily life.

The risk of animal diseases is expected to be smaller in large intensive production systems, but the impact will be much larger when hit by animal disease. At the same time, the disease dissemination can be better contained under more controlled conditions (Bergevoet, pers. comm.). Increasing insights as to how to deal with intensive pressure and introduced diseases, control measures and optimal institutional arrangements allow timely response to limit excessive effects

Meat or 'live livestock' exporting countries have to meet high quality standards and need to have a control system in place, as an export certificate is required. An exporting country like The Netherlands has a system in place to track a disease fast. France on the contrary produces meat mainly for local consumption, which does not have to meet the high standards of export quality (Maassen, pers. comm.).

Due to consumer preferences, it is possible that a country like The Netherlands is both importer and exporter of chicken. Whole chickens are imported, the fillet is used for local consumption and the remaining parts are exported (Hagenaars, pers.comm.).

In addition, feed imports are subject to strict quality control. Some diseases, like Salmonella and BSE find their origin in animal feed. The BSE disease led to a ban on usage of meat and bone meal by the EU commission in 2001. Feed ingredients are checked on bacterial and chemical contamination and on GMO; occurrence will lead to discarding the whole lot.

More information about different animal diseases is provided in the following sections.

Foot and mouth disease (FMD) is a very contagious viral infection that can cause death or permanent disability for cattle and swine and can spread very rapidly in a number of different ways. Beef and pork trade flows have long been defined by the identification of 'FMD-free' and 'FMD' zones. Countries not recognized as FMD-free can export only cooked meats, as cooking kills the virus. In the past, FMD outbreaks typically resulted in bans on imports from anywhere in affected countries. However, over the last two decades, importing countries have sometimes agreed to restrict their trade bans to those regions within the country where the outbreak occurred, allowing imports from other regions that are disease free, a practice known as regionalization.

Bovine spongiform encephalopathy (BSE), cases were first recognized in 1986 and incidences of the disease peaked in 1992. BSE in cattle, also called mad cow disease, has caused a widespread concern about the safety of beef consumption in some markets. It was thought to only affect cattle until 1996 when it was linked to a new human variant of Creutzfeldt-Jacob Disease. Unlike viral diseases such as AI and FMD cooking does not kill the causal agent. Exports from the UK and other affected EU Member States were banned within the EU and many beef importer also unilaterally imposed a ban on beef imports from affected EU member countries. The EU beef export average for 1995-1996 were 12.86% lower than the average level over the previous two years, due to this event.

World beef trade was directly affected by the demand response to concerns about the safety of consuming beef. For example, household consumption surveys in Japan during that same period reported a drop in consumption by 14%. The world price of beef dropped by 9.6% in response to the beef demand shock. With the decline in EU beef exports and recovery in beef demand, some other countries increased their export, including Argentina, Canada, New Zealand and the USA (FAPRI, 2000).

In 2003, BSE infected cows were discovered in North America, a region which accounts for nearly one quarter of the global beef exports. Since then, net export availabilities of beef have been reduced significantly by about 1 million tones. Asian beef markets started to reopen only 30 months after BSE was found. Reduced exportable supplies prompted a nearly 20% increase in Pacific market beef prices. Limitations on exportable supplies initially supported meat prices, with poultry prices rising over 30% over the 2004 and 2005 period. This trend reversed itself in late 2005 in response to the adverse consumption impacts of the spread of AI to major poultry markets in Europe, Africa and the Middle East (FAO, 2006).

Avian influenza (AI). Well-publicized outbreaks of the highly pathogenic H5N1strain of AI began in Asia in 1998. The strain was first identified in Hong Kong, where it killed several people. In response, the entire poultry population in Hong Kong, millions of birds, were slaughtered to eradicate the disease. However, in 2001, H5N1 reappeared in China, and in 2003 and 2004, it affected several poultry populations in Southeast Asia. In 2005, it spread across Asia and reached Europe; cases were reported in Europe and Africa in early 2006. Highly pathogenic strains of AI are very dangerous to birds, spreading quickly and often killing birds. The H5N1 strain has also spread from birds to people when people have been in close contact with diseased birds. Like FMD, AI viruses are killed by cooking. Unlike FMD, however, H5N1 can infect and kill humans from bird-to-human contact.

Trade disruptions from H5N1 AI affected two of the world's major exporters of chicken meat, Thailand and China. Onset of Avian influenza outbreaks in late 2003 and early 2004 in Asia coincided with the discovery of BSE in North America, a region that supplies nearly one-quarter of global meat exports (FAO, 2006). In late 2005 early 2006: new AI detections in the major consumption areas of nearly 40 poultry importing nations in Western Europe, the Near East and Africa lead to major consumption shocks and translated into shifting trade flows, dramatic price declines and supply responses in both infected and non-infected countries. Most of the market and trade impact of AI are closely linked to consumption and the imposition of trade restrictions.

In the European region, AI outbreaks were confirmed in 25 countries, with trade bans put in place for those 9 countries where AI was identified in domestic poultry operations. Approx. 69 countries put bans on poultry products from the various affected EU-25 Member States. Eleven of those did not adopt a regional approach and imposed bans on all EU products. In addition to bans related to H5N1, trade restrictions were also put in place on products from the Netherlands, which in August 2005 identified a low pathogenic bird flu strain on one farm. With short term consumption shocks in the EU-25 ranging between 70% in Italy, 40% in France and 0-10% in other member countries, EU aggregate chicken prices declined by 15% in late 2005 (FAO, 2006).

Blue tongue (BT). In 2006, a variant of a BT strain of serotype 8 seemed to have adapted to temperate host mosquitoes and a new BT epidemic has spread in Belgium, Germany, France and the Netherlands. The impact of the BT epidemic on EU meat trade is very limited because meat is not infected by BT. Also, EU exports of susceptible living animals has already considerably decreased as a result of animal welfare constraints. However, because of its relatively important mortality, BT has an important economic impact. Increased mortality and a decrease in milk productivity has caused below quota milk production in the most heavily affected Member States. The occurrence of the disease however showed how diseases spread. It was expected that the vector of the disease a midge, would not survive the winters in Northern Europe. It did survive however, due to relatively mild winters and had a chance to spread.

Meat sectors in a number of countries have suffered serious damage from disease outbreaks. On a global scale, however, trade disruption by and consumer reaction to fears of infectious animal diseases are not readily apparent. Global production, consumption and trade of pork and broiler meat have continued to grow and global beef production and consumption have stayed relatively constant since 1990.

According to USDA (2008), global levels of meat trade have not declined despite the last decade's high profile bans on meat trade flows. In most cases, diseases related import bans have been mitigated by increasing supplies from domestic or alternative foreign sources of meat. Furthermore, technological advances in identifying disease strains, in tracing the origin of meats and the increasing use of risk analysis offer hope that outbreaks may be avoided or contained more quickly.

Economic costs due to diseases per country vary and are dependent of three aspects:

- The relative importance of meat exports to producers in the affected country.
- The relative importance of meat imports from an affected country to consumers and available substitutes for banned trade.
- The question whether the animal disease poses a threat to humans, because consumers' fear can reduce consumption (Blayney *et al.*, 2006).

Consumers respond to the occurrence of disease by a decrease in meat consumption in general and in meat of the affected animal, in particular. Food scares have caused an increase in consumer awareness in terms of food safety and health. Consumption of some foodstuffs has consequently changed (Nowicki *et al.*, 2006a):

- Beef meat has seen its popularity decrease: in 1999, 26.2% of meat consumed was bovine, and this percentage decreased to 21.5% by 2003 (FAO, 2006).
- New labels have been created as consumers are expecting quality, information and traceability, such as the European quality labels PDO (Protected Designation of Origin) and PGI (Protected Geographical Indication).

3.3 Trade risks

Europe is highly dependent on imported vegetable oils or basic commodities for oil production. Palm oil dominates the oil imports with 57% in 2005 (ISTA Mielke, 2007) and a minor but increasing part of the imported oil being soy oil, 2.5% in 2005 and 11% in 2007. Oil produced from imported soybeans (about 2.6 million tons of oil) ought to be added to this foreign dependency, but is considered as own production. Most of these oils are an essential component in the food processing industry in combination with cereals. A combined reduction in the availability of both oils and grains could limit the supply of several food items simultaneously. Oil imports might be reduced because of problems in the supply chain, losses due to disease pressures in producing countries or ICT, while grain supply could be curtailed due to extreme weather events. The extent to which these calamities will affect food availability remains to be analyzed. Little research has been performed on these matters.

Soybean is an example of a commodity for which the EU is heavily dependent on imports. Of total world trade, the EU-27 imports account for 21% of total soybean trade, 45% of total soybean meal trade and 11% of total soybean oil trade. The trade volumes and demand by the EU27 have been projected to remain virtually unchanged up to 2020 (FAPRI, 2002). Detailed information on the EU soybean balance is provided in Annex 5. In this section, some general information on global soy production and trade is provided. The consequences of a collapse in soybean and soybean meal imports will be presented as a case study in Chapter 4.

Global soybean production and demand

Soybean is a versatile crop that is used for many purposes. The prime driver of soybean production has been the demand for feed for the production of chicken and pork, primarily in Europe and China. Soybeans are used for food consumption and its health aspects are increasingly recognized and being accepted. Some oil is used in the food industry sector while it could potentially be used for the production of bio-diesel, as is currently being done in Brazil. Soybean oil is a major source for the chemical industry for the production of an array of bio-based products.

Present global soybean production yields to 235 million tons, with the USA, Brazil and Argentina as main producing countries. Table 3.1 reveals the unprecedented increase in soy production, as present production already exceeds the estimated global production of 227 million tons in 2020 by the IFPRI (Rosegrant *et al.*, 2001). More recent estimations of ABIOVE (2005) project a global production of 307 million tons by 2020.

Table 3.1. Actual (1997) and projected (2020) soybean production (in million tons) in selected countries by IFPRI (Rosegrant et al., 2001), as compared to actual yield levels in 2006/7 (ISTA Mielke, 2007), and projections by ABIOVE (2005).

	Actual production in 1997	Projected production for 2020 (made in 2001)	Actual production in 2006/7	ABIOVE (2005) Projection for 2015	ABIOVE (2005) Projection for 2020
Argentina	14.1	26.8	46	51	58
Brazil	27.1	48.1	59	92	105
United States	70.9	94.9	87	83	87
EU15	1.4	1.9	1.3		
China	14.3	25.5	16	52	57
Southeast Asia	2.0	3.1	8*		
World	144	227	235	280	307

** India only*

At a world average rate of yield increase of 27 kg ha^{-1} y^{-1} (Bindraban and Zuurbier, 2007), these increases in production volume imply the expansion of the cultivation acreage for soybean, primarily in Latin American countries, and in Asia. The total acreage needed for the production of 105 million tons of soybeans in Brazil, for instance, indicates an expansion of the current acreage of 21 million hectares in 2006/7 to 30.1 in 2020 at a rate of 36 kg ha^{-1} y^{-1}.

In addition to these demands for food and feed, the current demand for bio-diesel will further accelerate the demand for soybean. In all the above mentioned projections, biodiesel was not accounted for. Bio-diesel is among the biofuels that are required by both Brazil and foreign countries because of policies for compulsory blending of transport fuel with biofuels. The current biofuel production in Brazil is made for over 80% from soybean oil. At an increasing rate of demand for edible oils of 3% per year (ISTA Mielke, 2007), the supply-demand ratio of vegetable oils may come under pressure.

3.4 Risk assessment

Overall, the European population is not likely to experience fierce shortages in food availability in the near future. Within Europe, however, under continued global liberalization an increasing proportion of food production may concentrate in North-western countries, while southern nations will experience an overall decline in production and might be exposed to increasing risks due to more frequent extreme climatic events. The importance of agricultural production in Eastern European countries is even expected to decline at the medium term because of their poor competitiveness. Liberalization will divert intra-European trade to extra-European trade because of the lowering of the EU common external tariffs. Intra European trade may have to be better coordinated under these conditions and stock volumes may have to be raised as a means to mitigate adverse effects of calamities.

The occurrence of single calamities so far have not caused problems of food insecurity in Europe. A sequential occurrence of calamities, such as dry and hot spells and floods together with disruptions in the soy chains under a globalizing scenario with concentrated production areas, might, however, reduce the availability of food within the EU to levels that have not been experienced over the past decades. The occurrence of such a sequence of calamities is not unthinkable. Bioenergy was discarded as a feasible option some 30 year ago, while it is heavily stimulated today. The coincidental occurrence of a number of developments over the past years has lead to this change.

Geopolitics and war might have a more pronounced effect under global liberalization than under regionalization. Whether the vulnerability of the EU will increase because of the concentration of agricultural production in North-western Europe (and Eurasia) remains to be assessed. Risks might be lower under regionalization scenarios, as virtually all EU-27 countries would continue to engage in production.

In a scenario with a large degree of state intervention (as was the case in the EU), the existence of intervention stocks (if positive…) helps secure provision of food and feed in cases of sudden shortfalls in supply. In a liberalized world, only private stocks matter. The recent prices have also made clear that in the short term prices may change beyond what fundamentals – including the diversion to biofuel - would indicate. While this is partly due to more intensive speculation on the futures markets, the past months have also made clear that states *can* rapidly respond and intervene in the international trade. Their objective is to safeguard local availability of food, but the side effect is to increase international price volatility. This suggests, that even in a scenario with liberalized trade, shocks are likely to lead to policy interventions that are geared toward domestic needs to the detriment of international stability. There is therefore a policy-induced self-reinforcing element in price shocks, which comes in addition to the 'speculative bubbles' that may occur in such situations.

The largest vulnerable groups that might be at risk under the combined occurrence of global changes could be the poorer people in South European countries. South European countries may be more prone to climate calamities, be less competitive in an international market and poor people currently spend up to 25-30% of their income to food. Vulnerability of some groups in some East European countries might be high also, and needs to be looked into in more detail. Measures taken by the EU to cope with and respond to the calamities might put a fierce claim on available food and feed items on the international market affecting the availability of these commodities for poorer people outside the community and jeopardizing their livelihoods.

The review of potential risk suggests the largest sensitivity of the European food system to be related to the imports of soybean, likely associated with other simultaneous calamities. In the following chapter, this case is analyzed to assess the quantitative implications and to reason possible externalities.

4. The soybean case

The review of potential risks, suggests that one of the largest sensitivities of the European food system is related to imports of soybean and soybean meal, likely associated with other simultaneous calamities. In this chapter, the importance of soy in the food and feed industry is reviewed. Consequently, the impact of a collapse of the import is presented, by estimating the impact on meat production and dealing with coping and response options.

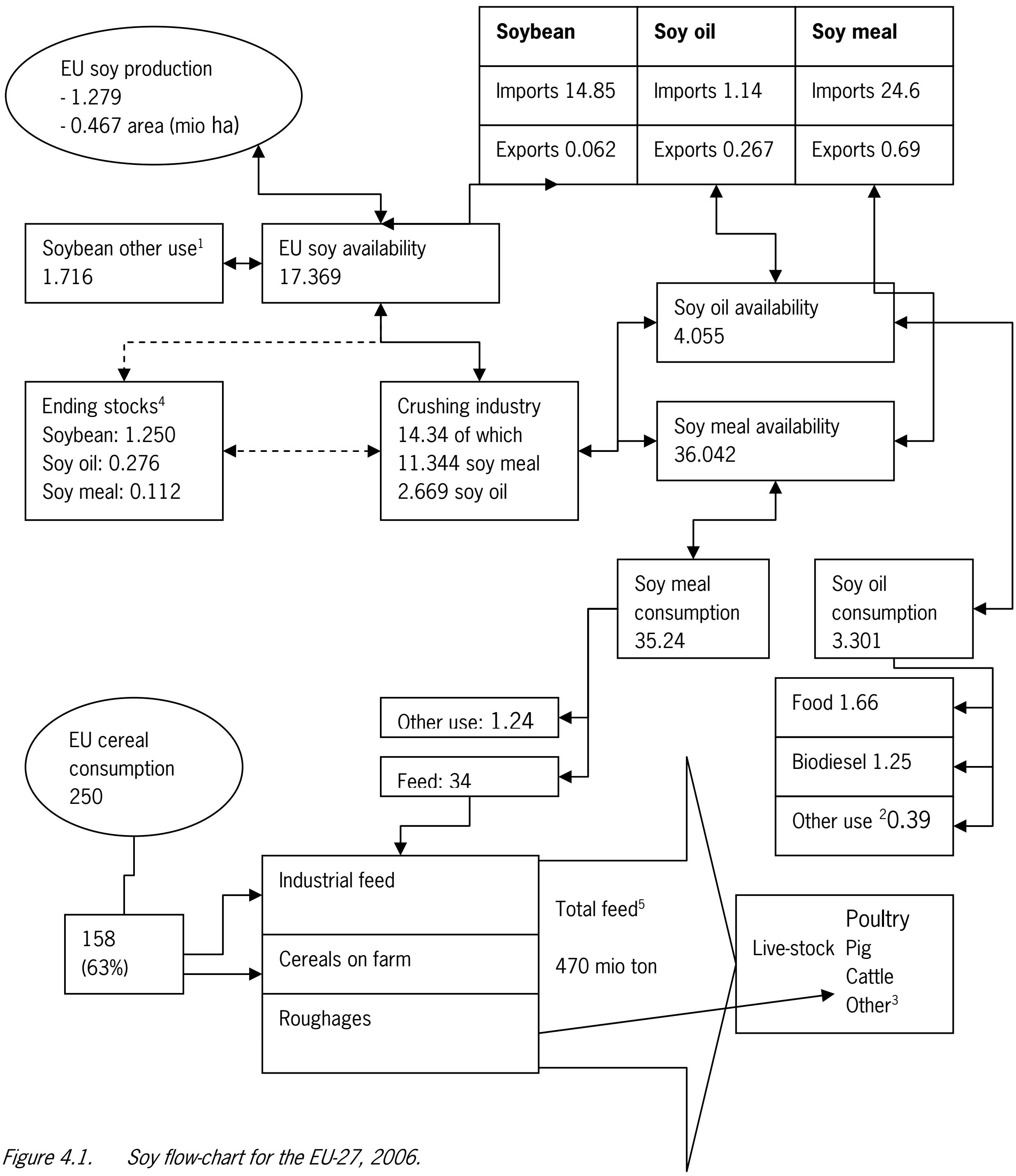


Figure 4.1. Soy flow-chart for the EU-27, 2006.

Notes to Figure 4.1.
All numbers are in million ton

Availability includes stocks
1 *Soybean other use goes to the food and feed industry*
2 *Other use from soybean oil goes to industry*
3 *Production of other meat includes sheep, goat etc*
4 *Change in stock are 0.037 for soybean, 0.0047 for soy oil and 0.029 for soy meal for the year 06/07*
5 *Data for feed apply to the EU-25*
Source: ISTA Mielke, 2007 and Fefac, 2007.

A collapse in imports of soybean and soybean meal could occur because of the zero-tolerance policy of the EU for GMO products. In that case, the EU would face a deficit of soybean meal, while outside the EU soybean meal would be available. A disruption of soybean imports could also be the result of a calamity, which would affect for instance the soybean production in Latin America. In that case, there would be a global shortage of soybean meal.

The soybean and soybean meal balance for the EU-27 in 2006 is presented in Figure 4.1. The beans (99% imported) are crushed and the oil is mainly used for food consumption. The soybean meal from the EU industry and the imported meal add up to 34.7 million tons and are used in the feed sector. Soy oil contributed to 10% of European vegetable oil consumption in 2005 (ISTA Mielke, 2007).

4.1 The EU livestock and feed sector

EU livestock production

The market for feeding stuffs depends on the market for livestock products. In 2006 the EU-25 livestock population produced 45 million tons of meat (thereof 8 million tons beef, 21 million tons pork and 11 million tons of poultry meat), 131 million tons of milk and 6 million tons of eggs. Average per capita consumption of meat in 2006 was 93.4 kg (Fefac, 2007). Table 4.1 presents the leading meat producing countries in the EU-25 in 2006, and shows that production is concentrated in Western Europe. Nearly 50% of total meat production in EU in 2006 was pork, with Germany as main producing country.

Table 4.1. Leading meat-producing countries in the EU-25 (2006).

	Beef & veal	Pig	Poultry	Other	Total meat
Total prod EU25 (mio tons)	7.9	21.4	10.8	4.9	45
	France 19%	Germany 22%	France 17%		Germany 17%
	Germany 15%	Spain15%	UK 15%		France 14%
	Italy 14%	France 10%	Spain 12%		Spain 13%
	UK 11%	Poland 10%	Germany 11%		Italy 9%
	Spain 8%	Denmark 8%	Italy 9%		UK 9%

Source: Fefac, 2007.

EU feed sector

The EU livestock sector consumes about 470 million tons of feed each year. Within this amount, about 229 million tons is (dried) forage consumed on farms; 55 million tons is home grown cereals; and 186 million tons is commercial feed which comprises manufactured compound feed (144 million tons) and feed mixed/manufactured by users (42 million tons) (Fefac, 2007). Figure 4.2 presents the livestock sourcing in feed for the EU 27 in 2006.

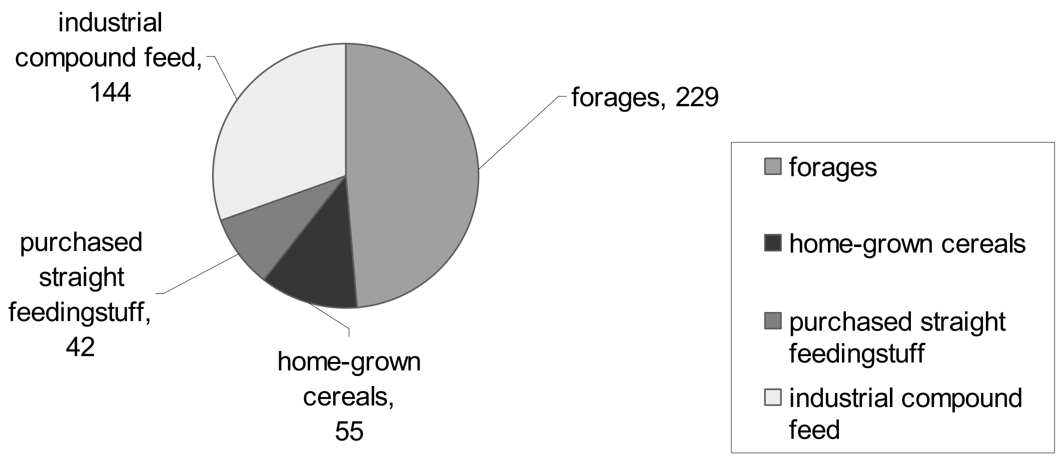


Figure 4.2. Livestock sourcing in feed in the EU-27, 470 million tons in 2006 (million tons).
Source: Fefac, 2007.

Within the EU, there is a large variation in feed rations. The typical monogastric feed (poultry and pork) is made up of a simple balance of protein for growth and fertility (usually 20-25% of feed volume), carbohydrates, and fats for weight gain and daily functioning (75-80%). The composition of feed is determined by the price of the available ingredient; nutritional value and specific requirements of the livestock to be fed. The availability of materials plays an important role in determining ingredient use. Regions with good port facilities and access to relatively low cost non-cereal feed ingredients have developed highly intensive livestock production systems, which rely relatively extensively on bought-in compound feeds. Other regions further away from major ports tend to feed more crops generated by farms themselves and incorporating bought-in supplements for mixing on-farm (Bergevoet, pers. comm.).

Feed represents 60 to 70% of COGS (Cost of goods sold) for pork and poultry (Rabobank, 2007). The development towards quality and efficiency in meat production is supported by a feed industry that strives to supply products that increase optimum feed conversion rates. Raw materials for animal feed is an opportunity market, dominated by the continuous search for substitutes, under a combination of constraints related to supply availability, nutritional value, price and formulation prices. The major trend in the EU15 is an increase in on-farm mixers or self-mixers and the evolution of corporate farmers overseeing large-scale highly efficient units. There is an increasing demand for tailor made pre-mixes and additives (Rabobank, 2007).

As Figure 4.2 shows, a major part of tradable feed ingredients is channeled through the compound feed industry, mainly situated in the major livestock producing areas as shown in Table 1, Annex 6. The main producers of compound feed in 2006 were France, Germany and Spain. The production of compound feed for pigs is the largest (34%) immediately followed by compound feed for poultry (Fefac, 2007).

About 60% of the EU cereal consumption is used in the feed sector, which underlines the importance of cereals as primary source of energy. For protein feed, the EU's livestock sector is highly dependent on imports of protein feed. The EU has only a self-sufficiency of about 33%. Total demand for protein feed in the EU reached about 67 million tons in 2006. With a consumption of 34 million tons, soybean meal dominates as a protein source in the EU feed sector, accounting for 68% of the total plant protein material used (in protein equivalent terms), with only 2% of the soybean meal derived from EU supplies. Soybean meal has the highest level of protein out of all oilseed and protein crops generally available and used by the EU animal feed sector (Fefac, 2007). The detailed balance sheet for protein rich feed materials is presented in Table 4.2.

In 1999, the feed sector of the EU-15 consumed 2.4 million tones of meat and bone meal (MBM), providing 1.3 million tons of protein. Because of the BSE crisis, the EU commission banned the use of meat and bone meal (MBM) in animal feed as from 1 January 2001. The ban on MBM resulted in an increase of soybean meal imports.

Table 4.2. EU-25 balance sheet for protein rich feed materials in 2005/2006.

(1,000 tons)	EU production[1]		EU consumption[2]		Protein self-sufficiency (%)
	products	proteins	products	protein	
Soybean meal	726	319	34,784	15,305	2
Sunflower meal	1,988	381	4,503	1,225	31
Rapeseed meal	8,291	2,079	9,254	2,868	72
Cotton seed meal	512	179	511	198	90
Copra palm meal	0	0	3,130	501	0
Pulses	3,350	754	3,850	810	93
Dried forage	4,600	736	4,400	784	94
Corn gluten feed	2,193	430	4,550	893	48
Miscellaneous	376	71	1,047	307	23
Sub-total	22,036	4,949	66,029	22,891	22
Fish meal	521	370	982	651	57
Total	22,557	5,319	67,011	23,542	23

[1] *EU-production from EU seeds*
[2] *Including consumption by the petfood industry and on farm uses*
Source: Fefac, 2007.

Ruminants are normally less demanding regarding the quality and digestibility of protein sources. Therefore they can be fed cotton meal, palmist, copra, corn gluten feed etc. Apart from these tradable feedstuffs, cattle and other ruminants get a large part of their protein needs through roughage.

Mono-gastric animals such as pig and poultry have more limits in the raw material use. Here soybean meal is the most important plant protein source because of its higher level of digestibility compared to alternatives such as rapeseed meal. Pig feeding has fewer constraints than the poultry sector, but amino acid composition is of major importance.

4.2 The impact of the collapse of soybean and soybean meal imports on pig production

After China, the EU is the largest production region for pork on a global scale (IFIP, 2006). Pig meat production dominates in volume the meat production in the EU, and about 36% of total soybean meal consumption is used as pig feed. According to Gatel and Porcheron (2003), the appraisal can be made that pig feed composition is intermediate between ruminant and poultry and thus can be approached through average animal feed composition. Therefore pig feed and pig production, are elaborated on. This section explores the impact on the pig feed sector in case of a collapse of soybean and soybean meal imports.

EU- pig feed sector

In this case study 'an average West European pig feed ratio' as presented by Van Cauwenberghe *et al.* (2003), is used as reference for estimating the impact of a soybean shortfall on EU meat production.

The required pig feed (complete feed requirement) in the EU-27 was calculated, based on parameter values given by Van Cauwenberghe and colleagues (2003). A pig carcass yields about 77% meat, and a pig feed conversion rate is 3.1. The complete feed requirement for pig meat production for the EU-27 in 2006 therefore approximates 88 million ton feed (Table 4.3), which comprises compound feed and on farm produced feed.

Table 4.3. EU pig meat production and required feed (mio tons).

(mio tons)	EU-15	EU-10	EU-2	Total EU-27
Pig meat	18.1	3.3	0.5	21.9
Required pig feed	72.7	13.3	2.0	88.0

Source: Van Cauwenberghe et al., 2003.

An average West European pig feed ratio

The feed formula as presented by Van Cauwenberghe and colleagues (2003) has been used for further analysis (Table 4.4). The proposed formula is modeled to average the different European practices, though feed composition is variable and depends on various aspects such as: local commodity prices and volumes, quality of feed, environmental constraints or nutritional concept implemented.

The formula roughly integrates:
- The various European practices in terms of nutrients levels and in terms of ingredient selection.
- The various types of pig feed, from piglet to sow feed, with the emphasis on growing and finishing pig diets as they represent the biggest pig feed tonnage.

The protein characteristics are the following:
- Digestible lysine level is set at 0.85% of the feed, corresponding to a total lysine level of around 1% of the feed.
- The amino acid balance follows the 'INRA ideal protein pattern' (thr:lys 65%, M+C:Lys 60%, trp:lys 18% digestible basis.
- The protein level is set at 17%.

Table 4.4. An average modeled Western European pig feed formula.

	Protein content feedstuffs (%)	Average pig feed formula		
		Feed formula (%)	Feed usage (mio tons)	Protein content (mio tons)
Soybean meal	45	14.0	12.3	5.5
Rapeseed meal	34	5.0	4.4	1.5
Sunflower meal	28	3.0	2.6	0.7
Soybean whole seed	35	0.6	0.5	0.2
Rapeseed whole seed	19	0.6	0.5	0.1
Pea	21	3.0	2.6	0.6
Wheat	11	25.3	22.3	2.4
Maize	8	10.0	8.8	0.7
Barley	10	25.0	22.0	2.2
Triticale	10	4.0	3.5	0.4
Oats	10	0.6	0.5	0.1
wheat bran	15	5.0	4.4	0.7
Skimmilk	34	0.1	0.1	0.0
Whey	10	0.1	0.1	0.0
Fishmeal	65	0.1	0.1	0.1
Premix	0	4.0	3.5	0
Total			88.4	15.2

Source: Van Cauwenberghe et al., 2003.

In this formula 12.3 million tons soybean meal and 0.5 million tons of whole soybeans are used, providing 5.7 million tons of protein. This is nearly 38% of the total protein content of the pig feed.

4.3 Impact on pig production in case of a collapse in soybean and soybean meal imports

A hypothetical collapse of soybean and soybean meal imports will affect pig meat production. If it is assumed that no substitution of soybean (meal) takes place and that protein is the limiting factor in pig meat production, then the pig meat production will decrease by 38%. Though this proportional decline is not likely to occur based on animal physiology, it does reflect the worst-case scenario in terms of decrease in production. Based on the pig meat production for the EU in 2006, as presented in Table 4.1, this would imply a decrease of 8.3 million tons pig meat.

Economic impact of unapproved GMOs on EU feed imports and livestock production

The study 'Economic impact of unapproved GMOs on EU feed imports and livestock production' (EC, 2007b) looked at the impact of a possible disruption in soybean meal and soybean imports because of the GMO-policy of the EU. Three scenarios with an import deficit of resp. 2.6, 16.9 and 32.3 million tons of soybean meal were examined. A volume of 6.6 million tons of soybean meal was assumed to be replaced by rapeseed meal and sunflower meal. The quantities of soybean are often expressed in soybean meal equivalents, which is the corresponding amount of soybean meal (80%) after crushing.

The minimal impact scenario concerned an interruption from US soybean (meal) imports. The quantity concerned of about 2.6 million tons, could be replaced by imports from Brazil and Argentina.

The medium impact scenario concerned an interruption from the US and Argentina representing, 16.9 million tons SBM-equivalents. With an increasing import from Brazil and substitution by rapeseed and sunflower seed meal, this would still result in a deficit of 3.3 million tons SBM eq. An increase in price for soy up to 60% would be the result.

The worst-case scenario is an interruption of US, Argentinean and Brazilian soybean (meal) imports without compensation from other exporting countries. This would leave an import deficit of 32.3 million tons in soybean meal equivalent, resulting in a net shortage of soybean meal of 25.7 million tons. The authors note that the impact of the worst-case scenario goes well beyond the technical limits of the model used for the analysis in the provision of precise and reliable estimation. The outcome can be used as an indication, only. The prices of soybean (meal) in the EU will increase due to reduced availability, leading to lower consumption levels of approximately 50% in this worst-case scenario. The study gives the impact of the soybean meal shortage on the meat production industry as deviations from the baseline in percentage as presented in Table 4.5.

Table 4.5. Impact on EU pig meat, poultry and beef meat sector (deviation from baseline, %), in case of 32.3 million tons import deficit of soybean (meal).

Deviation from baseline, %	Pork		Poultry		Beef	
	2009	2010	2009	2010	2009	2010
Net production	-29.3	-34.7	-29.2	-43.9	-1.1	-2.1
Import	637.0	5461.0	92.5	158.3	397.4	295.8
Export	-86.0	-85.3	-100.0	-100.0	-100.0	-100.0
Consumption	-23.9	-17.4	-15.7	-26.3	30.2	23.1

Source: EC, 2007b.

The study does not provide data on production, consumption and trade of meat. For calculation of the impact of the import disruption, projections for meat production in the EU in 2009 and 2010 as provided by EC (2007e) have been used. The results that are presented in Table 4.6 and Figure 4.3 show a sharp drop in pig meat and poultry production and consumption. Imports increase and exports decrease, resulting in a change in the position of the EU from net exporter to net importer. Beef production would be less affected due to its feed structure, but the impact on import and export would be considerable. Demand for beef would expand well above the baseline level to compensate for the shortfall in pig and poultry, triggering a sharp increase in the beef meat price.

Table 4.6. Impact of soybean import interruption on EU pig meat, poultry and beef meat sector (1,000 tons).

(1,000 tons)	2009 Base line	2009 Soy import collapse	2010 Base line	2010 Soy import collapse
		Pig meat		
Production [1]	22,049	15,589	22,232	14,517
Import	38	280	38	2,113
Export	1,217	170	1,187	176
Consumption	20,870	15,882	21,218	17,403
		Poultry meat		
Production [1]	11,295	7,997	11,451	6,424
Import	700	1,348	697	1,798
Export	777	0	756	0
Consumption	11,217	9,456	11,393	8,397
		Beef		
Production [1]	7,801	7,715	7,722	7,560
Import	633	3,149	664	2,628
Export	93	0	77	0
Consumption	8,341	10,860	8,310	10,230
Total consumption	40,428	36,198	40,921	36,030

[1] *Source: EC, 2007e.*

Due to the soy import disruption, the production of pork, poultry and beef in the EU in 2009 is projected to decrease from 41 million tons to 31 million tons, while consumption decreases from 40 million to 36 million tons. This means a per capita decrease in meat consumption of about 8 kg, assuming a population of 493 million people in 2009. The reduction in meat consumption is not likely to jeopardize health conditions of the average European, as current average annual consumption of 93 kg is well above the nutritional requirement (The Netherlands Nutrition Centre, 2008).

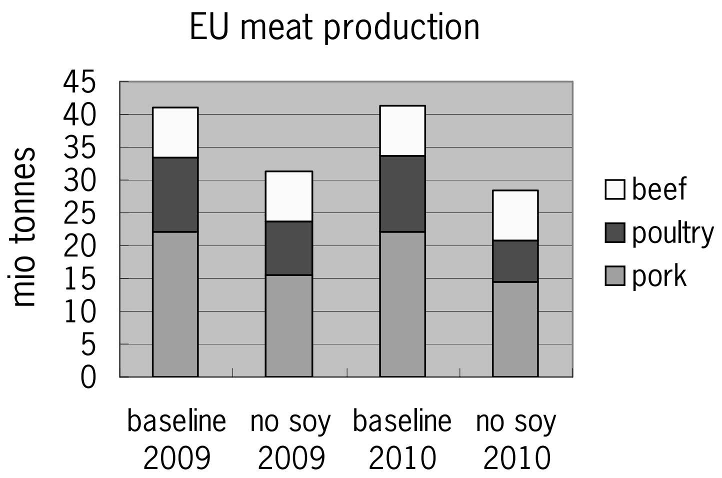


Figure 4.3. Decrease of EU meat production (beef, poultry, and pork) due to disruption of soy imports in 2009, as compared to baseline projections for 2009 and 2010.

The outcomes of this study are consistent with our own calculations on EU pig feed requirements. In the EC study, pig production drops with 29% due to disruption of soybean meal imports, and substitution with available rapeseed and sunflower meals. Pig production drops with 38% without substitution by other oil meals in our own calculations, which reflects well the analyses by the EU.

Time dimension of disruption in supply of feed (case of soya)

Suppose the imports of soybeans are suddenly banned, from one day to the next. What will happen in the sector? How long will it last until alternatives are available?

Initially, there are still stocks of soybean (meal) that can be used. Normal stock levels of soybean meal in the EU amount to less than 1% of global meal production. Hence, this will last for a few days only. Other soybean stocks are normally held in the producing countries, and therefore assumed not to be available. There are also stocks of feed present at the fattening farms themselves. These will typically last for some weeks. Hence, alternative feed ingredients must be sought within a short period. The feed distributors will try to import alternative sources of proteins to replace the soybean meal in their feed mixes. As indicated below, so much soybean meal is used in the EU that this cannot possibly be replaced. Nevertheless, for a few weeks, some stocks of ingredients can perhaps be found.

Note that, though normal stocks of soybeans within the EU are low, those in the producing countries are typically higher (global position on 31 August is around a quarter of total crop), as is presented in Table 4.7. If part of this stock would be in the EU, it would be available to smooth any transition to other feed sources. EU use per month corresponds with around 3.4 million tons soybean, or approximately 5% of the stock, so that if only 15% of the stock would be within the EU, this could cover about 3 months' consumption, enough time, perhaps, to secure other sources of proteins.

Table 4.7. Soybean, world supply, demand and stocks (mio tons) until 2007/2008.

	07/08 F	06/07F	05/06	04/05	03/04
Opening stocks	68.06	60.08	52.82	40.75	46.94
Production	228.50	234.98	222.01	216.40	185.52
Total supply	296.56	295.06	274.83	257.15	232.46
Disappearance	237.36	227.00	214.57	204.34	191.71
Ending stocks	59.20	68.06	60.08	52.82	40.75
EU-27		1.25	1.24	1.14	0.85
USA-aug 31		15.78	12.23	6.96	3.06
Argentina		22.80	19.14	18.30	15.52
Brazil		22.10	20.54	20.60	19.08
Stocks/usage (%)	24.9	30.0	28.0	25.8	21.3

Source: ISTA Mielke, 2007.

If no such stocks are available, as is the case now, then after the first month, it is likely that the shortage of proteins will be acute, but some information will have come available about the extent to which supply of feed is still possible. This new level must be quite below the original levels for several months to come. In anticipation of this, pig and poultry farms will reduce the scale of their new fattening cycles, while existing animal stocks are likely to be put up for slaughter at an earlier date, at least partly. This will lead to a (surprising) increase in meat supply soon after the onset of the disruption in feed. This meat may not reach the consumers yet, as (cold) storage should offer a more profitable perspective. The result is that consumer meat prices are unlikely to fall, even though more animals are slaughtered.

As the production cycle for poultry is short (say 6 weeks for meat production), poultry supply to the consumer market will falter first. Imported poultry can substitute, however, and it seems possible that substantial imports could be realised in a few months time. For pigs, the production cycle is closer to 4 months, leaving more scope to importers for finding other sources of meat. For cattle farmers, the cycle is even longer, and the importance of soybean is lower.

The repercussions for the poultry and pig farms seem strongest. Consumers would be affected, but less so if meat can be imported. Nevertheless, meat prices are likely to rise substantially so as to trigger such imports.

Alternative sources of feed are, as we shall see below, difficult to find in sufficient quantities to replace total soybean use in the EU. Some imported feedstuff can be expected to arrive rather soon, but most will require growing first and this may take some five months. In the EU itself, depending on the season in which the disruption strikes, it may take up to a year before the new protein crop can be harvested.

At that point, the feed will again be available as before (in the form of substitutes from abroad and locally grown protein sources), but obviously at a higher price. Hence, meat should be more expensive to leave sufficient margin for the growers and other intermediaries. This implies less consumption, so that less meat must be produced. Eventually, therefore, some farmers will have to diversify into other activities. To survive the year they all must rely on their savings, on loans and other temporary means of survival. If as the GMO study claims some 30% of production is lost, perhaps some 5% of farmers may run into trouble, assuming that notably the largest farms are affected by this kind of shock.

To locate areas that are possibly affected by this shock, the structure of pork production in Europe was examined. The main pork producing countries in Europe are Germany, Spain, Poland, France, Denmark and the Netherlands. The pork livestock in the six countries combined accounts for approximately 70% of total European pork livestock in 2003. In these countries, except for Poland, production of pork is mostly large scale, since large farms of 1000 or more pigs are the dominant farm structure. Poland is an exception since farms with a size of 10 to 200 pigs are most common in this country (IFIP, 2006).

In the scenario study quoted above, authors apparently are not optimistic about the possibilities to replace meat and feed in a year’s time. Even in two years, no substantial imports of meat are realised in their calculations. It is unclear why this would be so.

Difference between global calamity in soybean production and nullified soy imports to EU

A soy calamity in Europe due to a collapse of imports will lead to high feed prices only in Europe but low soy (feed) prices in the rest of the world. The price of meat will rise due to more demand from Europe on the meat market. Global meat production would increase due to these favorable price changes for global meat producers, but EU meat producers will produce less.

A global soy crisis will increase the price of soy and of feed globally. Fierce competition for feed between countries will drive up the price for feed and therefore meat. Especially economically weak countries will probably not be able to buy feed for their livestock. Livestock owners who cannot feed their animals will slaughter their livestock in the very short term, which will cause a temporary boost in meat storage and availability. In the medium term, global meat production will fall and prices of meat will rise substantially due to higher production costs and high demand. Eventually, demand and supply will adjust to the new price levels.

4.4 Substitution of soybean and soybean meal in feed

Here, alternative feed scenarios are presented to substitute the shortfall of soybean meal, based on replacement of the required amount of protein feed ingredients. Consequently, global trade figures are presented for these feed ingredients in order to see if these ingredients can possibly be purchased at the world market as a coping strategy. Calculations on how much land would be required to grow these feed crops in the EU are made as a response strategy.

There is a wide variety of feed ingredients, which provide protein as Table 3, Annex 6 shows. Technically, there is no problem in switching from soybean meal to alternative sources of protein material (Gerrits, personal comm.). In case of soybean meal, it is the magnitude of the volumes, which are difficult to replace.

The choice of substitutes will depend on many factors such as feed ingredient availability, its price and the animal, which has to be fed. Some feed ingredients provide both energy and protein such as cereals. In the pig feed formula as presented in Table 4.4, the contribution to protein content by cereals is as high as that of soybean (meal).

Potato is mainly used as a source of energy. At current prices, it is too expensive to be produced as feed. However, the by products of the potato agro industry, are used as feed. Protein from potato is a co-product from the potato starch production. It is high quality protein used for human consumption or in feed specifically for starter pigs or calves (Gerrits, pers. comm.).

Fish meal is produced either as a by-product of fish processing for human consumption or directly from fish species deemed unsuitable for human consumption (such as sand eels, blue whiting and sprats). Around 6.5 million tons of fishmeal and 1.2 million tons of fish oil are produced annually worldwide. For pig and poultry feed, fishmeal is often a preferred source of protein because of the balance of essential amino acids. However, the demand for fishmeal from the aqua sector is increasing, and made this sector look for alternatives, including soy. Overexploitation of marine resources is becoming more and more the concern of the European consumer. For these reasons, fishmeal has not been taken into consideration as an acceptable soybean meal substitute.

Van Cauwenberghe *et al.* (2003) refer in their article to the use of supplemental amino acids. From the amino acid nutrition standpoint, wheat supplemented with amino acids (lysine, threonine, methionine) is equivalent to soybean meal. Although presently supplemental acids are used in animal feed, the substitutes used here are restricted to oilseeds and pulses.

As possible substitutes for soybean meal, rapeseed meal, sunflower seed meal and pulses are most frequently mentioned in literature and by consulted experts. Rapeseed meal and sunflower meal are the major domestic produced oil meal sources for protein feed in the EU. Pulses are locally of importance and have a potential for cultivation, throughout the EU.

Soybean meal is replaced in three alternative feed scenarios:
Scenario 1: substitution by rapeseed meal and sunflower seed meal
Scenario 2: substitution by pulses
Scenario 3: substitution by rapeseed meal, sunflower seed meal and pulses

The pig feed formula in Table 4.4 has been taken as a starting point. In case of a collapse of soybean meal imports a total of 5.7 million tons of protein will have to be provided by other feed ingredients.

For the substitution scenarios:
- Total feed usage is kept constant at about 88 million tons.
- Protein content is kept at about 17%.
- As soybean meal has a higher protein content then the substitutes, total feed usage increases when substituting. As this might increase the feed intake too much, total feed usage has been kept constant by decreasing the amount of cereals.

- All scenarios: 1 million ton of additional soybean meal produced in the EU has been included, because the increased inclusion of sunflower meal must be fortified with soybean meal.
- Oil meals inclusion rate have been maximized as specified in Table 3, Annex 6 at 15% for rapeseed meal and 20% for sunflower meal.
- Pea is used as an example for replacement by pulses, as it is the major feed pulse in the EU. Other pulses such as faba bean can be used as well.

In the substitution rations, amino acid requirement is not taken into consideration, and could be considered in future calculations, in order to maintain a good nutritional balance. It is therefore assumed that the pig feed conversion rate for the substitution rations are the same as in the reference ration. The compositions of the alternative feed scenarios are presented in Annex 6, Table 5, Table 6 and 7. An overview of the inclusion rates and the changes in feed usage for the feed ingredients, which were changed compared to the average ration, is presented in Table 4.8.

For exploration, scenario 1 and 2 represent extreme values for single type of substitutes, while scenario 3 may resemble a more realistic scenario as it represents a combination of substitutes. This scenario 3 will be used for further calculations.

Table 4.8. Comparison of three feed scenarios compared to average European pig feed ration.

	Scenario 1		Scenario 2		Scenario 3	
	Inclusion rate (%)	Change in feed usage (mio tons)	Inclusion rate (%)	Change in feed usage (mio tons)	Inclusion rate (%)	Change in feed usage (mio tons)
Soya bean meal (Cultivated in EU[1])	1.1	1.0	1.1	1.0	1.1	1.0
Rape seed meal	14.7	8.6	5.0	0	14.7	8.6
Sunflower meal	13.6	9.4	2.9	0	6.8	3.4
Cereals	57.0	-6.6	39.0	-21.9	52	-10.3
Peas	2.9	0	40.0	32.4	14.7	10.4
Total (to substitute 12.7 mio tons SBM[2] equivalent)		12.4		11.5		13.1

[1] Additional to current soybean production in the EU
[2] SBM – Soy Bean Meal

Until now the scenarios have been restricted to the protein requirement of the pig feed sector. If all EU feed is taken into consideration 34 million tons soybean meal equivalent will have to be replaced instead of 12.7 million tons. The corresponding figures are presented in Table 4.9.

Table 4.9. Additional protein feed requirement in case of collapse of soybean and soybean meal imports for pig feed and all feed.

	Pig feed Substitution of 12.7 mio tons SBM[2] equivalent	All feed Substitution of 34 mio tons SBM[2] equivalent
	Change in feed usage (mio tons)	Change in feed usage (mio tons)
Soyabean meal (Cultivated in EU[1])	1	2.6
Rape seed meal	8.6	22.4
Sunflower meal	3.4	8.8
Cereals	-10.3	-26.8
Peas	10.4	27
Total	13.1	34

[1] Additional to current soybean production in the EU
[2] SBM – Soy Bean Meal

4.5 Coping with soybean meal shortfall

If imported soybean and soybean meal are not available, the EU feed sector will make an effort to purchase substitutes on the local and global market. It is necessary therefore to look into the availability of these substitutes. Table 4.10 presents global production figures of major oilseeds and oil seed meals, and their global trade volume. It has to be taken into consideration that the oilseeds are traded as whole seeds, or after crushing as meals. The quantities of seeds, which have been crushed, have to be deducted from the total production figures.

Table 4.10. Oil seeds and meals, global production and trade, 2005.

	Global production (mio tons)	EU-27 Production (mio tons) Percentage between brackets	Global trade (mio tons)	Main origins – Country: volume (percentage)	Main destinations – Country: volume (percentage)
Soybean	216.4	1.1 (0.5)	Import: 64.4 Export: 64.5	USA: 29.6 (46) Brazil 20.1 (31) Argentina: 9.5 (15)	China: 25.8 (40) EU-27: 15.4 (24)
Rapeseed	46.4	15.4 (33)	Import: 5.3 Export 5.5	Canada: 3.7 (67) Australia: 0.9 (16)	Japan: 2.2 (42) Mexico 1.2 (22) Pakistan 0.7 (13)
Sunflower seed	26.4	6.3 (24)	Import 1.3 Export 1.2	EU-27: 0.5 (42) CIS : 0.1(8)	EU-27: 0.5 (38) Turkey : 0.5 (38)
Soybean meal	143.3	11.3 (8)	Import: 47.2 Export: 47.3	Argentina: 20.6 (44) Brazil : 14.2 (30) USA 6.7 (14)	EU-27: 23.2 (49)
Rapeseed meal	24.0	7.7 (32)	Import: 2.4 Export: 2.3	Canada : 1.4 (61) India: 0.5 (22)	USA: 1.3 (54) Korea: 0.3 (13)
Sunflower seed meal	10.7	2.8 (26)	Import: 2.9 Export: 2.9	CIS : 1.5 (52) Argentina: 1.1 (38)	EU-27: 1.7 (59) CIS: 0.3 (10) Turkey: 0.3 (10)
Corn gluten feed meal	14.7	2.1 (14)	Import: 4.8 Export: 5.0	USA;4.7 (94)	EU-27 : 3.5 (73) Japan : 0.2(4)
Palm kernel meal	4.7	-	Import: 3.8 Export: 3.8	Malaysia: 2.1 (55) Indonesia: 1.6 (42)	EU-27: 2.9 (76) Korea:0.4 (10)
Fish meal	6.1	0.5 (8)	Import: 4.2 Export: 4.1	Peru: 2.1 (51) Chile: 0.7 (17)	China; 1.7 (40) EU-27: 0.7 (17) Japan: 0.4 (9)
Pulses[1]	60	5.9 (10)	8.6	Canada, UK, France, Australia	India, EU, Middle East

Source: ISTA Mielke, 2007

[1] *Source: GLIP, 2007.*
Pulses refer to dried pulses and exclude green beans, green peas and string bean. Global production for these beans in 2005 was 16.3 mio tons, (FAOSTAT).

The global production, global trade and the additional demand by the EU- feed sector if EU soybean imports have to be replaced are shown in Figure 4.4. The data for oil seed meals are presented in seed equivalents.

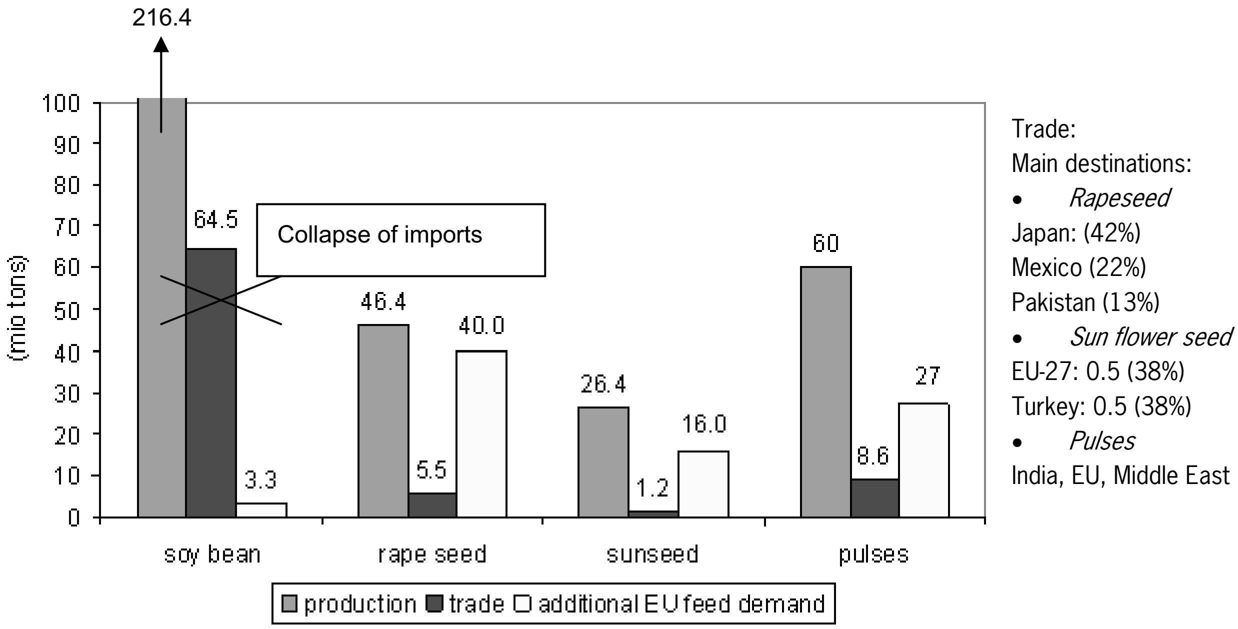


Figure 4.4. *Global availability and trade of soybean, rapeseed and sunflower seeds and pulses in 2005 and additional demand by EU feed sector to substitute the shortfall of 34 million tons imported soybean meal.*

These data show that the required amounts of oil meals and pulses to fully substitute the shortfall in soybean are **not available** at the world market. The study of the EC (EC, 2007b) assumed that about 6.6 million tons rapeseed meal and sunflower seed meal could become available for the EU in 2009-2010 to substitute the shortfall in soybean.

In case the interruption of soybean meal imports is caused by a zero tolerance policy of GM-soybean, soybean meal will become available at the world market as a cheap feed ingredient for non-EU countries. In this case, other protein feed ingredients such as palm kernel seed and cottonseed could become available to the EU as feed ingredients in higher volumes because present users of these items might switch to soybean. Still however, it is unlikely that the entire shortfall can be substituted which implies an impact on European meat production.

4.6 Response

Cultivation of protein feed in EU, 2005

Whereas purchase of substitute feed ingredients (and utilization of stocks) is (are) the only option(s) to cope with the soybean shortfall, feed crops can be cultivated in the EU at the longer term, of a crop cycle. Table 4.11 presents the quantity of additional feed ingredients required and the area needed for cultivation for replacement of soybean meal in all animal feed. For the calculations, the average yields in the EU-27 for 2005 were used because of the assumption that such a shortfall of soybean could occur at any time.

Table 4.11. Replacement of 34 mio tons SBM-eq in EU feed: implication for oilseed and pulse production in the EU-27 in 2005.

Crop	Substitution required in meal equivalent (mio tons)	Production volume requirement in yield equivalent (mio tons)	EU-27 production 2005 (mio tons)	EU-27 average yield 2005 (tons/ha)	EU-27 area 2005 (mio ha)	Additional area required to replace SBM (mio ha)	% change in area required
Soybean	2.6	3.3	1.1[1]	2.7[1]	0.4[1]	1.2	301
Rapeseed	22.4	40.0	15.5[1]	3.0[1]	4.6[1]	13.3	290
Sunflower	8.8	16.0	6.3[1]	1.6[1]	3.7[1]	10.0	270
Peas		27	2.7[2]	3.1[2]	0.9[2]	8.7	990
Cereals		-26.8	253[3]	4.5[3]	52[3]	-6.0	-11
Total						27.3	

Source:
[1] *ISTA Mielke, 2007*
[2] *COPA-COGECA, 2006*
[3] *EC, 2007e*

The claim on land for the cultivation of additional feed crops is included in EU land use in Figure 4.5. The utilized agricultural area (UAA) decreases from 203 to 197 million hectares because of the decrease in cereal demand. When this additional production of feed has to be realized today at yield levels of 2005, it will come at the expense of nature area. When such a claim would occur in 2020, sufficient land would have become available by then, under a liberalization scenario, to absorb the claim because of the decrease in required UAA for food production.

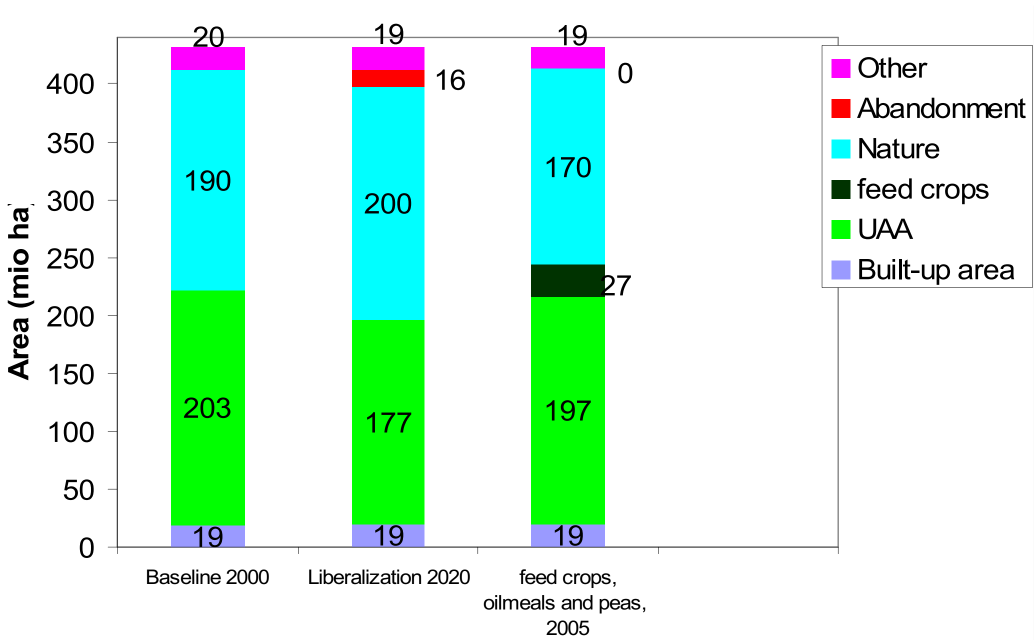


Figure 4.5. EU land use: baseline 2000, liberalization 2020 and replacement of soybean meal in EU feed sector based on 2005 yields.

In order to be consistent with the analyses in this report to take the projected situation of 2020 as a baseline, the production of the additional protein feed required were also calculated with 2020 crop yields (Table 4.12), based on projections of OECD-FAO (2007).

Table 4.12. Soybean meal replacement in EU: implication for oilseed and pulse production in the EU-27 in 2020.

Crop	Meal equivalent required (mio tons)	Crop equivalent required (mio tons	EU production 2005 (mio tons)	EU average yield 2020 (tons/ha)	EU area 2005 (mio ha)	Additional area required to replace SBM (mio ha)	% change in area required (compared to 2005 area)
Soybean	2.6	3.3	1.1[1]	3.2[4]	0.4[1]	1.0	+254
Rapeseed	22.4	40.0	15.5[1]	4.1[4]	4.6[1]	9.8	+212
Sunflower	8.8	16.0	6.3[1]	2.2[4]	3.7[1]	7.3	+197
Peas	n.a.	27.0	2.7[2]	3.7[4]	0.9[2]	7.3	+829
Cereals	n.a.	-26.8	253.2[3]	5.4[4]	51.5[3]	-5.0	-10
Total						20.4	

Source:
[1] *ISTA Mielke, 2007*
[2] *COPA-COGECA, 2006*
[3] *EC, 2007e*
[4] *Calculations based on projections of OECD-FAO (2007), see Annex 6, Table 8.*

This 'conversion' has not taken other factors into consideration, as it would confound the comparison with the information for 2005, which include the following possible changes between 2005 and 2020. Feed conversion rates are expected to be more efficient. This means that somewhat less soybean meal will have to be replaced and the quantity of substitution feed ingredients will be lower then projected in Table 4.12. However, the difference is minimal and does not significantly change the results of the analysis.

4.7 Feed and fuel

During the last 5 years, many initiatives to produce energy from biomass have emerged. This development has various consequences for the feed industry, like:

- An increasing competition between food, feed, fuel and other industrial applications for the use of agricultural products.
- A change in the supply and the type of feedstuffs worldwide.
- More by-products that become available for feed production and will compete and/or replace at least partly traditional feed ingredients.
- At the same time, use of agricultural waste for biofuels might reduce availability for feed.

Biofuel production is principally production of biodiesel and ethanol, presently still, through first generation technology. In both types of production the energy component of the crops are used. This results in a lower availability of both starch and vegetables fats for feed. The residues are protein and fibre rich and will become available in larger quantities for the feed industry. Rapeseed meal and sunflower seed meal, resulting from crushing the seeds, are commonly used feed ingredients. Distiller's dried grain soluble (DDGS) is a protein rich by-product of bio-ethanol production that can be used as feed. The cattle industry is the greatest beneficiary of this protein meal production as the inclusion rates are higher for both DDGS and RSM than for pigs and poultry (Rabobank, 2007).

Traditionally protein has always been the more expensive part of the feed component. It can be expected that in the future the price of feeds will be determined by the energy content of these feedstuffs, whereas protein will become cheaper (Doppenberg and Van der Aar, 2007; Rabobank, 2007).

In order to compare the by-products of the bioenergy sector with the demand of the feed sector, the production of protein rich feed ingredients and bioenergy crops are expressed in soybean meal equivalent. This means that the protein content of 1 ton soybean meal has been used as reference.

Table 4.13 presents this overview. For the cultivation of energy crops, the EU biofuel targets for 2020 have been taken as starting point. The calculations for the required area of bioenergy crops are presented in Annex 4. Bioenergy crops produce 21 million tons soybean meal equivalents in rapeseed meal and sunflower meal when 100% of feed stock is produced in the EU. When 57% of the feedstock for biofuels is grown in the EU the feed by-product decreases to 12 million tons.

DDGS production from bio-ethanol will provide an additional 8.2 million tons soybean meal equivalent under the 100% EU production scenario and 4.8 for the 57% scenario. When the quality of DDGS is such that it can be included in feed rations, the co-products from the 100% bioenergy scenario would nearly cover the entire protein content of the presently imported quantity of soybean meal.

Table 4.13. Production of protein rich crops, required area and production expressed in soybean meal equivalent.

	EU protein crop production to substitute soy imports		Bioenergy 2020 (100% in EU)[1]		Bioenergy 2020 (57% in EU)[1]	
	Area (mio ha)	SBM-eq (mio tons)	Area (mio ha)	SBM-eq (mio tons)	Area (mio ha)	SBM-eq (mio tons)
Soybean	1	2.6	0		0	
Rape seed	9.8	17	9.5	16.4	5.4	9.4
Sunflower	7.3	6.1	5.5	4.6	3.1	2.6
Pea	7.3	12.6	0		0	
Sugar beet			3.1		1.8	
Sub-total	*25.4*	*38.3*		*21.0*		*12.0*
Cereals grain	- 5.0	- 6.0	6.3		3.6	
DDGS				8.2		4.8
Total	20.4	32.3	24.4	29.2	13.9	16.8

2020-yields are used

[1] *Biofuel scenarios: 10% target to be met; either 100% or 57% of feedstock produced in EU (see Annex 4).*

In the biofuel scenarios, the oil derived from the oilseeds is used for biofuel production. However, the EU is importer of vegetable oils. The local oil production could be used for food or other industrial uses as well. The consumption of vegetable oils for the EU-27 in 2005 was 24.1 million tons, of which 32% was imported (Figure 4.6). If the oil production of imported soybeans is added to these oil imports this percentage increases to 43% (ISTA Mielke, 2007). The EU exports oil as well, and net trade was 25% of consumption in 2005.

A collapse of imports of soybean has therefore also consequences for EU oil production and implies a deficit of about 2.6 million tons of soybean oil. It has to be noted that import of soybean oil has increased recently from 0.2 million tons in 2005 to 1.1 million tons in 2007 (ISTA Mielke, 2007).
The output in protein (expressed in soybean meal equivalents), oil and bio-ethanol has been calculated for the three scenarios. A fourth scenario, which is the scenario to produce 57% of feedstock in the EU with additional soybean and pea cultivation (as in the feed scenario), is added. This scenario is referred to as "soy substitution + 57%' . The data for required area and output for the different products are presented in Table 4.14. The corresponding land uses for all scenarios are shown in Figure 4.7.

As Figure 4.6 shows, the scenario in which soy is substituted by feed production in the EU, would yield enough oil, to meet the 10% biofuel target in 2020, and would require some 20 million hectares. In the scenario 'soy substitution + 57%' the protein feed demand as well as oil required for 57% of the EU biofuel target, can be met on a cultivated area of 14 million hectares.

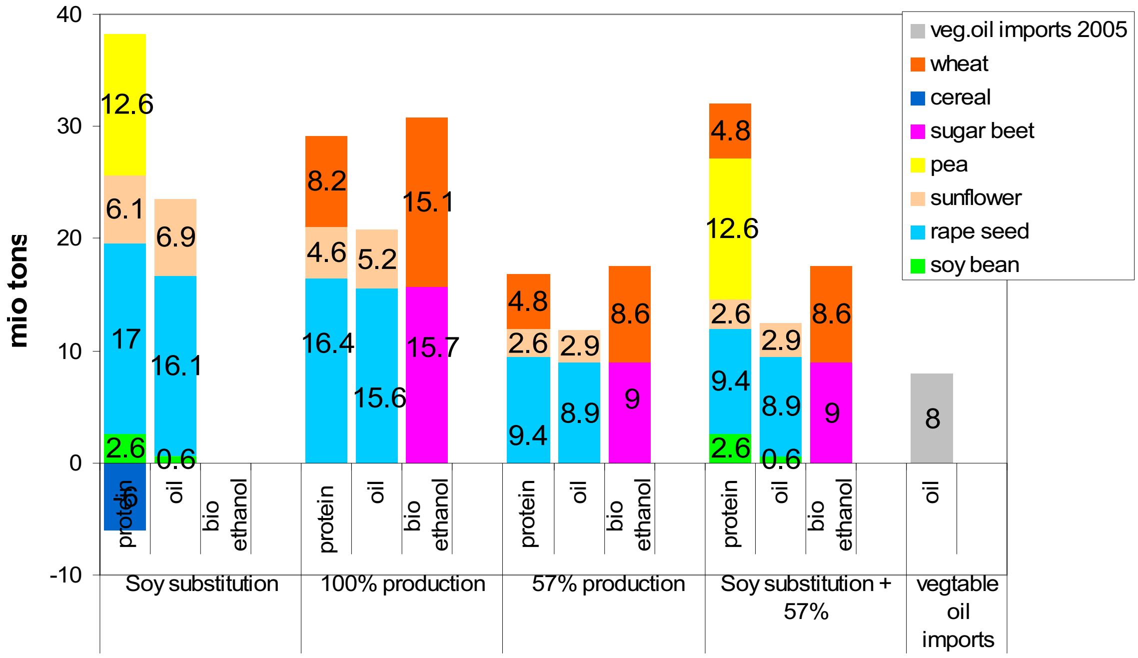


Figure 4.6. *Production of protein rich feed, oil and bio ethanol in four scenario's.*

Soy substitution is the scenario in which soybean (meal) imports are replaced by crops grown in the EU. 100% production and 57% represent scenario's in which respectively 100% and 57% of feedstock to meet the 10% biofuel target in 2020 are cultivated in the EU. 'Soy substitution +57%' , is the 57% scenario with additional soybean and pea production.
Protein is expressed in soybean meal equivalents.
Protein and oil are in million tons, bio ethanol in billion liters.

Table 4.14. Cultivation of oil seeds, pulses and crops for bio-ethanol for the 'soy substitution +57%' scenario.

Crop	Area (mio ha)	Production			
		Total crop production (mio tons)	Meal in SBM-eq (mio tons)	Oil (mio tons)	Bio ethanol (bio litres)
Soybean	1	3.2	2.6	0.6	
Rape seed	5.4	22.1	9.4	8.8	
Sunflower	3.1	6.8	2.6	2.9	
Pea	7.3	27	12.6	n.a	
Sugar beet	1.8			n.a	9.0
Wheat DDGS	3.6		4.8	n.a	8.6
Total	22.2		32.0	12.3	17.6

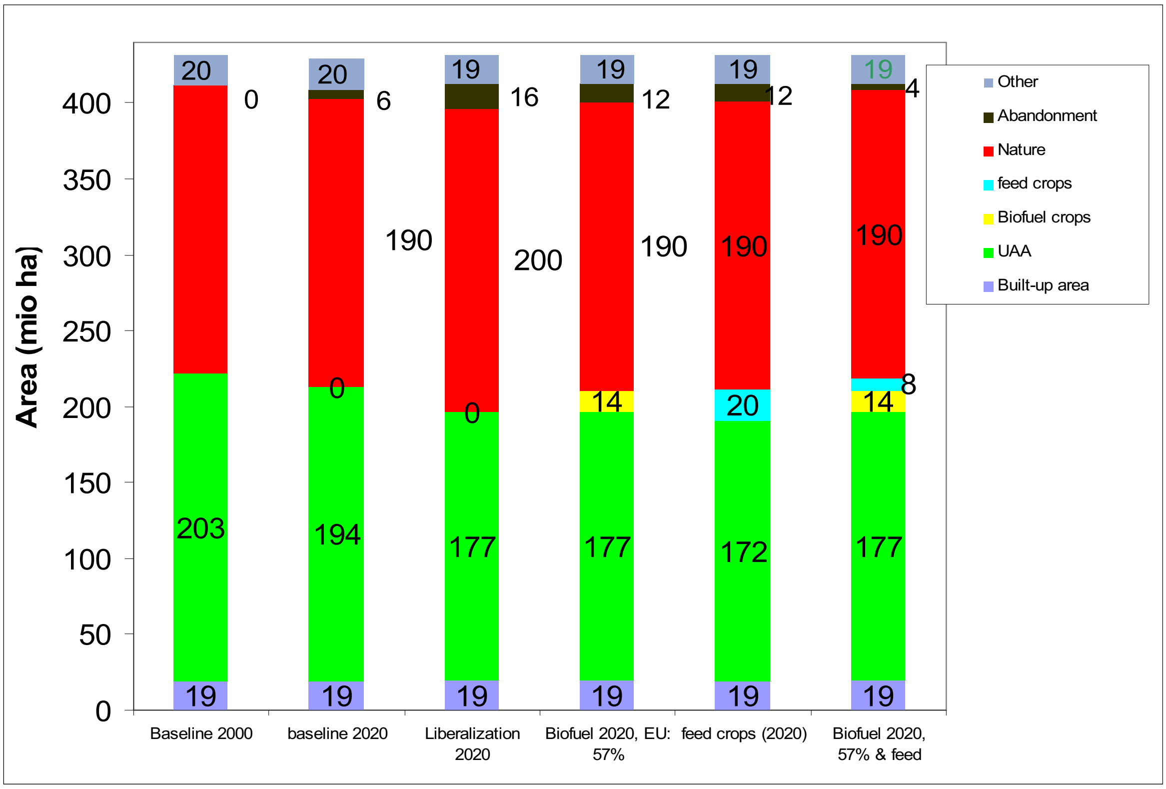


Figure 4.7. Land use in 2020 in EU-27: biofuel and feed scenarios compared to baseline and liberalization scenario 2020.

4.8 Discussion 'soybean case'

The impact of a collapse of the import of soybean has been estimated for the availability of meat. According to our own calculations, a total reduction of nearly 40% protein availability would translate in a similar reduction in pig meat production. Calculations based on the outcome of a study by EC (2007b) project a decline in meat production of 25% (beef, pork and poultry). Some of the decline in feed can be substituted by rapeseed meal and sunflower seed meal and other products, like peas, from Europe. Total consumption of meat will decrease by 10 to 15%, varying for pork, poultry and beef, due to increased import and reduced export. The reduction in meat consumptions is not likely to jeopardize health conditions of the average European.

A collapse in the import of soybeans will have an impact on oil availability as well. A reduction in availability of soybean oil that would be produced by crushing imported soybeans of 2.6 million liters (over 10% of domestic consumption in 2005) will affect the food-processing sector, but has not been further studied.

Animal feed is composed from many components and the composition for different animals between different countries within the EU is so large that there is a great overlap between animal feeds. Because we make an aggregate estimate of the impact of a soybean shortfall on meat production at the European scale, disaggregation feed composition between animals without a regional disaggregation is not effective. The composition of feed for pigs has therefore been used to represent the average feed composition for further calculations.

Coping

Our average pig feed ration has a high inclusion of cereals. This means that in other rations the quantity of cereals could indeed be decreased as has been assumed in our analysis. This has resulted in an alleviated cultivation area prior used for cereal production. On the other hand, the amount of protein crops and pulses used to replace soybean may lead to changes in quality of animal products, while cereals maintain meat quality. High inclusion rates of rapeseed meal in poultry feed for instance, result in off-tastes in meat and eggs (Van der Zijpp, 2008). These effects would imply a slight exchange in feed components, but the overall claim on feed and land use might alter slightly only. European cereal production could then replace the shortfall of soybean to some extent for poultry and import of cereals would be less difficult than protein crops whenever needed. Substitutes derived from the food industry have not been taken into consideration.

The substitution feed formulas have been composed by replacing the proteins as these are strongly related to the growth of animals. The proportional decrease in meat production with decreasing protein intake may overestimate the impact, and has not been supported from the view of animal physiology (Gerrits, pers.comm.). As our analysis looks into the coping and response measure to the soybean shortfall, the replacement of the protein is the central issue.

In identifying substitutes, we have emphasized the cultivation of crops within the territories of the EU27, from the perspective of reducing the dependence on imports. The feed sector will apply optimization programs to compose economically viable feed mixes that comply with nutritional requirement. Given the large number of components that can be used, it is likely that more than the four protein crops will be cultivated than assumed in our analysis. The results on the cultivation area required might however not differ much from our estimates, except for soybean. It is technically feasible to expand the cultivation area for soybean in Southern and Eastern Europe, but is at present not economically viable.

Impact on meat production and consumption

Applying the outcome of the EC study on soy import interruption on projected EU meat production indicated that, overall (pig, poultry and beef) meat production would fall by 10 million tons or 25% of projected meat production. Our analysis has numerous shortcomings because of the high level of aggregation, and more accurate estimates ought to look at disaggregate sub-regional levels and distinguish animal groups. While more regionally specific information would be generated, the impact on the total production volumes is not expected to differ greatly. At a sudden increase in feed prices, producers may cope with the situation by slaughtering animals at a younger age leading to a sudden excess availability of meat. This meat might not reach the consumer yet as cold storage and processing could offer a more profitable perspective.

If imported soybean and soybean meal are not available, the EU feed sector will make an effort to purchase substitutes on the local and global market. Up to 6.6 million tons of rapeseed meal and sunflower meal could become available and probably minor quantities of oil meals such as palm kernel oil meals, but not enough to substitute the soybean meal deficit.

As soybean meal is an ingredient in dairy feed as well because of its high protein quality, milk production may be affected but the extent to which this might happen has not been analyzed. A study, looking into alternatives for soybean meal in feed for Dutch dairy cattle, identified, lupines, vicia faba and peas as potential substitutes. However, the required amounts of these substitutes are presently not available (Boer, H.C., de *et al.*, 2006).

Response

Substitution of a soybean shortfall can be realized at the medium term by cultivating an additional acreage of 27 million hectares for all meat production. Irrespective of the reason for the shortfall, Europe will not be able to entirely cope with the shortfall by increased imports of feed, which would lead to a decline in meat production. Europe has sufficient production potential to replace the shortfall and could recover over time though the time lag will depend on various factors, including trade agreements and the willingness to reclaim natural lands. It is expected that by 2020 sufficient agricultural land will have become available to supply the required acreage, due to increasing land productivity and land abandonment (under the liberalization scenario).

The combination of protein production for the replacement of soybean and the need for vegetable oils for biofuel production might be complementary claiming the same land area as both oil and proteins will be produced.

There is likely to be a synergistic effect between the need for additional production of protein and oil crops in Europe to respond to a shortfall in soybean (for meal replacement), the replacement of vegetable oil imports and the need for biofuels. The associated decline in the area for cereals can be taken into production for bio-ethanol.

With increasing feed prices, the conversion efficiencies of feed and the efficiency of the animal production systems becomes increasingly important. The dramatic price increase for all key feed materials in 2007 had two main consequences. First. the high cereals prices encouraged farmers to put their cereals on the market, rather than using them in the farm and secondly, livestock producers facing a huge increase in feed costs, which they could not pass on to consumers of animal products, turned to use the most efficient feed, i.e. compound feed (Fefac, 2008a). Under this scenario it is likely that farmers in Eastern Europe may move into cereal and protein crop production, away from meat production, while Western European countries that have improved the production efficiency of the systems through heavy investments over a period of 20-30 years may well remain in business (Bergevoet, pers.comm.).

From 2000 onwards, the percentage of obligatory set-aside in the EU-15 was set at 10%. The set-aside regulation allowed industrial production of crops for non-food or feed purpose. In 2007, the obligatory set-aside percentage was set at 0% because of the increasingly tight situation on the cereal market. It is expected that due to this proposal 1.6 to 2.9 million hectares are returned into agricultural food production (MNP, 2008). The set-aside areas turned out to contribute positively to support bio-diversity in farmland areas. It is presently a point of discussion whether set-aside land can be used for biofuel production without affecting biodiversity concerns.

Multiple calamities

A combined shortfall of soybean with a decreased production of cereals and green fodder in Europe for instance, due to adverse climatic conditions may have an accumulating effect, as the availability of three major feedstuffs is limited. Cereals might well be purchased at the open market, for soybean meal, it is not likely to find the required substitutes. As green fodder is a non-tradable feed ingredient, the producer will depend principally on on-farm stocks.

If the same calamity (heat) would decrease the number of animals this would result in a decreasing feed demand. This was also experienced during the drought of 2003 when specifically the poultry sector in Spain was hit, and an estimated 15 to 20% of animals, which could not resist the heat, died, compensating for the decline in cereal production (COPA-COGECA, 2003).

A simultaneous occurrence of animal diseases might even further mitigate the impact of both a shortfall in soybean imports and a climatic calamity, as the number of animals would decrease. Obviously, no surplus meat would enter the market under these conditions, so that the ultimate impact on meat availability and price would be different from a single event of a collapse in soybean imports.

5. Shocks, stocks and price development

5.1 Introduction

The previous chapter indicated that stocks (of soybean meal for example) could have helped to limit, if not prevent, the impact of a sudden disruption in imports. In a more general sense, this holds for all shocks: the higher the level of stocks, the lower is the potential disruption that any shock may cause. A shock in supply can be coped with by reducing the level the stocks. Like saving accounts help to smooth consumption while income may fluctuate, so can stocks help to smooth sales while supply may fluctuate or help smooth food provision, while production fluctuates. But, while credit may provide a solution in case savings accounts are insufficient, such credit does not exist in the real world of commodities. This is the reason for strong price peaks in case stocks reach low levels. In this chapter this role of stocks is investigated, first in a theoretical model of demand and supply, then in a model with shocks occurring, and finally in relation to the physical markets for grains and for soybeans. The conclusion is that stocks are important still for mitigating the fluctuations of grains prices, while the role of stocks in the soybean market appears to have become less instrumental.

5.2 Cob-web approach

This section clarifies how the 'laws' of economics come to play in times of scarcity and how one scarcity can follow from the other. The focus is on a single storable commodity that is subject to the normal regularities of agriculture: production is affected by rainfall and other climatic uncertainties; consumption has its ups and downs due to changes in income and other factors. Prices are established for each period in such a way that demand meets supply, but demand need not be equal to consumption and supply need not be equal to production, because stockholders can intervene and purchase or sell in this market. How does this work out on the prices that one may expect?

We consider first the case without stockholding and then introduce stockholding into the model. Stockholding affects more than one period: what is bought or sold now affects the prices next period and hence affects production and consumption, provided these are price responsive.

Without stocks, demand must meet supply and in this case, this amounts to consumption being equal to production. In agriculture, supply takes time and the decision to grow a crop is taken (long) before the product is supplied to the market. Hence, at some point t, the supply to the market is determined by past decisions. The crop was in the field, and if prices or yields are not dramatically low, the crop will be harvested and offered for sale.

Consumers, taken as an aggregate, normally consume more of the crop when prices are low, than when they are high. To consume the quantity that has come onto the market a certain price must materialize. If little is supplied, high prices will choke off some of the consumer demand so that demand meets the given supply.

Graphically, the correspondence between demand and the price looks like a downward sloping line if we set prices against demand in one graph (Figure 5.1, next page).

To sell a given amount of product, say S_0 prices should be P_0. Higher prices will mean that not all of it is sold, and lower prices will not function as an adequate distribution mechanism, as some existing consumer demand cannot be met. In such a situation, where prices are lower than the demand curve indicates, the sales must be rationed. This may, of course, be appropriate in instances where one wants supply to reach groups whose purchasing power is insufficient. It is, however, normally a costly affair to set up an efficient and fair rationing system.

In a dynamic setting with a free market, the price P_0 is the price established by the market mechanism. It serves as a signal to the producers who consider the next period. Higher expected prices normally lead to more crops being sown. Whether the observed price P_0 is a good predictor of next period's price is subject to intensive research. In a stable environment, the expected price should actually also be stable and the same for every period, but normally high prices in one year trigger more supply in the next year. One reason is that farmers may hold incorrect expectations; another reason is that higher prices now enable farmers to buy more inputs (with less credit) which are used in the next period and leads to higher yields.

This behaviour induces cob-web type of links between the demand and supply and prices in various years.

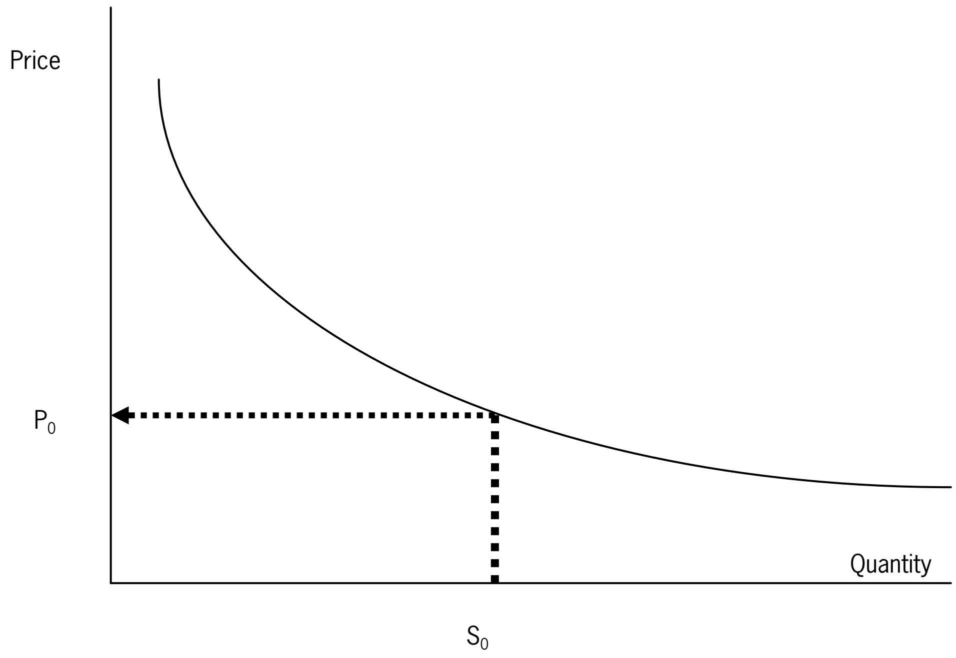


Figure 5.1. *Demand curve, showing the market combinations of demand and prices.*

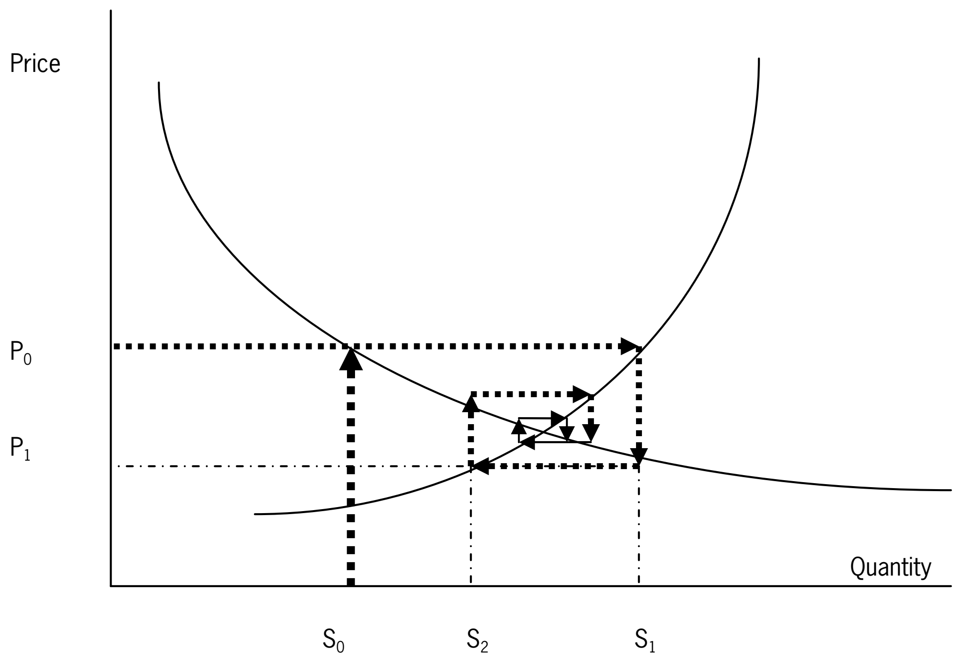


Figure 5.2. *Demand and supply curves, showing a cob-web pattern how prices would converge to a stable situation, in the absence of shocks.*

Figure 5.2 shows how the initial production of S_0 needed a price of P_0 to be sold to the consumers. If producers take this price as indication, they will produce S_1, which requires a price P_1 to be sold, which leads to a production of S_2 etc. In the end, the equilibrium combination of price and quantity would result which forms the intersection of the demand and supply curves.

5.3 Impact of shocks on price responses

The above situation of a dynamic free market will not normally be observed however, because of shocks to supply and demand (and prices). The reason why supply was S_0 in the fist place, and not the equilibrium quantity, was a shock that led to this particular *unexpected* supply. The farmers may have responded to previously prevailing prices, but their production will still be unpredictable. Even when they take P_0 as their guiding price for period 1, their production may not be S_1, but a quantity that can be higher or lower than this. Demand too can be subject to shocks, as income may vary, or other prices. And the relevant price can be different due to changes in inflation, in exchange rates etc.

In Figure 5.2, a low supply, such as S_0 leads to a high price and thereby to a high supply in the next period. If, however, a second shock occurs in this period, so that not supply S_1 materializes, but only a quantity of, say, S_2, we should see two consecutive years with relatively high prices and shortage of supply.

If government intervention occurs, and prices are not allowed to rise to P_0, e.g. in order to protect poor consumers, farmers would not have the guiding price P_0, but a lower price to take as decision price for their crop in the next period. Absent any shock, a lower quantity will be produced than S_1, and prices higher than P_1 will prevail in this period.

The Figures 5.3 and 5.4 give an indication of what prices may prevail in such conditions. Here we simulated an equilibrium price that made (non-random) demand equal to a random supply. Basically, supply and demand are equal to 100, and so is the price. But supply is subject to shocks in the range between -10 and +10, and is also responsive to last year's prices with a supply elasticity of 0.2.

Figure 5.3 shows how volatile prices are, if demand is not very sensitive to prices: here the demand elasticity is -0.2. Any shock in supply must now lead to large changes in prices in order to make demand meet the shocked supply. Figure 5.4 shows the same type of supply shocks, but now combined with price-sensitive supply: clearly more stable prices result.

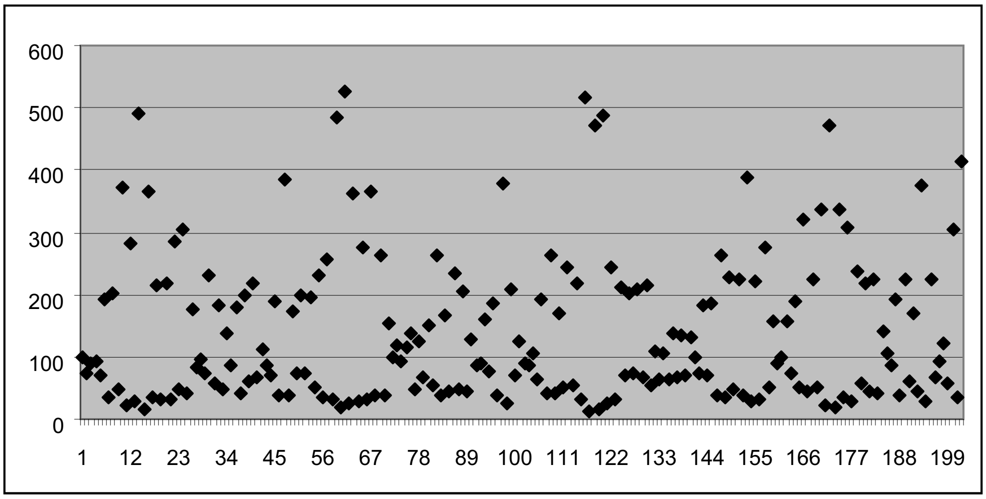


Figure 5.3. Prices simulated for 200 periods, with shocks in supply, a supply elasticity of 0.2, in response to price (t-1), and a demand elasticity of -0.2. Price at 'unshocked' supply would be 100.

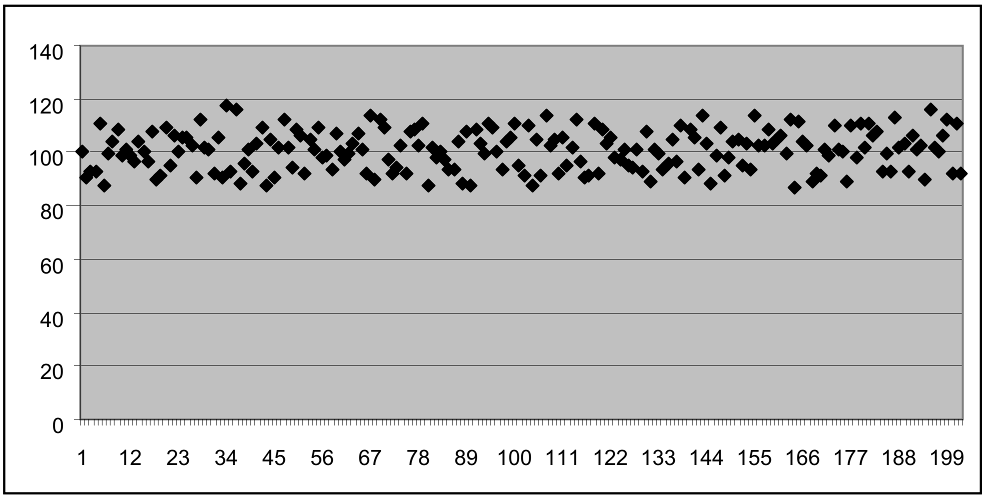


Figure 5.4. *Prices simulated for 100 periods, with shocks in supply, a supply elasticity of 0.2 and a demand elasticity of -0.8. Price at 'unshocked' supply would be 100.*

Typically, low price elasticities refer to basic consumer goods, such as food. For single commodities, without alternatives, it is also applicable. As long as alternatives are available, price elasticities are likely to be high: a small price change can lead to strong responses in demand, as buyers turn to other commodities. If the alternatives are not any more available, e.g. because their prices have soared, price responses to the commodity in question become weaker, and stronger price changes are in order to effect a certain volume change. When, for example, grain prices are very high, soybean demand elasticities should be smaller and the soybean market would become more 'nervous'.

A very high price in Figure 5.3 typically results from low supply in that period, due to negative supply shocks but combined with low prices prevailing in the earlier period. This is of course due to the assumption that farmers respond to last year's prices. If we weaken this assumption and have farmers responding to a more fuzzy price, somewhere between the last period's price and the stable equilibrium price of 100, a picture emerges that shows less volatile prices, as in Figure 5.5.

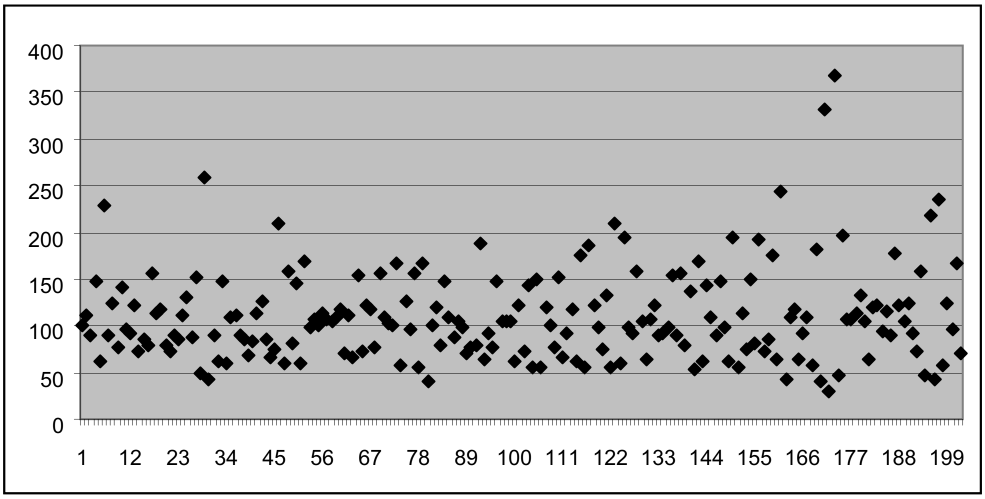


Figure 5.5. *Prices simulated for 100 periods, with shocks in supply, a supply elasticity of 0.2 (in response to a random price between price(t-1) and 100) and a demand elasticity of -0.8. Prices at 'unshocked' supply would be 100.*

In Figure 5.5, too, the highest prices result from very low prices in the previous period combined with a negative shock. The top price of 367, for example, is preceded by the bottom price of 30.

As shown in Figure 5.6, this relationship between two consecutive prices is not a very reliable one: prices of below 50 in one period may also come along with prices around the mean in the next period.

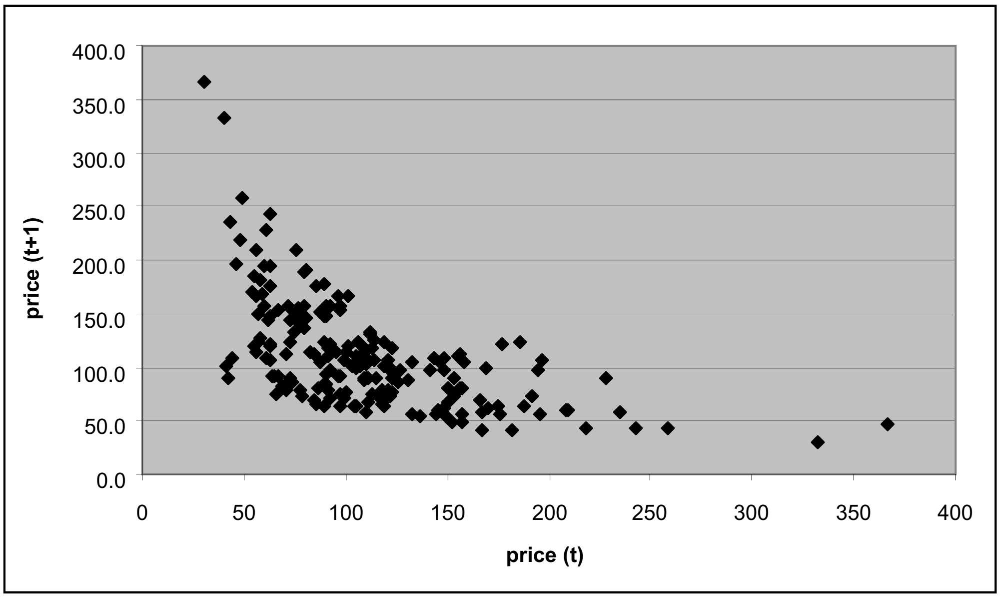


Figure 5.6. Relationship between prices in one period and those in the next (model as in Figure 5.5).

Adding more volatility on the demand side would obscure the relationships even further. This shows that any occurrence of very high prices (indicative of scarcity) has multiple causes, both in the period itself and in the past.

5.4 The impact of stock on supply, demand and price response

The role of stocks is to arbitrage between one period and the next. If a certain supply manifests itself, prices now need not accommodate fully to clear the market between production and consumption. Stockholders will consider that low prices now promise higher prices in the next period and vice versa. Hence, when low prices prevail, they will enlarge their stocks to benefit from the expected price difference in the next period. When prices are high, they can sell whatever they have in stock and carry very little over to the next period.

This means that, normally, when prices are low, the activities of stockholders imply that demand is stronger, so that higher prices result. If prices are high, and stockholders are able to sell, prices will be adjusted downward.

A special mechanism occurs when stockholders, or better speculators, use a rally of increasing prices (or actually also falling prices) to make short profits by trading in derivatives, i.e. trading in certificates that entitle the holder to delivery or sales at some time at some price. Such activities tend to strengthen movements upward or downward, but for a limited period of time (speculative bubbles).

If the original demand and supply curves are as in Figure 5.2 and S_0 would be the supply that materializes, additional supply from stocks may come forward to shift S_0 to the right, closer to the equilibrium price. A similar movement will occur in case supply happens to be high: some of this will be put in stock, and not consumed in that year.

Figure 5.7 shows the effect. Here, we have introduced stock changes that help clear the market in a period. Consumption is permitted to respond to last period's prices only, and the resulting stock changes trigger a price change. This reflects implicitly that these stock changes are a response to the prevailing prices: the lower the equilibrium prices would have been, the more demand for storage will occur thereby pushing up the price. At high prices, a similar pattern occurs, dependent on whether stocks are available.

Figure 5.7 shows in the open squares the prices that would prevail if no stocks were carried over, while the solid diamonds show the prices with stockholders in the market. Clearly, the latter price series is less volatile.

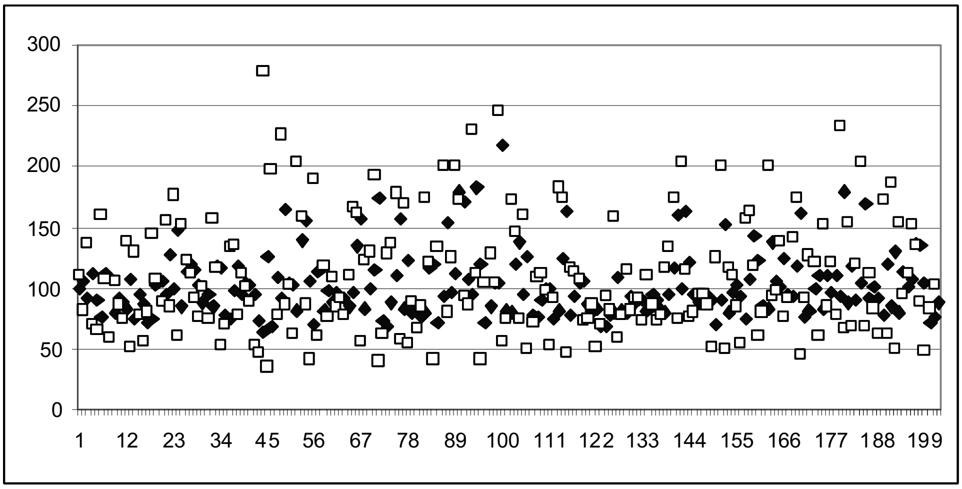


Figure 5.7. Prices with (solid diamonds) and without (open squares) stockholding.

The highest prices that now occur are considerably lower than before. The highest price of 219 results from a preceding price of 105 and a preceding stock of 28 (mean is 30) which are both quite normal. In the particular period, supply happened to be low (92) while demand happened to be high (109) resulting in a stock of only 11 thus triggering the high price. In the period after this, farmers in the model 'reckoned' with an expected price of 166, consumption fell to 85 and stocks improved to 38 so that the new price became 82.

The relationship between prices in one period and the next has, as the example shows, also changed, and low prices are now less predictive of high prices. Figure 5.8 shows the new relationship, which is much less clearly downward sloping (if at all) than the one in Figure 5.6.

This simulation is based on a reference level of 30 for the stocks. Deviation from 30 triggers the prices. A given shortfall of 10, for example, leads to prices going up to 134. If the reference level is lower, the same shortfall of 10 would carry much more weight: it would push prices to 173 at a reference level of 20. With such small stock levels, the use of the stockholding would no longer stabilize the market compared to the case without stockholders. If reference levels of the stocks would be higher, 50 say, the stockholders' activities have more stabilizing effect on the prices.

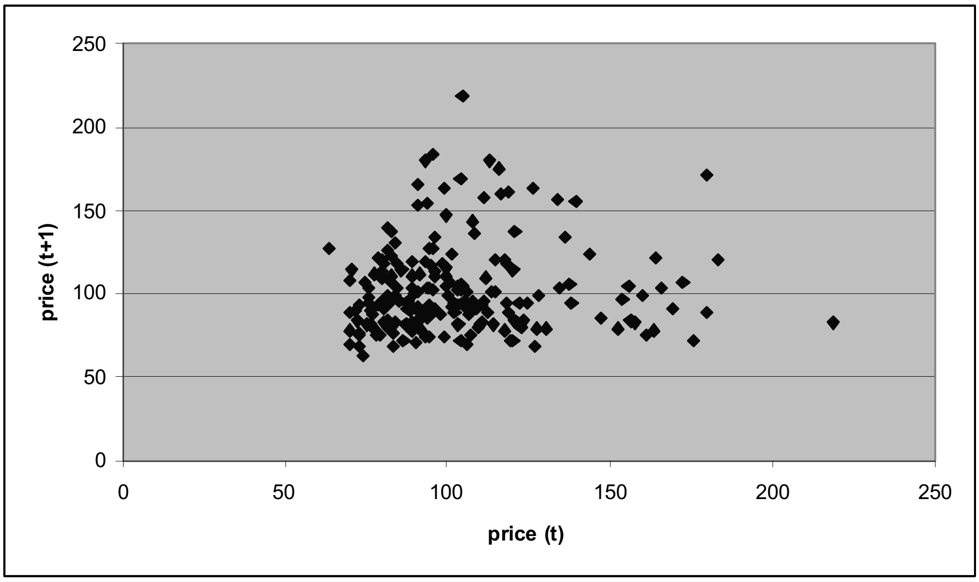


Figure 5.8. *Relationship between prices in one period and those in the next (model as in Figure 5.7, i.e. with stock intervention).*

Figure 5.9 shows the differences between the cases with small stocks and large stocks for the spread of the prices.

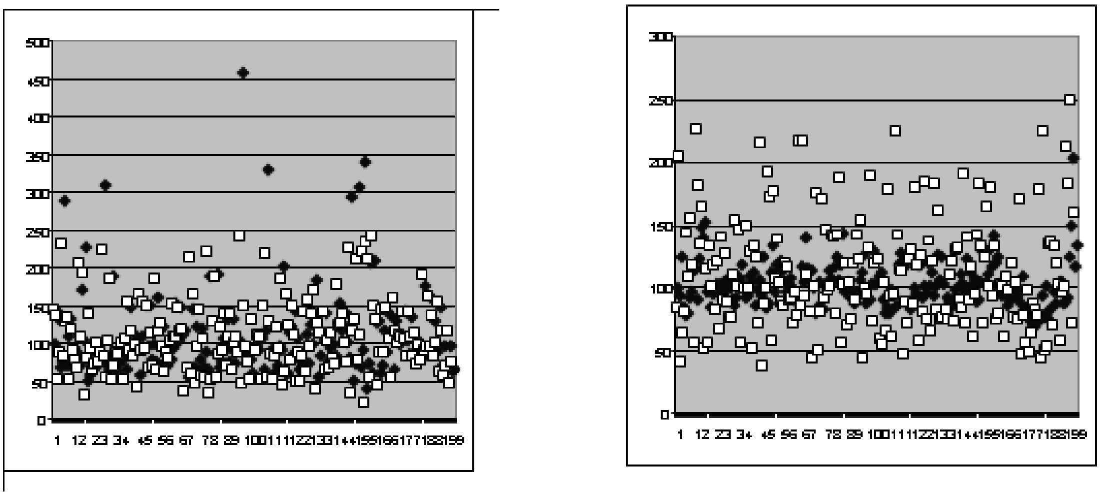


Figure 5.9. *Prices in 200 simulations*
a) with reference stock of 20 *b) with reference stock of 50*

5.5 Lessons from the simulations

The above simulations are for a model, using elasticities of supply (0.2) and demand (0.3) that are in the order of size that applies to soybean production in Brazil or soybean demand in the EU. Hence, the outcome has some relevance for the soybean market, but the extent of uncertainty of supply (here set at a uniform distribution between -10% and +10%) is an exaggeration compared with reality.

The simulations show that even with ‘normal’ demand and supply relationships and behaviour, very high prices can result. This is in line with experience and in this sense, the occurrence of price spikes need not surprise us. But these spikes result from specific constellations in the market. As shown by Figures 5.6 and 5.8, previous low prices may lead to present high prices in cases without stocks, but with stockholding such relationship is disturbed. Other factors such as shocks in supply and demand, which are unpredictable, play a role. Their role is particularly strong, when no stocks are there to keep prices within bounds. Hence, low levels of stocks need not lead to very high prices, but certainly increase their likelihood. In 200 simulations we saw that if the stocks are below their reference level of 30, prices are higher (by assumption of the model), and that the prices next period are only slightly higher: 107 for prices in t+1 when stocks in t are below 30; and 102 on average when last year's stocks are above 30. Taking a more extreme view: If stocks are below 20, immediate prices are on average 168, next period's prices are 113. If stocks are above 40, immediate average prices are 72, next period's prices are 96. Hence, low stocks and high prices are a warning signal for (again) higher prices, but not significantly so (standard deviations are in the range of 25), at least in this application.

To the extent that this model is relevant for every day life, the conclusion would be that reasonable levels of stocks help limiting price movements, but would not always help to avoid high prices from occurring. The presence of alternatives for supplier and customer is likely to offer scope for improved stabilization of the market too. The more alternatives farmers have, the stronger their responses to prices, but the more stable these prices will be. Likewise for the consumers.

5.6 Empirical evidence of the grain market

Data on the world wheat market are used to investigate the relationship between stocks and volatility of the prices. Do lower levels of stocks make the market more prone to shocks, and do we see larger movements in prices when stocks are low?

We use data from the International Grains Council (2008) to have a basis for the levels of stocks: 112 for 2008, going up to 141 for 2005. This information is combined with data on world production and (apparent) stock changes taken from FAOSTAT to reconstruct the stocks back to 1980. While data on stocks might be available for the earlier years, the stock change data should provide a reasonable approximation. This information is then combined with monthly data on world wheat prices from UNCTAD trade yearbook (2008). This index refers to US wheat in US dollars.

An index for the price volatility is constructed by calculating the ratio of the maximum of the monthly prices per year and the minimum of these prices. The higher the ratio, the more the maximum price differs from the minimum and the more volatile the market.

Figure 5.10 below shows two series for the years 1980-2006. One is for the thus constructed max-min ratio of monthly wheat prices. This shows a cyclical behaviour with some hick-ups. This deviation can be due to monetary factors and other disturbances that may plague the market. After all, the prices are determined by many factors, of which the level of stocks is only one. The ratio of stocks to production is the other line shown in the Figure. This shows a cyclical pattern too but with movements contrary to those of the price volatility. The higher the relative level of stocks, the less is the change in prices. In cases of low levels of stocks, say below 30% of the production, prices become more volatile. In fact, when we calculate the mean volatility of the years with relative stock level; below 17, we find a score of 1.33 and for the years with more than 18% stocks, a volatility score of 1.23, a difference equal to more than the standard deviation (0.13) of the max-min ratio.

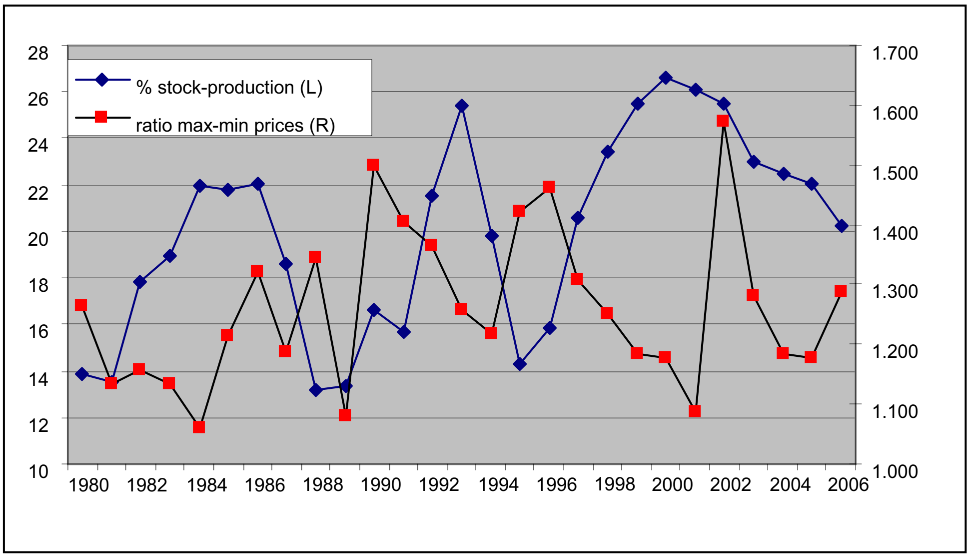


Figure 5.10. Wheat price volatility and stock-to-production ratio 1980-2006.

As Figure 5.10 shows, the relative stocks of wheat in recent years were above the norm set by the FAO (17%) as the minimum to avoid disruptive movements in the wheat market. In more recent years, after 2006, the stocks have fallen to 112 in 2008 with a production of 604 million tonnes in 2007/08, i.e. a ratio of 18.5%, increasing the volatility in the market.

For soybean prices a similar analysis was done. Here, data on stocks were derived from ISTA Mielke (2007), while price data were from UNCTAD (2008) and refer to US soybeans.

Figure 5.11 shows the movements over the past 25 years. We see a cyclical behaviour comparable to that of wheat, but with falling trend until the mid nineties, after which the stocks start rising and the volatility does not decrease any further.

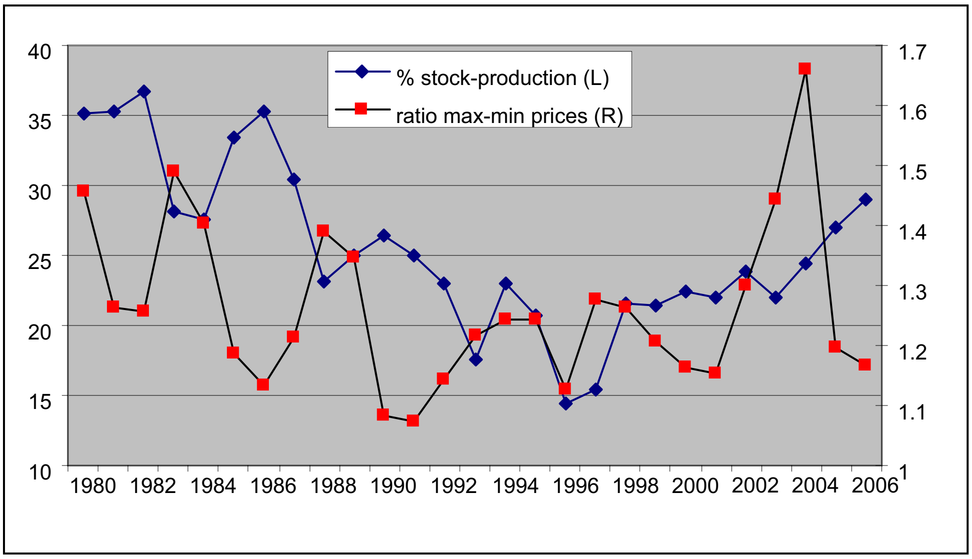


Figure 5.11. Soybean price volatility and stock-to-production ratio 1980-2006.

Next to the impact that stock levels have on the volatility of the market, there is the direct impact on the level of the prices. Higher levels of stocks trigger lower prices, and this can be seen in Figure 5.12.It shows on the vertical axis the relative change in the annual average prices and on the horizontal axis the relative change in the levels of stocks in the preceding year.Thus, for example, in the year 1997, stocks were 18% higher than in 1996, upon which prices in 1998 decreased by 22% compared with the year before. This then leads to the point in the most SE corner of the figure. Clearly, the relationship shows a negative correlation with increases of stock levels coinciding with decreases of prices and vice versa.

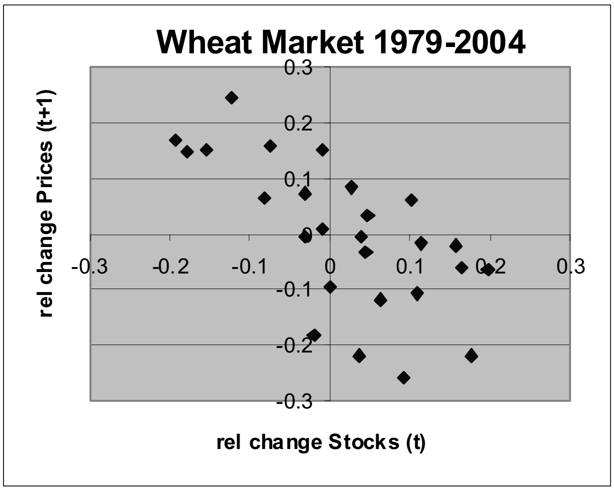


Figure 5.12. Changes in stocks and subsequent change in prices of wheat.

A similar relationship holds for the soybean prices, but somewhat less outspoken. Here we compare the change in the (closing) stocks in the USA (USDA/ERS, 2008) with the changes in the annual average value of the index of soybean prices (Figure 5.13).

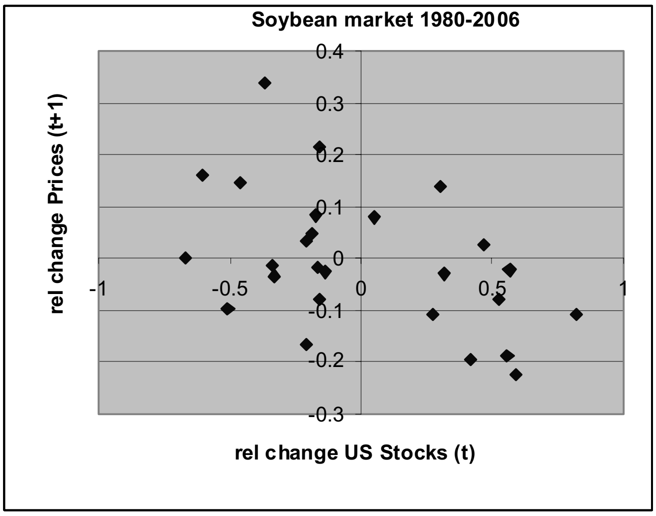


Figure 5.13. Changes in stocks and subsequent change in prices of soybeans.

5.7 Conclusion

Stocks are clear signals of impending shortages, which can only be prevented by higher supply, or – to a limited extent – by falling consumption. Higher supply can be the normal response to higher prices, but farmers not always ‘feel’ the higher prices, as government measures and other economic variables, such as exchange rates, may intervene. In addition, even when farmers would be bale to get the high prices, they may not respond positively when prices of other commodities are even more attractive, or when high prices of inputs undo the positive influence of high product prices.

Keeping high levels of stocks, as a measure to secure sufficient supply, has the likely effect of stabilizing the market (price), but it has also a negative effect on the level of the prices.

6. Discussion

This study has analyzed the impact of possible calamities on the food security of Europe (EU-27) in 2020 in a context of evolving globalization. It is hypothesized that Europe might be at risk at least for some basic food commodities if further globalization would lead to geographical specialization, and even more so if biofuel targets would need to be met. The complete unravelling of the world and European food system to test such a comprehensive hypothesis is beyond the scope of this study. For now, partial but reasoned approaches were adopted to shed light on the main aspects that yielded some valuable issues for further discussion. Data discrepancies between different data sources remain a major problem in this study. Many simplifications in the analysis have been done which allowed us to analyze the very complex problems. However, these simplifications need to be kept in mind when interpreting the results.

EU, scenario under trade liberalization

In a scenario under trade liberalization, no additional risks due to exposure to increased international trade are expected as the EU's dependence on foreign supplies will not change much. In the EU, agricultural productivity and farm size will increase, and total production of some commodities will be reduced, as is the agricultural area. Concentration of production is expected in North-western Europe due to its competitive ability with other global regions and within Europe. The positive effects of climate change may reinforce the intensification of agriculture in these most productive areas. It is not likely that this concentration of production will make the food system much more prone to calamities.

Bioenergy

Over the past year some side effects of biofuels on global food security have become apparent. Analyses show that food prices have increased by 30 to almost 80% due to the use of food commodities for biofuels, dramatically affecting the food security of the poor, directly or indirectly (Von Braun, 2008; Mitchell, 2008). Another issue currently under debate is the actual contribution that biofuels can make to mitigate GHG emission. While for some food commodities the GHG balance within the chain can be positive, i.e. a net reduction in the ultimate GHG emission, these gains can be completely reversed when additional natural lands have to be cleared for the production of these (additional) commodities for biofuels. It might take 20 to over 200 years before the initial loss of GHG due to land clearing can be compensated (Searchinger *et al.*, 2008). Moreover, other issues including the loss of biodiversity, the competition for water and nutrients with food production, may further constrain the sustainability of biofuel production.

Towards 2020, the EU faces land abandonment, which is a continuation of past trends. This abandonment can be reduced by more than 50% in 2030, with support of CAP and stimulation of bioenergy crops (Rienks, 2008).
The feasibility of meeting the 10% biofuel target in 2020 is not likely according to an EC study which indicates that only approximately 7% blending can be realized when taking market and technology development into account (EC, 2007d).

Though policy targets concerning the EU biofuel policy are currently under debate, the EU 10% biofuel target for 2020 has been taken as a starting point in this study. When using existing technologies ('first generation') the required area for cultivation of energy crops will put a claim on 20 to 30 million hectares in the EU (MNP, 2008). Our own calculations (Annex 4) are well within this range, as in a scenario in which all feedstock (rapeseed, sunflower seed, wheat and sugar beet) are cultivated in the EU, an area of 24 million hectares would be required. Comparable amounts of agricultural land are projected to become available in the EU by the year 2020 under a liberalization scenario, when some 26 million hectares less is expected to be used for agriculture, as compared to 2000. A study by MNP (2008) argues that areas between 20 and 30 million hectares will become available as it is not likely that full liberalization will occur in the short time frame up to 2020 and that the land which becomes available does not necessarily suit large-scale biofuel production. Especially under a liberalization scenario, it will be nearly impossible to govern foreign biofuel production with European policies. Rienks *et al.* (2008) conclude that more than 50% of Europe's biofuel demand would be imported, in a fully liberalized world. In a scenario with no blending obligation, about 5 million hectares in the EU will be dedicated to energy crops as an alternative energy source according to the Eururalis study (Rienks *et al.*, 2008). Nowicki *et al.*, (2006a) project in such a scenario that biofuels will contribute up to 3.6% of total fuel consumption in 2020.

In accordance with a study of MNP (2008) which suggests that imports will be required to meet the biofuel target, a scenario was used in which the 10% target in 2020 is realized with 57% feed stock produced in the EU and 43% out of the EU, and with biofuel production using first generation technology. This would claim an area of nearly 14 million hectares in the EU in addition to 3.3 million hectares in Asia and Brazil assuming palm oil and sugar cane as feed-stock (Annex 4). Within the EU, it is likely that this amount of land might become available, without decreasing the area dedicated to nature. Under a baseline scenario, the decrease in utilized agricultural area is expected to be in the order of 10 million hectares, relative to 2000, and set-aside area is projected to remain at the level of 2000 (Nowicki *et al.*, 2006a). As in 2007 the obligatory set aside percentage was set at 0%, an additional area of approximately 4 million hectares could be cultivated, without policy restrictions.

The imported biomass however, will put extra pressure on land resources and biodiversity, in this case specifically in Asia and Brazil.

Climate change

Assessments of climate change impacts on agriculture in the EU predict benefits such as increase in yields and possibilities for new crops and varieties in Northern Europe. Across Europe, the south-east regions and the Mediterranean areas are considered the most vulnerable. Agricultural production systems are expected to gradually adapt to these changing conditions.
Reidsma and Ewert (2007) analyzed the relationship between farm diversity (i.e. diversity amongst farm types) and the effects of climate variability on regional wheat productivity. Their results suggest that the diversity in farm size and intensity reduces vulnerability of regional wheat yields to climate variability, and therefore increasing farm diversity could be a strategy to adapt to unfavorable conditions.

Animal diseases

An overall increase in global livestock production and in trade volumes for meat contributes to a possible fast spread of diseases. For major animal diseases, disease monitoring is in place at international, regional (EU) and national level. Timely reporting of a disease is important in order to contain a disease and restrict socio-economic damage.

Even in countries with strict monitoring systems in place, outbreaks are unavoidable. Out breaks of Classical Swine Fever, for example, occur in The Netherlands about every 15 years. The recent outbreak of Blue Tongue has shown how a new disease can spread rather fast over EU territory, but in this case with relatively little impact on overall food security. Experts consider a future outbreak of an unknown disease possible.

The risk of animal diseases is expected to be smaller in large intensive production systems, but the impact will be much larger when hit by animal diseases. At the same time it is suggested that disease dissemination can be better contained under more controlled conditions (Bergevoet, pers. comm.). Hot spot regions of livestock production however, pose environmental risks in the form of pollution of air, soil and water and strict implementation of environmental policies on water quality is needed. In regions with high production of arable crops, additional livestock might create opportunities for more efficient nutrient cycling (Rienks *et al.* 2008).

The EU meat sector has suffered serious damage from disease outbreaks. Consumers' immediate response to the occurrence of disease is a decrease in meat consumption in general and of the affected animal in particular. Food scares have caused an increase in consumer's awareness in terms of food safety and health. Trade disruption by and consumer reaction to fears of infectious animal diseases are not reflected in long-term consumption patterns, as per capita meat consumption in the EU was only 50 kg in the EC-6 during the late 1950s, 87.3 kg in the EU-15 in 1990 and 93 kg for the EU-27 in 2006 (Fefac, 2007; Nowicki *et al.*, 2006a).

Trade risk – collapse of soybean imports

For commodities for which the EU relies on imports, trade risks were hypothesized to inherit a potential risk to European food security. Soybean is the only commodity that is almost fully imported, and is an important source of feed both because of the quantities imported and because of the protein quality. The soybean case was taken as an example of a possible sudden disruption of an important supply line.

The chance that soybean imports would collapse due to the EU's zero tolerance regime is considered realistic by organizations such as Fefac (The European Feed Manufactures' Federation) and MVO (Product Board for Margarine, Fats and Oils). The presence of EU non-approved GMOs has already affected imports of maize feed products as the import of 5 million tons of corn gluten feed (CGF) and distiller's dried grain soluble (DDGS) was rejected, resulting in 5 billion euro additional costs to livestock producers (Fefac, 2008b). Overall, economic implications for EU livestock production are limited. Even when considering the combined imports of maize grains, CGF and DDGS, an interruption is unlikely to have a strong economic impact on future feed imports and livestock production at the overall EU feed level. The imported maize and CGF correspond with about 9 -12% of the EU-27 maize production of 54 to 62 million tons. These feed ingredients can be purchased GMO free from other origin, or be replaced by other cereals or no-grain feed ingredients or by-products (EC, 2007b).

A collapse of the total imported amount of about 34 million tons soybean meal equivalent is projected to result in a decline in EU meat production of roughly 25%, assuming 6.6 million tons soybean meal to be substituted by rapeseed meal and sunflower seed meal. It is expected that per person meat consumption would decline by some 10-15% only because of reduced meat export and increased imports. Food security will not be jeopardized, as current meat consumption is more than twice the recommended volume of the dietary guidelines (The Netherlands Nutrition Centre, 2008). A sudden disruption might push numerous farmers that depend on this feed source into great difficulties to maintain their livelihood, while the viability of various feed enterprises may be at stake. Notably the production of the pig and poultry sector will be severely affected, as their feed rations have high inclusion rates of soybean meal, and are more limited in the raw material use.

As soybean meal is an ingredient in dairy feed as well, milk production may be affected but the extent to which this might happen has not been analyzed. In the poultry sector, egg production might be affected as well. This study has only looked into meat production and has not studied the consequences for egg production and consumption.

There are limited options to cope with a collapse of soybean imports. The number of substitutes is large, but the replacement of the soybean protein calls for high quality feed products. There are no, or not enough, immediate substitutes available on the world market, as traded volumes of the substitute crops are only some 10 to 20% of required amounts. It would take several months before a new harvest would become available, and even then, it is not sure if that would suffice to replace the shortfall. Current levels of stock are insufficient to cover the needs beyond the first few weeks after the disruption. Faced with a shortage of feed, livestock farmers will reduce the inflow of young animals and (surprisingly) increase temporarily the outflow of older livestock. Consequently, meat may be briefly in higher supply.

A similar pattern can be seen with increasing feed prices as experienced in 2007. Producers looked for cheaper feed ingredients and replaced for instance wheat by millet (Klein, pers. comm.). Producers, who have the flexibility to switch from livestock production to arable cropping, might do so if high feed prices make livestock production unprofitable. In Eastern Europe high feed prices resulted in early slaughtering of livestock (Köster, pers. comm.).

There is some scope to mitigate adverse short-term effects by raising the stock levels of soybean in Europe. Soybean stocks are kept primarily in the USA, Argentina and Brazil, and global soybean 'stock to use ratios' exceeds 25%, while it is less then 3% in Europe. Higher stocks in the EU would smooth a transition to other feed sources. With a monthly use equivalent to about 3.4 million tons soybean, a soybean stock of about 10 million tons could cover about 3 months' consumption providing time to secure other sources of proteins. A stock in the EU of 10 million tons would correspond with 10 to 15% of the global stock over the past four years.

Europe could respond to this collapse by producing the substitutes on its own territories. Though increased demand for protein rich feed might cause higher international prices to trigger production elsewhere, this effect is not further considered and all substitutes are assumed to be produced in the EU. Considering cropping seasons, the first harvests could be expected under most favourite conditions at the earliest 6 to 10 months after the import interruption, though not yet in quantities to replace the deficit.

To cultivate protein rich feed crops, including soybean, rapeseed, sunflower and pulses, Europe would have to allocate an area of some 27 million hectares if this calamity would occur in the very near future and some 20 million hectares in 2020 due to productivity increase. In the very near future, this can partly be met from formerly set-aside land, and by converting some arable land from food to feed production, but nature area would have to be claimed as well. The latter is expected to meet much resistance, as it would be conflicting with EU biodiversity policies. It could have far-reaching adversary effects on efforts that are being made to meet the target of the EU to stop the loss of biodiversity by 2010.

Sufficient agricultural land is projected to become available by the year 2020 when some 26 million hectares are expected to be superfluous under a free trade scenario. If land is in the meantime, used for biofuel crops, the pressure on land is likely to be augmented only partially, as the proteins form a natural by-product of the 1st generation biofuel crops. Hence, the introduction of biofuel crops in Europe increases the domestic supply of proteins, and might thus reduce the exposure of the EU to possible trade shocks in the supply line of soybeans or may even replace the imports of soybean meal.

Further analysis on the synergy between biofuel crops and feed is needed to properly evaluate the contributions of such dual-purpose crops. Europe should, for instance, comply with international agreements that may set limits to production. Until recently the Blairhouse agreement limited oilseed production in the EU. At present, this agreement does not seem to pose restrictions on expansion of oilseed production due to decoupling of subsidies and direct payments and abolishment of the obligatory set-aside regulation (Van Berkum, pers. comm.). Therefore, agricultural and economic viability are relevant issues and the consequences for third countries should be better assessed.

In addition, the quality of feed with high inclusion rates of rapeseed and sunflower seed meal and peas, has to comply with demand of the feed sector. The growth rate of animals decreases too much with a higher proportion of rapeseed meal. Substitution by peas is also bound to limits, due to its high variability of digestibility of the proteins in monogastrics.

The consumption of rapeseed meal in the EU-27 has steadily increased over the last five years from nearly 6 million tons in 2003, via 7.7 in 2005 to over 9 million tons in 2007 (ISTA Mielke, 2007). According to Rabobank (2007), biodiesel production in the EU would result in a rapeseed meal production of 17.3 million tons by 2010. This figure would correspond with the maximum absorption by the feed industry in the EU-15, with the cattle, pork and poultry sector consuming respectively about 10, 5 and 2 million tons of rapeseed meal. About 90% of rapeseed meal was consumed in the EU-15 in 2006 (Fediol, 2007). In our study, substitution of soybean meal by other protein crops would result in an inclusion of 22 million tons in addition to the actual consumption of 7.7 million tons in 2005, which would imply a total consumption of nearly 30 million tons for the EU-27. The substitution for soybean meal in our analysis has been restricted to four protein crops, which possibly has resulted in extreme values. The inclusion rate of rapeseed meal of 15% is the maximum for pig feed, but exceeds the acceptable inclusion rate for poultry feed. In practice more than the four selected protein crops will be used for substitution and cultivated than assumed in our analysis. The results on the cultivation area required might however not differ much from our estimates.

It has to be noted that despite an increasing demand for protein crops, which is mainly used as feed, the area under protein crops such a peas is constantly decreasing (Eurostat, 2008).

In case the collapse is caused by a restriction of the EU to import soybean, such as GMO regulations, the EU will face a deficit in soybean meal, while a surplus amount of soybean will enter the world market. The EU will also be confronted with a shortage in vegetable oil, as it will lose the oil obtained from crushing imported soybean, which in 2005 was 2.6 million tons, about 11% of domestic vegetable oil consumption.

A soy calamity will influence world prices of feed, meat and oil differently, depending on whether the calamity only affects Europe (e.g. due to an import restriction) or the whole world (e.g. when soy production collapses). If soybean meal is available for non-EU countries, substitutes like copra, cottonseed meal or palm kernel meal might become available to the EU, slightly reducing the decline in soybean meal availability. When only European farmers are affected by higher feed prices, the global meat price will rise due to an increased meat demand from Europe and the global feed price will decline, due to a surplus of soybean meal available on the world market. However, if global soy production collapses, possibly fierce competition for feed will drive up prices. Livestock producers all over the world face higher production costs which will likely decrease production of meat in the medium term. Next to the EU, large importers of soybean and soybean meal currently are the emerging economy of China, Central and South America, Japan, Indonesia and Thailand. Higher feed costs and lower meat availability will drive up the global meat price, which will affect consumers all over the world.

A calamity in soybean production in the USA or Latin America, the main production areas, would not only result in a decrease in protein rich food and feed but in oil as well. Especially developing countries, such as Bangladesh and Syria, which have recently shown an increase in vegetable oil imports and consumption, will be harmed if global oil availability declines. Substitute crops produced in the EU to compensate for the protein shortfall will result in the simultaneous production of vegetable oils. The produced oil is enough to compensate for the oil deficit in the EU and the surplus would be required to supply the global gap. Hence, the use of the vegetable oils for biofuels under this scenario would adversely affect the food security of the poorer oil importing countries.

The impact of European coping measures and response strategies are likely to have little impact on developing countries in case of a collapse of EU soybean (meal) imports. Soybean is a commodity primarily used for feed, while the substitution crops are generally grown and traded in and between current developed nations, such as the USA, Canada and Eastern Europe.

The quantity of imported soybean (meal) by the EU in 2007 puts in the main countries of origin a claim on land of 7.1 million hectares in Brazil, 6.4 million hectares in Argentina, 1.3 million hectares in the USA and 0.3 million hectares in Paraguay, totaling to approximately 15.1 million hectares (ISTA Mielke, 2007). The area required to cultivate feed substitutes in the EU with comparable protein content, is in the order of 27 million hectares, primarily because of lower protein contents of the substitute crops. Alternatively, a comparable area of 15 million hectares would be needed in South and South-eastern Europe if soybean production would be expanded at current yield level (Stehfest, E. *et al.*, 2007). The EU has potentially sufficient agricultural land. In order to be assured of access to land for agricultural expansion in case of calamities, areas could be earmarked for that purpose and serve as a buffer.

A consequence of the claim on land outside the EU is that associated land expansion is likely to results in loss of biodiversity, such as the Cerrado and Amazon biomes in Brazil and the Chaco biome in Argentina.

The study of a disruption of the soybean supply to the EU revealed that the EU production of meat could be drastically affected by trade measures, despite the overall self-sufficiency in food of the EU. It also showed that to cope with such a disruption, the EU would call upon the world market for substitute sources of proteins (and substitute meat) as the EU would have severe difficulty to find these substitutes within its own borders. This assumes a properly functioning global market.

Biodiversity

Loss of biodiversity occurs principally because of conversion of forests and grasslands into agricultural land. Since further expansion of agricultural lands for cultivation of food, feed and fuel, is expected in (sub-) tropical regions, pressure on biodiversity will increase specifically in those areas. Within the EU approximately 26 million hectares are expected to become available by 2020 under a liberalization scenario, due to the trends of land abandonment, increase in productivity and stagnating production, that might suffice to a large extent in meeting the current obligatory blending targets and hence, not leading to a decline in natural area. Biodiversity linked to extensively used agricultural land (farmland biodiversity), might decline due to intensification. However, largest decline in biodiversity is expected when natural land is converted into cultivated land (Hengsdijk *et al.*, 2005; Tonneijck *et al.*, 2006).

The present livestock production in the EU depends apart from locally available feed resources also on feed concentrates that are traded. Feed trade and the related transfer of virtual water, nutrients and energy is a determinant factor of the sector's environmental impacts. While these impacts are out of the scope of this study, they ought to be taken into consideration when outlining coping and response strategies to calamities, because of their indirect effect on competition for natural resources.

Shocks and price development

Policies to shield domestic markets from the international market are not opportune for the EU, which calls for the search of other options to reduce the adverse effects of trade shocks. Stocks of goods may offer a buffer against strong negative effects, like sudden shortfalls in production and price hikes. However, using strategic stocks as a preventive measure may give rise to some questions regarding the price effect. High levels of stocks stabilize prices, but also depress the prices somewhat, depending on the rules and institutions set up for these strategic stocks. Rules regarding stocks could include regulations about under which conditions stocks should be released on the market (conditions for sale). For example, when a production distortion causes a sudden price increase, strict regulations concerning the stocks should decide whether stocks are sold on the market or not. If the rules and regulations are fixed, stocks do not play a role, as long as the conditions for sale are not (almost) met. When in a situation stocks are almost released, speculators will anticipate on this possibility, which could influence market prices.

Recent history showed that stocks of raw materials did not depress prices when prices were low, but did (temporarily) prevent price increases when stocks were (almost) sold (Herrmann *et al.*, 1993). In general, international agreements provide stricter rules to stock usage than national plans. National governments are more likely to be pressured to sell (or not sell) stocks, which increases uncertainty on the national markets. This could have a negative (or positive, in the case of not selling stocks) impact on production. Alternatively, policy measures concerning stocks could also imply stimulating or discouraging different applications of grain, to have some control on grain production. Furthermore, by providing subsidies for area used for grain production, governments can also control the amount of land used for grains, which can be seen as an indirect form of land use planning. The need for stocks as governing tools has been recognised by IFPRI. It is suggested to use an international institutional arrangement, involving building up a physical, public, globally managed grain reserve to cope with possible shocks to the grain market (Von Braun and Torero, 2008).

Openness to trade serves as a source of exposure to risks and also as an opportunity to cope with the adverse effects that a disruption might have. Such additional trade can also help in case of production shortfalls that occur within the EU itself. Since globalization does not directly imply increasing risks, openness to trade seems more likely to mitigate risks rather than increase the exposure to risks. Furthermore, trade agreements play an important role in global trade. It is debatable whether strategic behaviour in the future may play a role when it comes to these agreements. However, it is not very likely that international agreements in the global market will exclude certain countries from trade flows of commodities in the near future. Currently, structural flows of grains between countries are in the form of food aid and are monitored by international organisations such as the World Food Programme (WFP) and the International Grains Council (IGC). The possibility to secure trade flows from food exporting countries to the EU seems difficult since it would imply foreign governments imposing commitments of delivery on private organisations and buying these commodities. Such a measure would be very expensive and politically difficult. This could probably be less difficult for countries with high government intervention in the food sector like, China, Russia, India and Egypt. However, large private parties like ADM, Bunge, Cargill and Dreyfus, as well as governmental organisations are active on the world grain and soybean market. If these parties and governments would be involved in trade agreements involving large quantities, their actions might influence the prices on the world market.

Presently, prices on the grain market seem to reflect current scarcity and real prices are not determined by price-fixing behaviour of governments. It could be interesting to look at the influence of trade agreements on the world market to be able to understand the effects better.

Single versus multiple calamities

Although a single calamity does not seem to drastically affect food security in Europe, the accumulation of different calamities, such as dry and hot spells together with disruptions in the soy chains under a globalizing scenario with concentrated production areas, may have a bigger impact on the European food system. On the other hand, one calamity could also reduce the impact of the other for instance if a serious outbreak of animal disease would occur simultaneously with a shortage in feed. These accumulated effects have, however, not been investigated in this study and need further attention, as unexpected effects might become apparent, such as on synergies, mutually enforcement, and oscillations.

7. Conclusions

This study has looked into the resilience of the European food system to calamities in an ever-globalizing world with regard to the availability of food.

1. The current food security of the EU-27 is well guaranteed, with self-sufficiency in basic food items with the exception of soybean (meal) and vegetable oils. Projections towards 2020 show that this will virtually remain unchanged, also in a scenario of trade liberalization, because of the strong economic viability of the European food system compared to other global regions. Within Europe, a concentration of production is expected in the most favorable regions of North-western Europe.

2. Consumption patterns contain hidden buffers in the sense that 60% of our cereals are used for meat production and meat consumption could be halved without harming dietary needs. Moreover, much food that appears as 'consumption' is actually not eaten, but wasted.

3. Climate change will not endanger the food situation of the EU-27 as a whole before 2020, but it is likely to favor the production conditions in Northern Europe, while Southern Europe will face increasing drought. However, these effects may not entirely materialize within the timeframe of this study, i.e. 2020.

4. Single event calamities as have occurred over the past decades such as drought, animal disease outbreaks and the Chernobyl nuclear accident, have put food production under pressure, but did not put European food security into jeopardy. Outbreaks of animal diseases pose a continuous threat, but this can be controlled by sound monitoring systems and control strategies to be in place at global, regional and national level.

5. A combination of two or three calamities, either occurring simultaneously or sequential, could expose the European food system to additional risks, but little is known about these scenarios. Therefore, careful assessment is necessary, before making firm conclusions, because of the complexity of mutually reinforcing and reducing effects.

6. The EU has formulated an energy policy with a target of 20% renewable energy by 2020, with bioenergy providing two-thirds, equivalent to 210-230 million ton oil equivalents (Mtoe). This figure includes 31-43 Mtoe biofuel, which represents a share of 10% of biofuel in transport fuels. To meet this biofuel target, between 20 and 30 million hectares will be needed if all energy crops are cultivated in the EU, and 1st generation food-based technology is used. It is estimated that 10 to 26 million hectares would be available by 2020, depending on the trade scenario. Approximately half of the feedstock required to meet the biofuels target could then be met, while the remaining feedstock will have to be imported. Not included in these estimates of land requirement is the area needed for the remaining 180 Mtoe for the production of electricity and warmth, which implies an increased pressure on land and nature resources.

7. A hypothetical complete collapse of EU imports of soybeans, will lead to a major deficit of protein-rich feed. Immediate coping measures include use of stocks and substitutes for soybean meal. However, as EU stocks in oilseeds and meals are low and as there are not enough immediate substitutes available on the world market, these measures will not suffice to substitute the entire shortfall in soybean. Consequently, the meat production and the processing and feed industries will be severely affected, but European food security will not be under threat. European meat production, primarily pork and chicken, is expected to decrease by roughly 25% and annual per capita meat consumption by some 10-15%, because of increased meat imports, but will still remain well above recommended volume of the dietary guidelines. Employment in the pig and poultry sector is likely to be reduced. Prices of feed will rise dramatically and those of meat substantially, with consequences for inflation rates and real consumer budgets.

8. As a response strategy substitute crops for soybean imports could be cultivated in the EU. This would require an area of approximately 27 million hectares if this calamity would occur in the very near future and some 20 million hectares in 2020 due to productivity increase. In the very near future, this can partly be met from previous set-aside land, or other crops, but would put a claim on nature area as well. Taking cropping seasons into consideration the first harvests could be expected under most favourite conditions not before 6 to 10 months after the import collapse. Over time Europe can agro-technically respond by producing its own protein crops though policy support will be required to stimulate this development, e.g. by taking into cultivation the released 10 to 26 million hectares by 2020.

9. Synergy might be attained by combining the claims on land for some of the substitute feed crops and energy crops. Oilseeds such as rapeseed, sunflower and soybean, after crushing yield protein-rich oil meals, which can be used as feed and vegetable oil which can be used for biodiesel. DDGS a by-product of bio-ethanol production from cereals can be used as feed as well. Some pit-falls should however be analyzed in more detail to prevent hasty conclusions, such as the actual land areas that will become available, costs involved to stimulate the cultivation of these crops in Europe, maximum amounts of oil crop meals that can be mixed in feed, the use of the oil to replace the shortfall in oil import or production elsewhere in the world, et cetera.

10. There is some scope to mitigate these short-term effects by raising the stock levels of soybean in Europe. High levels of stocks as a measure to secure steady supply can stabilize market price but also depress overall price levels. It might be advisable though to have an international or European institutional arrangement for building up a physical, public, globally or European managed reserve to cope with possible shocks.

11. The impact of coping and response strategies of Europe, in case of a collapse of EU soybean imports, is not likely to adversely affect developing nations to a significant extent. Most of the substitute crops will be purchased in developed countries. A larger impact is expected due to the shortfall in vegetable oil in case of a collapse of global soybean production.

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Annex 1.
Leading hypotheses to the study

Table 1 presents two overall hypotheses and four partial ones, which were formulated by the Steering Committee for Technology Assessment and served as leading questions for this study. These hypotheses have been indirectly answered in the report, but are explicitly addressed here.

Table 1. Hypotheses 'Resilience of the global food system to calamities' .

Hypotheses 'Resilience of the global food system to calamities'

The following hypotheses will be researched in this study:

1. In case of further geographically specialization (as a result of increasing globalization) the vulnerability of the (global agricultural system) increases due to following calamities such as drought and floods, pests and diseases, bio-terrorism, disruption of trade flows (e.g. as a result of war),collapse of the internet system and nuclear disaster (accident in nuclear plant)
2. Food security in the EU will not be endangered overall, but the availability of some basic food items will be at risk, such as cereals, soy and meat.

In order to test these two overall hypotheses, the (possible) consequences of the evolving process of globalization will be studied first along the following partial hypotheses

3. The expected evolution of globalization will result in increasing geographically specialization of agricultural production. For instance: in each climate and energy scenario Brazil's share in global agricultural production will at least triple (Food and feedstock).
4. This trend is accelerated by liberalization of trade and agricultural policy.
5. Climate change does have an impact on geographical distribution of agricultural production, but not on the degree of geographical specialization.
6. Higher energy prices and policy measures result in increasing agricultural production for bioenergy and therefore decrease food security and area dedicated to nature.

Outcomes of the study with regard to the hypotheses

- *In case of further geographically specialization (as a result of increasing globalization) the vulnerability of the (global agricultural system) increases due to following calamities such as drought and floods, pests and diseases, bio-terrorism, disruption of trade flows (e.g. as a result of war), collapse of the internet system and nuclear disaster (accident in nuclear plant).*

This hypothesis is based on the assumption that globalization leads to geographical specialization of the global agricultural system, which might therefore be more vulnerable to calamities. The overall assessment suggest that this hypothesis is not likely to be true, because a strong geographical concentration is not likely to take place within the timeframe of this study, i.e. 2020, and because calamities elsewhere are not likely to cause dramatic effects for the EU food provision.

The impacts of droughts and floods (as under climate change) will be discussed under hypothesis 5. The nuclear accident of Chernobyl was a disaster in terms of casualties, but it did not have a large impact on food security. An area of 784 thousand hectares of agricultural land was taken out of production, which could be compensated for. Trade is one of the ways to spread pests and diseases. In that respect, the increase in trade might increase occurrence of pests and diseases. However, the export criteria for traded goods, serve as a safety system, if all parties involved cooperate. Bioterrorism and collapse of the internet system have not been further studied, as is the case with geopolitics

- *Food security in the EU will not be endangered overall, but the availability of some basic food items will be at risk, such as cereals, soy and meat.*

Europe's food self-sufficiency will roughly remain at current levels, also under full trade liberalization and taking population growth and increasing demand for food on the world market into consideration. Although geographical specialization within Europe may lead to higher production in favorable areas (North-West and East of Europe), it is not clear whether this leads to a higher vulnerability and higher risks. Since Europe is self-sufficient when it comes to producing cereals, only a shock within European borders can threaten food availability of cereals. The drought event of 2003 caused a decrease of some 10-15% in cereal production, but the effects were mitigated by stocks and additional purchase from the international markets.

As the annual soybean consumption of 34 million tons is nearly fully imported and an important protein feed ingredient, a collapse of imports will make itself felt in the livestock sector. The case we analyzed in this study was the impact of the collapse of soybean imports to the EU. European meat production is projected to decrease with roughly 25%. This decrease of meat availability in Europe will not threaten food security in general, as current consumption of approximately 93 kg per person per year is well above recommended levels, but it will however harm the meat production and processing industry and feed industry. The EU is presently self sufficient in meat, though the availability of home produced cereals and imported soy are main feed ingredients that will affect animal production in case of calamities.

- *The expected evolution of globalization will result in increasing geographically specialization of agricultural production. For instance: in each climate and energy scenario Brazil's share in global agricultural production will at least triple (Food and feedstock).*
- *This trend is accelerated by liberalization of trade and agricultural policy.*

It is indeed presumed and projected in various analyses that the contribution of Brazil and other Latin American countries to the global food availability will increase, though a tripling may take a period beyond the timeframe of this study. Within Europe, policy, even more than ecological comparative advantages, will influence production of food commodities. It is not expected that the geographical specialization will become sharper than it is at the present.

- *Climate change does have an impact on geographical distribution of agricultural production, but not on the degree of geographical specialization.*

Climate change is projected not to have much impact on total global food production. The positive effects are mainly experienced in the temperate zones and the negative aspects in the tropical and sub tropical zones, which might lead to higher dependence on food imports. For the EU, climate change may reinforce intensification of agricultural production in Northern and Western Europe and extensification in the Mediterranean and South-eastern parts of Europe. At the short term, an increasing frequency of extreme conditions is likely to have an impact on plant and animal production. Single event calamities as experienced up to now did not result in such large decreases in food availability that this could not be replenished from stocks or bought at the (open) market.

- Higher energy prices and policy measures result in increasing agricultural production for bioenergy and therefore decrease food security and area dedicated to nature.

Within the EU approximately 26 million hectares are expected to become available, under a liberalization scenario, due to the trends of land abandonment, increase in productivity and stagnating production, that might suffice to a large extent in meeting the current obligatory blending targets and hence, not leading to a decline in natural area. Biodiversity which is linked to extensively used agricultural land might decline due to intensification. However, large decline in biodiversity is expected only when natural land is converted into cultivated land.

Higher energy prices do increase world demand for biofuels. However, the biofuels policy targets set by governments influence demand for biofuels much more than high oil prices. Studies showed that food and energy markets are interlinked. The oil prices put both a ceiling and a floor for prices in the food market. However, the driver for biofuel production in the EU, USA, and Canada is mainly political, including tax exemptions, investment subsidies and obligatory blending of biofuels. The influence of the mandatory blending is expected to be more significant than the influence of the crude oil price.

Annex 2.
Consulted experts

The following experts have been interviewed, and provided us with information and insight in their fields of expertise.

Climate Change:	
Verhagen, J.,	Plant Research International (PRI), Wageningen UR
Bioenergy:	
Elbersen, B.S.,	Alterra, Wageningen UR
Langeveld, J.W.A.,	Plant Research International, Wageningen UR
	Present contact address: Biomass Research, Wageningen
Biodiversity:	
Kleijn, D.,	Alterra, Wageningen UR
Plant diseases:	
Schans, J.,	Plant Protection Service (PD), Wageningen
Animal diseases;	
Bergevoet, R.H.M.,	Agricultural Economics Research Institute (LEI), Wageningen UR
Hagenaars, T.J.,	Central Veterinary Institute (CVI), Wageningen UR
Maassen, C.B.M.,	Central Veterinary Institute (CVI), Wageningen UR
Poel, W.H.M. van der,	Central Veterinary Institute (CVI), Wageningen UR
Animal feed:	
Gerrits, W.J.J.,	Animal Nutrition Group, Wageningen UR
Meijer, G.A.L.,	Animal Science Group (ASG), Wageningen UR
Sebek, L.B.,	Animal Science Group (ASG), Wageningen UR

Additional information has been provided by the following persons:

Berkum, S. van,	LEI, The Hague
Blok, M.C.,	Product Board for Animal Feed (PDV), The Hague
Klein, F.T.J.,	Produktschap Akkerbouw (PA), The Hague
Köster, F.,	Product Board for Margarine, Fats and Oil (MVO), Rijswijk
Verstegen, M.W.A., emeritus professor,	Animal Nutrition Group, Wageningen UR

Annex 3. EU land use

1. Definitions of land use type

The total land area for the EU-27 sums up to 432 million hectares, including inland waters. Different land use types can be distinguished and are defined in Table 1. These definitions are provided by Nowicki *et al.* (2006b) and EC (2007c) and will be used throughout this chapter.

Table 1. Definitions of land use types.

Land type	Definition
Built-up area	All areas occupied for residential, commercial, industrial and infrastructure purposes. These areas are considered not to be any more available for economic forestry or agricultural activities.
Arable land	Land worked regularly, generally under a system of crop rotation; which includes fallow land
Permanent crops	Crops not grown in rotation, other than permanent grassland, which occupy the soil for a long period and yield crops over several years
Grassland	Land used permanently (for five years of more) to grow herbaceous forage crops, through cultivation or naturally and that is not included in the crop rotation on the holding; the land can be used for grazing or mowed for silage or hay
Natural vegetation	Natural vegetation includes natural grasslands, scrublands, regenerating forest below 2 m and small forest patches within agricultural landscapes.
Forest	Includes forest area, other wooded areas
Other	Land assumed to be unsuitable for agriculture or urban expansion, which is based on adverse environmental conditions at these locations. Examples are inland wetlands, glaciers and snow, beaches and dunes, water and coastal flats etc.
Recently abandoned arable land/grassland	i.e. 'long fallow', it includes very extensive farmland or grassland not reported in agricultural statistics, herbaceous vegetation, grasses and shrubs below 30 cm
Utilized Agricultural Area (UAA)	The total area used for crop production, which is exhaustively described as arable land including temporary grassing and fallow and green manure, permanent grassland, land under permanent crops, crops under glass and other utilized agricultural areas.

Source: EC, 2007c; Nowicki et al., 2006b.

2. Developments and trends in land use

Table 2 shows land use for the EU in 2000 and the projections to the baseline 2020 and liberalization 2020 scenario. Nowicki *et al.*, (2006b) obtained these results from calculations based on LEITAP/IMAGE results. The transitions are the results of changes in land claim due to economic changes, but can also be the result of changes in location without a change in demand (Nowicki *et al.*, 2006b).

Data from EURURALIS show similar land use patterns when comparing it with the Scenar 2000 level. However, discrepancy in the available data exists since the UAA provided by EUROSTAT in 2005 is much lower (184 mio ha) than the 2000 level (203 mio ha) provided by Nowicki *et al.*, 2006b. This will be elaborated in the discussion (section 4).

Table 2 shows an expected increase in built-up area under all scenarios and a decrease in arable land and land under permanent crops. The UAA in the baseline sums up to 203.4 mio ha (47% of 432 mio ha) and is expected to decline under the liberalization scenario to 177.12 mio ha which corresponds to a decrease in UAA of 12.92%.

Table 2. Change in land use EU-27.

% of total land area	2000	2020 baseline	2020 liberalization
Built-up	4.4%	4.5%	4.5%
Arable	29.8%	27.5%	25.0%
Permanent crops	3.5%	3.2%	2.9%
Grassland	13.7%	14.1%	13.1%
Natural vegetation	11.7%	11.8%	13.2%
Forest	32.3%	32.8%	33.1%
Arable land -Recently abandoned	0.0%	1.0%	2.6%
Grassland- recently abandoned	0.0%	0.4%	1.1%
	95.4%	95.3%	95.5%
Other	4.6%	4.7%	4.5%

Source: Nowicki et al., 2006b.

Built-up area

Built-up area is increasing in all scenarios and in all countries in the EU-27.

Most of the changes involve a relatively small area since built-up areas do not occupy a very large area compared to agricultural area in most parts of the EU. However, changes in built-up areas can have a large effect on the landscape and the surrounding functionality of the agricultural, natural and abandoned areas to meet recreational demands. It is assumed that built-up area is not converted back into another land use type, even when population is deceasing (which can be noticed in the case for the Czech Republic, Hungary, Poland and Slovakia).

Arable land

The general trend for arable land is a decline in total area except for Romania and Bulgaria (in all scenarios) and the Baltic States (in the baseline scenario).The decrease in arable land is largest in the liberalization scenario. Liberalization does not include any support for the Less Favored Areas (LFA), and therefore the effect on abandonment of marginal scenarios is more pronounced. In the liberalization scenario, land abandonment occurs in almost all countries in multiple hotspots. The hotspots are predominantly located in the marginal agricultural areas.

Grassland

Some countries show an increase in grassland while other countries show a decrease in area under grassland. This effect is due to relocation of grassland areas, to replace arable land or permanent crops, which are abandoned. As areas of arable land are decreasing; grassland areas move to more suitable areas which are released by this decreasing arable land area. Grassland is also relocated due to urbanization pressure.

Forest

Forest areas are determined by the current pattern of forest and will change due to deforestation and succession of abandoned farmland and scrubland into forest

The trend shows an increase in forest areas in all scenarios for the regions Southern France, Italy and the North West of the Iberian Peninsula. A decrease in forest area due to agricultural expansion is expected for Bulgaria and Romania under all scenarios. For Latvia and Lithuania, this decrease is also expected but only under the baseline scenario. Furthermore, under the liberalization scenario part of the forest area in Ireland will be converted into grassland.

Recently abandoned arable land/grassland

This type of land use is considered an intermediate state in the natural succession from recently abandoned farmland to forest. Under certain conditions, succession will be so slow that the vegetation will remain in the abandoned farmland class for a long period. The abandonment of land under the liberalization scenario will be much larger (16 mio ha) than the abandonment under the baseline scenario.

Figure 1 presents the predicted trends from the Scenar 2020 study (2006b) in land usage (data correspond with those in Table 2) . Remarkable is the difference in development in grassland; the baseline scenario predicts and increase in grassland which is in contrast to the liberalization scenario.

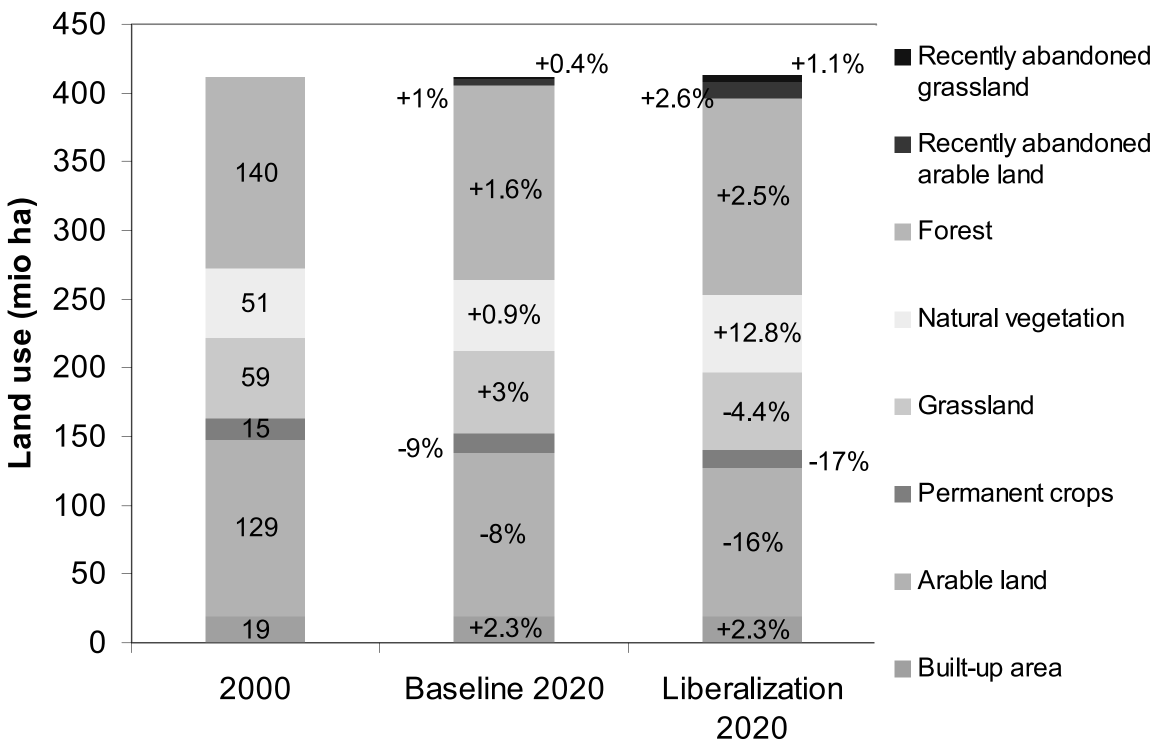

Figure 1. Trends in land use patterns under baseline and liberalization 2020.

3. Land availability in 2020

Based on land abandonment and decrease in UAA projected by the Scenar-2020 study, land will become available in 2020 to grow crops such as energy or protein crops. Table 3 presents the projections from Scenar-2020. Under the liberalization scenario, more land will become available than under the baseline scenario. The available amount of land in 2020 will therefore depend on the condition under which land will become available. In the baseline scenario, the reform of the CAP is less drastic than the reform under the liberalization scenario, as explained in Table 2.3, chapter 2.The future changes in CAP will therefore be an important determinant for the amount of land available in the near future.

Table 3. Area available in 2020 due to land abandonment and decrease in UAA.

	Baseline 2020	Liberalization 2020
UAA under scenario	193.5	177
Land abandonment	6 (3.1%)	16 (9%)
Decrease in UAA	9.5 (203-193.5)	26 (203-177)
Total land availability	15.5	42

Source: Nowicki et al., 2006b.

The EURURALIS simulations show that agricultural abandonment is the most important land use conversion in the EU-27. Abandonment of agricultural land occurs in all scenarios of EURURALIS and it ranges from 2 to 13% of the agricultural area. This means that roughly between 3.5 million hectares and 25 million hectares of agricultural land may become abandoned between now and 2030. This is roughly in line with the scenarios of the Scenar 2020 study (2006b).

Furthermore, the European Environment Agency (EAA, 2006) expects an amount of 16 million hectares to be available in the year 2020, which is also in line with the baseline scenario of the Scenar 2020 study (2006). EAA (2006) states that the potential available land is made up of arable land released from food and fodder production, and land that is released through productivity increase. However, whether the latter development will indeed cause a decrease in land use is debatable. In economic theory farmers behave like ‘profit maximizers’, meaning that in stead of a decrease in land use, an increase in production will occur.

In addition to the actual amount of land availability in 2020, it is also important which lands will become available. Not all land is suitable to grow crops on, for example, marginal lands are not very suitable. The actual amount of available land to grow oil crops on can therefore differ from the projections given by the different studies.

4. Discussion

Some comments can be made when looking at the projections provided by Nowicki *et al.* (2006b). Although there are other studies that show similar patterns and numbers, like EURURALIS and the EAA (2006) study, there seems to be some discrepancy in the data when comparing the 2000 baseline level with more recent numbers. For example EUROSTAT data for 2005 show that the UAA of the EU-27 sums up to 184 mio ha. Nowicki *et al.* (2006b) provided an UAA of 203 mio ha in 2000, which is much larger. These discrepancies can lead to under- or overestimating the available land area in 2020.

The discrepancy in the data could possibly be caused by inaccurate use of data for the EU-25 translated to EU-27 data. Another reason could be that there are differences in definitions in the land use areas. Table 4 provides data on land use from EUROSTAT data.

Table 4. Land use in the EU in 2005.

Land use 2005	Million ha	Percentages
Built-up	19.4	4.5%
Arable	109.4	25.3%
Permanent crops	12.2	2.8%
Grassland	63.6	14.6%
Nature	207.4	47.9%
Of which forest and woodland	*160*	*37%*
Other	20	4.6%
Total	432	99.7%

Source: EC, 2007c.

Annex 4. Bioenergy scenarios

4.1 Land use and feed stock production

Bioenergy scenarios

Assumptions

General Assumptions

- The 10% biofuel share is mandatory and will be met in a linear fashion up to 2020
- 10% of the European transport consumption is provided by biofuels in 2020, demanding a biofuel production equivalent to 34.6 Mtoe (MNP, 2008)
- There are no restrictions for the direct blending of biofuels up to a 10% share
- All rape seed oil and biodiesel will meet sustainability standards and be freely available
- 1st generation biofuels is assumed for all scenarios
- Share of biodiesel is 55% : 19.0 Mtoe, expressed in litres of fuels this equals 22.9 billion litres of biodiesel (MNP, 2008)
- Share of bioethanol is 45%: 15.6 Mtoe, expressed in litres of fuels this equals 29.2 billion litres of bio-ethanol (MNP, 2008)

Rapeseed

- Yield in EU in 2005: 3.0 ton/ha
- Yield in EU in 2020 (+38%)= 4.1 ton/ha (OECD-FAO outlook, 2007)
    - oil-extraction rate is 40%

Sun flower seed

- Yield in EU in 2005: 1.6 ton/ha
- Yield in EU in 2020 (+38%) = 2.2 ton/ha (OECD-FAO outlook, 2007)
    - oil-extraction rate is 43%

Wheat: yield 2020 = yield 2005 + 20% (OECD-FAO outlook, 2007)
Sugar no yield increase yet

Scenario 1:
- All feedstock to be cultivated in EU
- 75% of the biodiesel is from rapeseed, as in 2005 (MVO, 2007)
- 25% of the biodiesel is from sunflower
- 50% from bio-ethanol is from wheat
- 50% from bio-ethanol is from sugar

Scenario 2:
For the EU, it is assumed that about two-thirds of the required feedstocks for the production of biofuels will be produced in the EU locally, and one third will be imported from both Brazil (bio-ethanol) and Asia

10% target to be met in 2020
57% of feedstock from EU
43% imported from Brazil (sugarcane) and Asia (palmoil)

Scenario 3: full liberalization -> no EU target
Production and import contribute to 3.6% of total fuel consumption in 2020 (Nowicki *et al.*, 2006a).

Table 1. Cultivation of energy crops: area required for three scenarios for EU-27 in 2020.

(mio ha)	Scenario 1	Scenario 2	Scenario 3
Rapeseed	9.5	5.4	
Sunflower	5.5	3.1	
Wheat	6.3	3.6	
Sugar beet	3.1	1.8	
Palm oil (Asia)		1.5	
Sugar cane (Brazil)		1.5	
Total	24.4	16.9	
Of which in EU	24.4	13.9	Max 8.8
Of which outside EU		3.0	

Calculation scenario 1

Biofuel target for 2020 is 34.6 Mtoe
19.0 Mtoe (55%) to be substituted by biodiesel and 15.6 Mtoe (45%) to be substituted by bio-ethanol

Biodiesel

As presently rapeseed oil makes up for 75% of biodiesel use, this percentage is projected to 2020. (14.3) Mtoe biodiesel) Adjusting for the energy content of biodiesel with respect to mineral oil (0.92) this will be a total demand of 15.5 million tons of biodiesel.
The production of 15.5 million tons of rapeseed oil requires 38.8 million tons of rapeseed cultivated on 9.5 million hectares.
The production of 5.2 million tons of sunflower oil requires 12.1 million tons of seed and 5.5 million ha for cultivation.

Bioethanol

15.6 Mtoe bio-ethanol equals 30.6 bio liters
For the EU the following calculations can be used, and have to corrected for increase in productivity.
Wheat: 2000 l bio-ethanol/ha (in 2020: 2400 l bio ethanol/ha)
Sugar beet: 5000 l bio-ethanol/ha
(USDA/FAS, 2006)

Assumption: wheat and sugar beet contribute both 50% to bioethanol production.
Production based on wheat, requires 6.3 million ha.
Production Based on sugar requires 3.1 million ha.

DDGS production: 1 ton of processed cereals yields 310 kg DDGS. (Woods and Bauen, 2003)
Protein content of DDGS: 36%

The total area required for bioenergy prod EU in 2020 is 24.4 million ha.

Scenario 2:
10% target to be met in 2020 (MNP, 2008): 34.6 Mtoe
57% of feedstock from EU: this implies 57% of the areas in scenario 1
The remaining 43% have to be imported.
Bio-diesel, based on palm oil from Asia require an area of 1.5 million ha
Bio-ethanol imports: based on sugar cane from Brazil requires about 1.5 million ha

Scenario 3: full liberalization -> no EU target
Production and import contributes to 3.6% of total fuel consumption in 2020. If these energy crops would be produced in the EU this would require an area of 8.8 million ha.

NB: the full liberalization scenario should be scenario 3 as described in this section (and includes at the most 8.8 Mio ha of energy crop production).

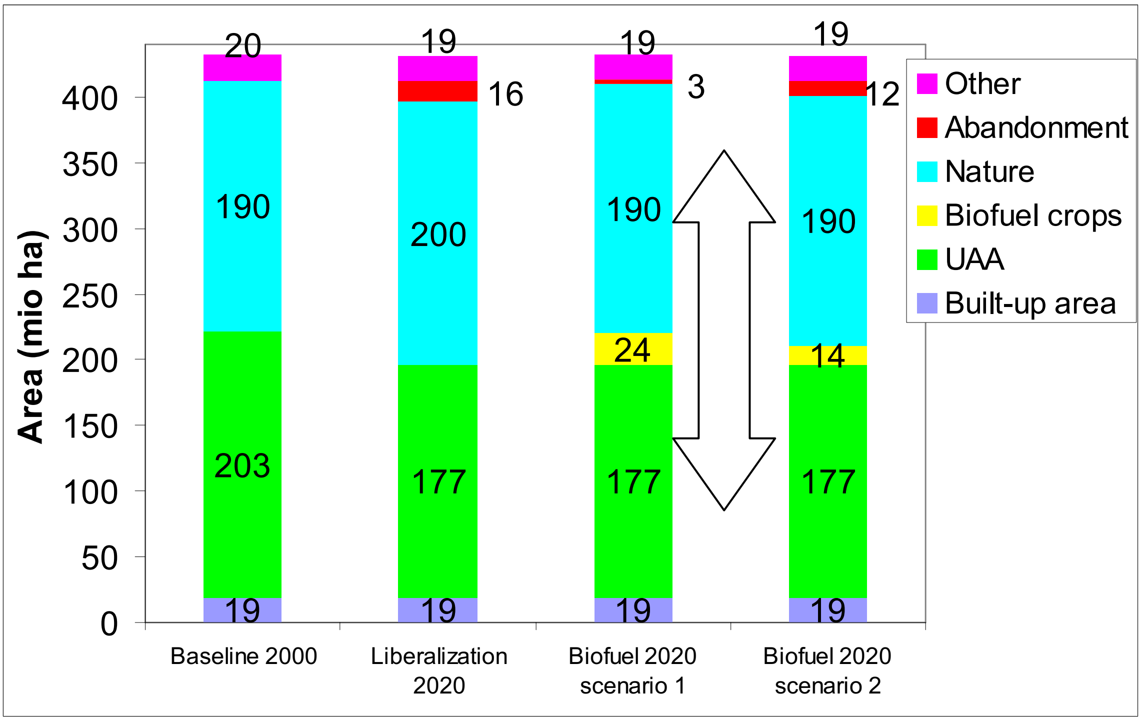

Figure 1. Land use in EU-27: scenarios for 2020, 2 biofuel scenarios compared to liberalization scenario 2020.

Figure1 shows that under full liberalization, the UAA decreases with 26 million ha as compared to 2000. The area required for biofuel production requires 24.4 million ha. The energy crops could theoretically be cultivated on this land.

4.2 Impact of biofuel and fossil fuel prices on agricultural markets

- The overall share of biofuels in fuel consumption for transportation in 2010 in Europe is expected to increase, due to increasing crude oil price and environmental concerns.
- The driver for biofuel production in the EU, USA and Canada is mainly political, including tax exemptions, investment subsidies and obligatory blending of biofuels. High energy prices further enhance biofuels production and consumption in other regions.
- Linkages between food and energy production include the competition for land, but also for other production inputs. Furthermore, the effect of an increasing supply of by-products of biofuel production such as oil cake and gluten feed also affect animal production.
- Food and energy markets are interlinked. The oil prices put both a ceiling and a floor for prices in the food market. (Schmidhuber, 2007)
  - Ceiling price effect: as feed stock costs are the most important cost element of all forms of bioenergy, feed stock prices (food and agricultural prices) cannot rise faster than energy prices in order for agriculture to remain competitive in energy markets.
  - Floor price effect: if demand is particular pronounced as in the case of cane-based ethanol, bioenergy demand has created a quasi intervention system and an effective floor price for sugar in this case.
- According to Schmidhuber (2007), sugar cane in Brazil becomes a competitive energy provider at oil prices about US$ 35 per barrel.

Banse *et al.* (2008) look at the effects of biofuels on agricultural production under four different scenarios. These scenarios are:

- **Reference scenario:** Global economy of the EURURALIS project (A1, includes trade liberalization).
- **High oil price scenario:** 20% higher price than reference scenario.
- **BFD-5.75% scenario:** mandatory blending obligation of biofuels of 5.75% in 2010 in each EU-27 member state.
- **BFD-11.5% scenario:** mandatory blending obligation of biofuels of 11.5% in 2010 in each EU-27 member state.

Under all the four scenarios, even without mandatory blending, the share of biofuels in the fuel consumption for transportation will increase from 2001 to 2010 in Europe. Banse *et al.* (2008) state that this is due to the fact that the ratio between crude oil price and prices for biofuels crops changes in favor of biofuels crops. This means that the crude oil price will increase relatively more than the biofuels crop price over time.
A crucial assumption about the relation between crude oil and biofuels has to be taken into account. The degree of substitutability between crude oil and biofuels according to Banse *et al.* (2008) is assumed to be relatively high. For this study, a substitution elasticity of 4 is assumed in the medium term (2001-2010).
Furthermore, the analysis done in this study focuses only in the 1st generation biofuels for the period until 2010.
Table 1 presents the simulation results from Banse *et al.* (2008).

Table 1. Change in agricultural EU-27 production, 2010 relative to 2001.

Percentage change	Arable crops	Biofuel crops	Oilseeds
Reference A1 scenario	+ 8.7	- 4.5	+ 5.0
High oil price	+ 9.3	- 0.2	+ 28.7
BFD-5.75%	+ 10.7	+ 7.6	+ 45.4
BFD-11.5%	+ 12.2	+ 17.3	+ 14.4

The A1 scenario:

- EU-27 will become a net importer of biofuels crops, therefore production of biofuels crops will decrease
- Production of other crops will increase on an aggregate level, due to the annual growth rate in agricultural production, although it is negatively affected by the liberalization. '

High oil price scenario:

- Global high oil prices lead to an increase in global demand for biofuels, since crude oil and biofuels are assumed to be substitutes. Therefore higher crude oil prices lead to more competitive power of biofuels.
- The EU-27 will not produce biofuels crops since other countries are more efficient in producing these biofuel crops, therefore the EU-27 will be a net importer.

BFD-5.75% and BFD-11.5% scenario:

- Mandatory blending of biofuels in the EU will lead to increase in demand for biofuels from the EU-27.
- The EU is not able to produce the needed biofuel crops and therefore biofuel crops will also be imported from the rest of the world.
- Increase in demand from the EU-27 will increase the global biofuel price.
- Higher biofuel prices result in relatively cheaper crude oil, therefore demand from the rest of the world for biofuels decreases. (However, EU demand will over-compensate the lower demand from the rest of the world therefore the use of biofuel crops increases under this scenario)
- Since the mandatory blending will be reached by subsidizing production of biofuel crops in order to make biofuels more competitive, production of biofuels in Europe will also increase, much more compared to the high oil price scenario.

Banse *et al.* (2008) conclude that the influence of the mandatory blending is much more significant than the influence of the crude oil price. The EU biofuel directive has a strong impact on agriculture at global and European level. The long-term trend of declining real world prices of agricultural products will be slowed down or even reversed for the biofuel crops.

Discussion on substitutability between fossil fuels and biofuels:

- In the long run it is expected that fossil fuels can easily be replaced by biofuels (they are close substitutes) which is indicated by a high substitution elasticity. This indicates that in the long term, demand for biofuels will be more sensitive to price increases in crude oil.
- However in the short/medium term it is more realistic not to consider fossil fuels and biofuels to be close substitutes. From now until the year 2010 production processes have to be adjusted and capacity to produce biofuels has to be build, meaning that fossil fuels cannot yet be easily replaced by biofuels.

Recent developments in crude oil prices

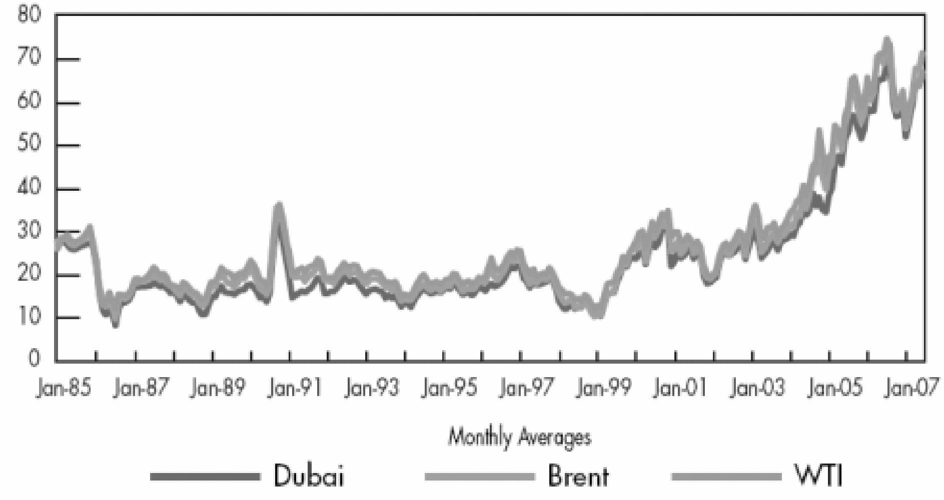

Figure 1. *Key crude oil spot prices in US dollar/barrel.*
Source: IEA, 2007

- Recent oil price have risen substantially (Figure 1)
- Banse *et al.* (2008) underestimate the rise in oil prices. A critical note must therefore be made. The 2001 price levels are used to project the changes to the year 2010. However, looking at recent developments, these projections are very much below current price levels.
- From Figure 2 it can be seen that Banse *et al.* (2008) expect a price increase in oil price of approximately 4% under the reference scenario A1. However, Figure 1 shows that oil prices have increased from US$ 20 in the year 2001, to about US$70 in January 2007 but current (June, 2008) oil prices are already around US$138 per barrel (bloomberg.com). Clearly, Banse *et al.* grossly underestimate the crude oil price increase. Also the 'high oil price' scenario must therefore be analyzed bearing in mind that the oil price is underestimated.

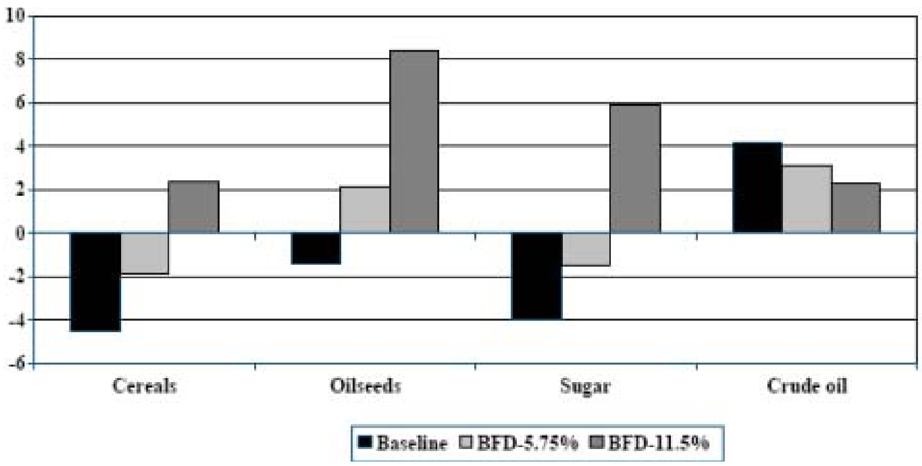

Figure 2. *Changes in real world prices according to Banse et al. (2008) in percentage, 2010 relative to 2001.*

Annex 5. Soybean

5.1. World soya balance

Global soybean production and demand

Soybean is a versatile crop that is used for very many purposes. The prime driver of soybean production has been the demand for feed for the production of chicken and pork, primarily in Europe and China. Soybeans are used for food consumption and its health aspects are increasingly recognized and being accepted. Soybean is a major source for the chemical industry of the production of an array of bio-based products.

Projects made by the International Food Policy Research Institute (IFPRI) in 2001 for the year 2020 (Rosegrant *et al.*, 2001) show the total production volume of the largest producers and consumers of soybean to increase from 130 million tons in 1997 to 200 in 2020 (Table 1). Then, the United States was expected to strengthen its positions as largest soybean exporter at over 30 millions tons and to raise its total production volume to almost 95 million tons. The Latin American countries Argentina and Brazil were expected to substantially increase their export volumes to close to 20 million tons each. The EU15 would remain the largest importer at 19 million tons followed by China with 12 million tons. Overall, total production volumes estimated through the econometric approach of the IFPRI are grossly underestimating soybean production for the future. The total production volume of 235 million tons of soybean today (2006/7) already exceeds the estimated global production of 227 million tons in 2020 by the IFPRI (Rosegrant *et al.*, 2001).

ISTA Mielke (1998) projected the production of soybean to increase to 265 million tons in 2020, increasing from an estimated 198 million tons in 2005. Actual production in 2006/7 had already exceeded 235 million tons, which reveals the unprecedented increase of soybean for food and feed purposes only.

ABIOVE (2005) more recently projected future production volumes of soybean taking production levels in 2005 as a starting point. They project global soybean production to increase to 280 million tons already in 2015, reaching 307 million tons in 2020. Brazil's share will increase to 92 million tons in 2015 and 105 million tons in 2020, surpassing production by the USA of 83 and 87 million tons in those years. Argentina is expected to produce 51 and 58 million tons in 2015 and 2020, respectively, with comparable volumes of 52 and 57 million tons by all other producers together.

Table 1. Actual (1997) and projected (2020) soybean production (in million tons) in selected countries by IFPRI (Rosegrant et al., 2001), as compared to actual yield levels in 2006/7 (ISTA Mielke, 2007), and projections by ABIOVE (2005).

	Actual production in 1997	Projected production for 2020 (made in 2001)	Actual production in 2006/7	ABIOVE (2005) Projection for 2015	ABIOVE (2005) Projection for 2020
Argentina	14.1	26.8	46	51	58
Brazil	27.1	48.1	59	92	105
United States	70.9	94.9	87	83	87
EU15	1.4	1.9	1.3		
China	14.3	25.5	16	52	57
Southeast Asia	2.0	3.1	8*		
World	144	227	235	280	307

** India only*

At a world average rate of yield increase of 27 kg ha^{-1} y^{-1} (Bindraban and Zuurbier, 2007), these increases in production volume imply the expansion of the cultivation acreage for soybean, primarily in Latin American countries, and in Asia. The total acreage needed for the production of 105 million tons of soybeans in Brazil, for instance, indicates an expansion of the current acreage of 21 million hectares in 2006/7 to 30.1 in 2020 at a rate of 36 kg ha^{-1} y^{-1}.

In addition to these demands for food and feed, the current demand for bio-diesel will further accelerate the demand for soybean. In all the above mentioned projections, biodiesel was not accounted for. Bio-diesel is among the biofuels that are required by both Brazil and foreign countries because of policies for compulsory blending of transport fuel with biofuels. The current bio-diesel production in Brazil is made for over 80% from soybean oil. At an increasing rate of demand for edible oils of 3% per year (ISTA Mielke, 2007), the supply-demand ratio of vegetable oils may come under pressure.

European soybean balance

Almost all the soybean used in the EU is imported (Table 2) except for a total production of some 1.2 million tons on its own territories. Moreover, the EU is a net importer of vegetable oil. An increasing part of the imported oil is soy oil, 2.5% in 2005 and 11% in 2007. Oil produced from imported soybeans (about 2.6 million tons of oil) ought to be added to this foreign dependence, but is considered as own production. After crushing the soybeans, the oil is used for human consumption and the oil cake is used in the feed sector.

Table 2. EU-27 balance of soybeans meal and oil for 06/07 (million ton) from ISTA Mielke.

EU-27 balance (mio tons)	Soybeans	Soybean meal	Soybean oil
Opening stocks	1.240	0.098	0.246
Production	1.279	11.344	2.669
Imports	14.850	24.6	1.140
Total availability	17.369	36.042	4.055
Exports	0.062	0.69	0.267
Crushings/Disappearance	14.340	35.24	3.512
Other use	1.716	-	
Ending stock	1.250	0.112	0.276

Source: ISTA Mielke, 2007.

Table 3. EU production of soybeans 06/07.

Country	Production in (1000 T)	Harvested area (1000 ha)	Yield per ha (ton/ha)
Italy	600	172	3.5
Romania	360	163	2.2
France	123	45	2.7
Hungary	82	35	2.3
Austria	65	25	2.6
Slovakia	24	12	2.0
Czech Republic	17	10	1.7
Greece	4	2	2.0
Spain	2	1	2.0
Bulgaria	1	1	1.0
Germany	1	1	1.0
Total	1279	467	2.7

Source: Forecast ISTA Mielke, 2007.

Of total world trade, the EU-27 imports account for 21% of total soybean trade, 45% of total soybean meal trade and 11% of total soybean oil trade. The trade volumes and demand by the EU27 have been projected to remain virtually unchanged up to 2020 (FAPRI, 2002).

Total availability of beans, meal and oil is calculated by adding opening stocks with production and imports (Table 2). To calculate crushings and disappearance, the exports and ending stocks are subtracted from the total availability. Table 3 provides productions numbers per country and shows which countries are the main producers of soybean in the EU. In Table 4, the most important trading partners for soybean, oil and meal are presented.

Table 4. EU-27 soya imports from other countries (1000 T) for 06/07.

Country	Imports of soya oil	Country	Imports of soya beans	Country	Imports of soya meal
Brazil	625	Brazil	9,200	Argentina	14,645
Argentina	188	USA	3,550	Brazil	8,606
Norway	84	Paraguay	870	Norway	141
USA	9	Canada	630	U.S.A	78
Serbia/Monten.	6	Argentina	270	China, PR	7
Ukraine	5	Uruguay	150	Other countries	30
Moldova	4	Ukraine	130		
Bosnia-Herzeg.	3	Other countries	50		
Other countries	10				
Total	943	Total	14,850	Total	23,507

Source: ISTA Mielke, 2007.

Soybean makes a significant contribution to the food and feed availability of European countries, but also to other sectors. The schematically presented flow of soybean in Figure 4.1. shows its contribution to the production of food, feed, fuel and other uses. It makes a significant contribution to meat production as feed, and soya oil contributed to 10% of European vegetable oil consumption in 2005. Some oil is used in the industry sector while it could potentially be used for the production of bio-diesel, as is currently being done in Brazil.

Table 5 presents the world balance for whole grain soybeans forecasted by ISTA Mielke for the year 2006/2007. Soybeans have widened their market share relative to other crops, accounting for 59% of world production and 84% of world oilseed exports. Yields for the three main soybean producers, USA, Brazil and Argentina have increased, also due to the new genetically modified (GM) varieties that are used. Average yields are estimated at 2.90, 2.81 and 2.87 ton/ha in Argentina, Brazil and the USA, respectively. The worldwide average yield is 2.50 ton/ha. The soybean world production has grown with an average annual growth of 6.2% in the ten years until 2006/07. This growth is mostly due to sizably increased plantings and better yields per hectare. Yields increase by 1.6% over the past 4–5 decades and 2.6% over the past 10 years in Brazil for instance, underlining the need for area expansion (Bindraban and Zuurbier, 2007).

Rapidly rising demand for vegetable oils and oil meals has been the driving force for above average growth rates in oilseeds crushing. World crushing of soybeans is estimated to increase with 11 Mt in 2007 compared to the level of 04/05, while other oilseeds crushings will stagnate, according to ISTA Mielke (2007) due to insufficient production. World trade in soybeans will continue to grow due to larger import requirements of China, the EU-27, Mexico, Japan and several other countries in Asia and North Africa.

For the world exports of soybeans, the USA will remain the largest supplier with an export of 30.9 Mt. However, USA exports will show a declining trend, due to the shift in US acreage in favor of corn. Exports in soybeans from Brazil will increase in the coming years. In Argentina, soybean exports will decrease and will eventually become an importer of soybeans due to the rapid increase of the domestic processing industries.

Harvested area for soybean has been increasing over the past years. The estimated harvested area worldwide is 93.9 million ha in the year 06/07, which is an increase of 0.9 million ha from the previous year and an increase of 6.6 million ha from the average of the past five years.

Soybean stocks are expected to increase after 06/07 because of the boost in soybean production and better than expected production of the last year. Total world oilseed production of 401 Mt will exceed the total demand of 396 Mt, which ends in increasing stocks at the end of the year 06/07 compared to previous years (ISTA Mielke , 2007).

Table 5. World supply and demand of soya beans forecasts (in million ton).

World production	06/07	World imports	06/07
USA	86.77	China	30.50 (43%)
Brazil	59.00	EU-27	14.86
Argentina	46.20	Japan	4.10
China	15.90	Mexico	4.00
India	7.65	Taiwan	2.37
EU-27	1.28	South Korea	1.22
Others	18.18	Others	13.28
Total production	234.98	Total imports	70.33
Beginning stock	60.08		
Total supply	295.06		
World crushings	198.04		
Total disappearance	227.00		
Ending stock	68.06		

Source: ISTA Mielke, 2007.

Consumption cannot be measured directly on the world market. However, volumes of production, trade and stocks are known, therefore the disappearance is used as an indication for consumption. The disappearance provided by ISTA Mielke (2007) is the residual of the balance. It is calculated by adding the production with the beginning stocks and imports, and subtracting the exports and ending stocks. For the calculation, the unrounded figures are used.

A total amount of 198.04 Mt soybeans are crushed into 156.1 Mt of soybean meal and 36.7 Mt soybean oil, which implies an oil content in beans of 19%. The trade volumes of these amounts are given in Table 6.

Furthermore, Table 6 shows that the disappearance of soybean meal in the producing and exporting countries is about 100 Mt, which is actually are relatively large amount. An explanation could be that these countries use the soya meal as feed ingredients for their livestock sector. Producers of soya meal are for example the USA, Argentina and the EU-27, which are indeed countries with relatively large livestock sectors.

Table 6. World balance and imports of soya meal and oil forecasts (in mio tons).

Soya meal balance	06/07	Soya oil balance	06/07
Total production	156.07	Total production	36.72
Beginning stock	6.65	Beginning stock	3.87
Total supply	162.72	Total supply	40.59
Imports	54.67	Imports	10.66
Exports	54.79	Exports	10.61
Disappearance	155.86	Disappearance	36.59
Ending stock	6.74	Ending stock	4.05
World imports soya meal		World imports soya oil	
EU-27	24.6 (45%)	C & S. America	1.73
C & S America	7.5	China, PR	1.70
Indonesia	2.3	India	1.46
Thailand	2.2	EU-27	1.18
South Korea	1.8	N. Africa	1.02
Vietnam	1.7	Iran	0.76
Japan	1.6	Turkey	0.23
Philippines	1.6	Others	2.58
Others	11.37		
Total	54.67	Total	10.66

Source: ISTA Mielke, 2007.

5.2 Prospects for the world market of soya

ISTA Mielke (2007) also provides the price history for soybean, soybean oil and soybean meal. Historic prices show an upward trend in prices for the last years. Furthermore, price expectations from organizations such as OECD-FAO and FAPRI are probably underestimated since current prices already exceed expectations. These price projections show that soybean prices are expected to rise in the very short term (until approximately 2007/2008) due to various factors in the market currently driving up the prices. However, around the year 2010 soybean prices are expected to decline and stabilize, due to supply and demand adjustments (OECD/FAO, 2007; FAPRI, 2007).

5.3 EU-27 soya balance 2016/2020

Figure 1 shows the soya balance of the EU-27 projected to the year 2016/2020. Numbers from FAPRI agricultural outlook are used to project future flows. The projected numbers are compared with recent numbers from ISTA Mielke, which are presented in Table 3, 4 and 5. The numbers of FAPRI project that volumes concerning soya will increase with a relatively small amount. Total soya availability is calculated by adding imports, beginning stocks and production.

The framework presented in Figure 1 can be used to aid in the line of reasoning when assessing shocks to the EU-27 soya balance. It shows how different factors in the market are determined and can influence each other.
The numbers in Figure 1 are calculated by using production and trade data from most recent outlooks (FAPRI and EC). These outlooks take into account different autonomic trends. However, the FAPRI outlook used only projected data to the year of 2016 and the EC outlook doesn't look beyond 2014. Comparing actual 2006/2007 levels with projections to 2016 shows that there is only a small difference between the levels. The overall volumes of the soya balance will increase in the year 2016 compared to 2007 but only by a very small amount.

To impose the effect of trade liberalization, data from FAPRI and IFPRI (Rosegrant *et al.*, 2001) are used. FAPRI and IFPRI provide data on percentage change in production and consumption due to full trade liberalization. (Data from FAPRI show the effects of trade liberalization for the period 2002-2012, which makes the application of the numbers a bit less realistic.) These changes are imposed on the outlook data and a new market equilibrium in volumes is then realized. It must be noted that the effects of trade liberalization are again relatively small. Changes in production and consumption patterns for soya products are around 1% hence the effect on the soya market is hardly noticeable. Although the framework is quite simplistic, its application is straightforward and therefore easily used as a guide for a line of reasoning.

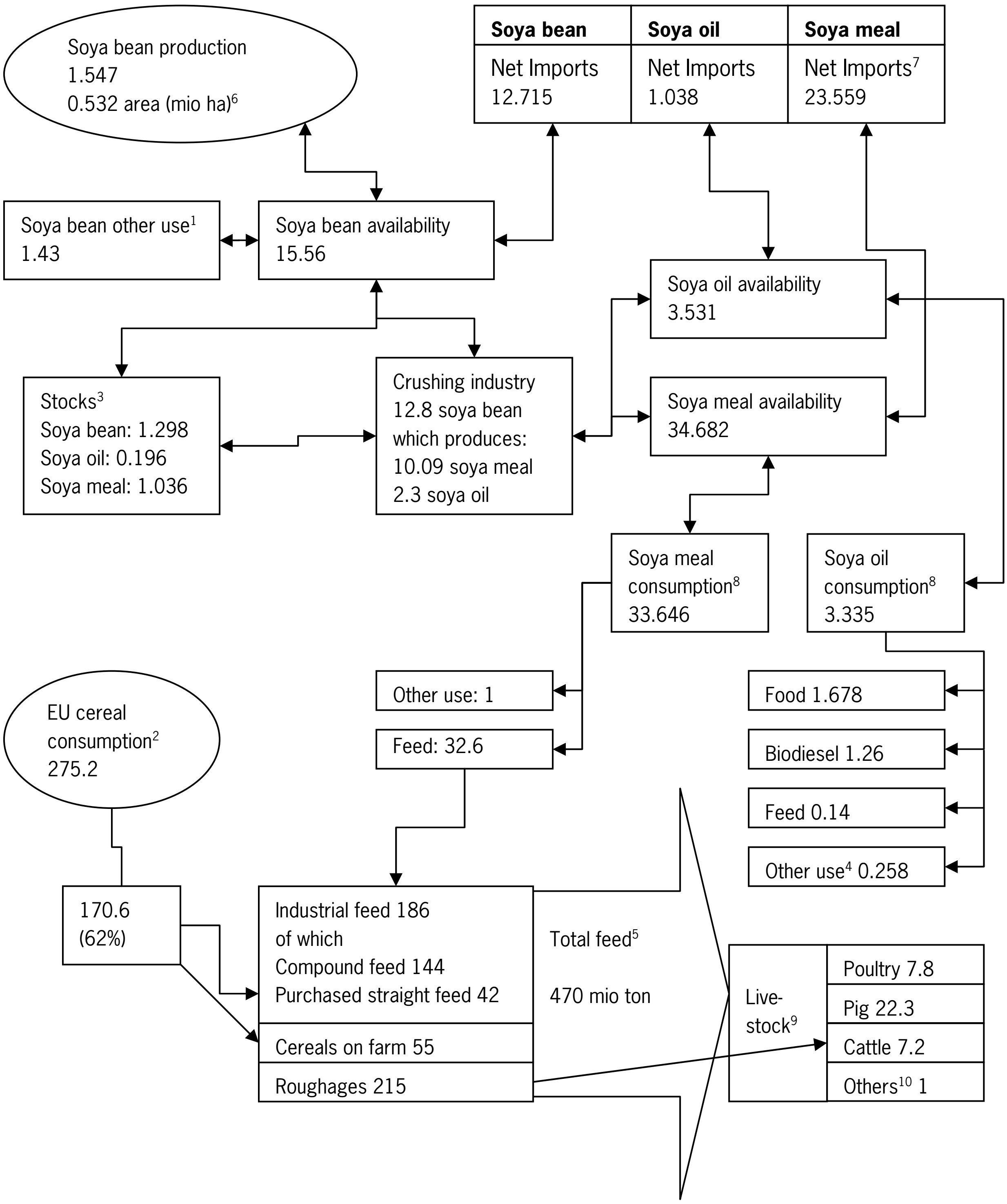

Figure 1. Soy flow-chart for the EU-27, projected to 2016, under full trade liberalization.

N.B
All numbers are in million ton
Availability includes stocks
[1] *Soy bean other use goes to the food and feed industry*
[2] *Number from EC, prospects for 2014, trade liberalization effect from IMPACT (-1%)*
[3] *Stocks are assumed to remain at the baseline level*
[4] *Other use from soya oil goes to industry*
[5] *Data for feed are not projected to 2016 since accurate data is not available, 2006 levels are used*
[6] *Yield per ha (2.9 ton/ha) is assumed to remain at the baseline level, total area needed for production is then calculated*
[7] *Net imports is the difference between domestic production and consumption, excluding stocks*
[8] *The distribution ratio of oil and meal for the different user destinations is assumed to remain constant at baseline level*
[9] *The applied percentage change for meat production is the percentage change in the year 2012, in stead of the average over the period 2002-2012 which is used for the other numbers.*
[10] *Production of other meat includes sheep, goat etc and is assumed to be 1.*

Table 7 presents an overview of data provided by FAPRI, 2002. The percentage change in production and consumption for different commodities are given under the full trade liberalization scenario. The changes in production and consumption are applied to the numbers in Figure 1, where possible. It must be noted that the numbers provided by FAPRI were calculated for the EU-15. Therefore, same percentage changes have been assumed for the EU-N10, which can be different in reality. Furthermore, it must be noted that the application of these numbers can give possible under- or overestimations. This has to do with the fact that the study from FAPRI was conducted in the year 2001 hence the influence of biofuels isn't taken into consideration.

Table 7. Percentage change due to full trade liberalization scenario, EU-15.

Commodity	Percentage change in year 2011/2012	Average change for period 2002-2012
Pork production	-2.2	-0.94
Pork consumption	-1.2	-0.33
Beef * production	-6	-4.18
Beef consumption	+2	+1.63
Broiler production	-6	-3.88
Broiler consumption	0	-0.20
Soybean meal production	+1.11	-0.34
Soybean meal consumption	-3.21	-3.84
Soybean production	-1.18	+1.34
Soybean consumption	+0.98	-0.33
Soybean oil production	+1.11	-0.34
Soybean oil consumption	+0.87	+0.11

* *includes meat and meat equivalent of live cattle trade*
Source: FAPRI, 2002.

Annex 6.
EU Feed sector

European Union compound feed production and ingredient usage

Industrial compound feed production

The main producers of compound feed in 2006 were France, Germany and Spain.
The compound feed production in the EU is broadly split into three main sub-groupings of cattle/calves, pigs and poultry, as presented in Table 1.

Table 1. Production of compound feeding stuffs, EU-27, 2006.

(x 1000 t)	Total EU-27	Of which			
Feed type		France	Germany	Spain	UK
Poultry	45995 (32%)	8491	5265	3959	6111
Pigs	49857 (34%)	6302	8142	8690	1672
Cattle & claves	38243 (26%)	4778	5970	5400	4778
Milk replacers	1591 (1%)	449	142	0	21
Others	9726 (7%)	1596	785	1726	1544
	145412 (100%)	21616	20304	19775	14126

Source: Fefeac, 2007.

- France dominates the production of poultry feed and is the third largest pig feed producer.
- Germany is the largest producer for feed for cattle and calves, second largest producer of pig feed and third largest producer of poultry feed.
- Spain is the largest producer of pig feed and the second largest producer of feed for cattle and calves
- The UK is the second largest producer of poultry feed.

Feed ingredient usage

A breakdown of the main ingredients used in the manufactured compound feed sector in the EU-25 is shown in Table 2. This highlights the importance of cereals (as primary source of energy) and oil meals/cakes (as a primary source of protein) relative to a wide variety of alternative ingredients used.

Table 2. EU-25 industrial feed material consumption (1000 T), 2005.

Ingredient	Consumption	% of total ingredients used
Cereals	66,818	47
Oilseed meals and cakes	38,509	27
Pulses	2,413	1.7
Co-products from the food industry	17,980	12.9
Minerals & vitamins	3,724	2.6
Dried forage	1,817	1.3
Oils & fats	2,010	1.4
Others (including pulses)	8,626	6.1
Total	141,897	100

Source: Fefac, 2007.

Cereals, which account for nearly half of all ingredients incorporated, are the main ingredients used in animal feed, mainly as a carbohydrate energy source. In the EU, wheat is the most used cereal (34%), followed by maize (29%) and barley (23%) (EU-27, 2005). Each cereal tends to have a high degree of interchangeability as raw material ingredient.
Some other energy sources are tapioca and molasses.

Oilseed meals and cakes are the second most important group of ingredients in animal feed, which are mainly used as primary source of protein. Soybean meal is by far the most consumed oil meal (34 million tons) followed by rapeseed meal and sunflower meal with consumption volumes of 9.2 and 4.5 million tons respectively.

Soya meal has the highest level of protein out of all oilseed and protein crops generally available and used by the EU animal feed sector. It is also a preferred protein source, especially in the pig and poultry sector, because of its higher level of digestibility compared to alternatives such as rapeseed meal.

Pulses mainly comprising peas, beans and to a lesser content lupines. Imports, where they occur are mostly from central Europe into the eastern countries of the EU (high transportation costs). Of particular value to peas is the large concentration of lysine, relative to the needs of mono-gastric animals. In contrast, cereal grains and rape seed meal contain less lysine but are rich in methionine and cystine. Therefore, pea protein and proteins from cereals and rape seed meal are, nutritionally complementary, and enhance each other's value when used in diets.

In addition to these protein rich feedstuffs, numerous feed stuffs used for their energy content also contribute to a large extent to livestock protein supply. In this way, cereals play a significant role in protein supply for pig production (Table 6).

By products from food industry

Some examples:
- brewers grains. Low in protein and energy is useful as a cheap filler ingredient.
- molasses: by product of sugar manufacturing and mainly used as a cereal substitute.

Feed ingredient composition: factors of influence

Protein is essential for all animal production. It is available in nearly all feeding stuffs whether tradable or non-tradable. According to their protein content (measured as crude protein) one can distinguish raw material with:
- *high protein content* , for example fish meal 60%, meat bone meal 55% soy bean meal 45%
- *medium protein content*, for example rape seed meal 34%, sunflower meal 28%, palmist/copra 23% etc, peas 21% and corn gluten feed 23%
- *low protein content*, for example: dried fodder 15-20%, cereal 9-12%, tapioca <2% and vegetable oil 0%

Not only the content of protein is important but also the composition in (essential) amino acids plays a role, as well as the digestibility of the protein by the different species.

Ruminants are normally less demanding regarding the quality and digestibility of protein sources. Therefore they can be fed cotton meal, palmist, copra, corn gluten feed etc. Apart from these tradable feedstuffs, cattle and other ruminants get a large part of their protein needs through roughage.

Mono-gastric animals such as pig and poultry have more limits in the raw material use. Here soy meal is the most important plant protein source. Pig feeding has fewer constraints than the poultry sector, but amino acid composition is of major importance.

In order to calculate possible substitution for soybean/meal as feedstuff, Table 3 provides an overview of protein rich feedstuffs and their characteristics.

Table 3. Main protein sources used in animal feed: some key features.

Protein source	Comments (relative to soya)
Soybean meal	Protein 44%-46%. Lysine 2.8%, good palatability. Because its amino acid profile is highly digestible, fits the requirements of many animals during all stages of their life. *Pig feed*: Incorporation rate of 20% common. (Fediol, 2007)
Rapeseed meal	Lower protein level (34%-38%), lower lysine level (2.27%), excellent balance of essential amino acids, slightly higher levels of methionine and cystine, higher fiber level than soya. Anti-nutritional factor: glucosinate determines inclusion rates. Ruminants have higher inclusion levels then pigs; pigs higher inclusion rates then poultry (Fediol, 2007) *Ruminants:* offers high levels of fibres necessary for efficient rumen function; *Poultry*: not preferred ingredient *Pig feed*: can be used as substitute for soya (e.g. up to half of soya protein used in pig feed could technically be substituted) Max inclusion rates: pigs 12%, dairy 15%, beef 12%; poultry: 6-8% (Rabobank, 2007) Pigs: max incorporation rate for finishers: 15% (Raamsdonk, L.W.D. *et al.*, 2007)
Sunflower meal	Lower protein level (30-35%), lower lysine level (1.68%) than soy meal but more methionine. *Pigs and poultry*: must be fortified with soya bean meal *Pig feed:* can be used as substitute for soya (e.g. can replace 25% of the soy bean meal protein) Pigs: max inclusion rate for finishers: 22% (Raamsdonk, L.W.D. *et al.*, 2007) *Ruminants and horses*: generally mixed with grain.
Maize gluten feed	Lower protein level (23%), lysine (0.64%) *Pig feed:* can be used as substitute for soya (e.g. can replace 25% of the soy bean meal protein)
Maize germ meal	Protein content of about 60% and is mainly used as a protein source in the poultry sector.
Fish meal	Protein63-68%, lysine 4.74% mostly used in the pig and poultry sector for small/young animals.
Meat Bone Meal	Protein 51-55%, lysine 2.89%, prohibited after BSE crisis
Peas	Protein 21% High starch content, protein level and high % of lysine in their protein Ideal pig feed: inclusion rate 25% Pig: max inclusion rate pulses; 15% (Raamsdonk, L.W.D. *et al.*, 2007); 20-35% (national pork board); up to 40% (GLIP, 2008)
Wheat DDGS	Protein 36% • DDGS protein is less digestible than protein in RSM and much less than SBM • Needs to be upgraded with addition of essential amino acids • Lower protein content • Varying quality of byproducts Max inclusion rate; pigs 8%; broiler 6%; cattle 10% (Rabobank, 2007)

An average west European pig feed ratio

The feed formula as presented by Van Cauwenberghe and colleagues (2003), has been used for further analysis (Table 4). The proposed formula is modeled to average the different European practices, though feed composition is variable and depends on various aspects such as: local commodity prices and volumes, quality of feed, environmental constraints or nutritional concept implemented.

The formula roughly integrates:

- The various European practices in terms of nutrients levels and in terms of ingredient selection.
- The various types of pig feed, from piglet to sow feed, with the emphasis on growing and finishing pig diets as they represent the biggest pig feed tonnage.

The protein characteristics are the following:

- Digestible lysine level is set at 0.85% of the feed, corresponding to a total lysine level of around 1% of the feed.
- The amino acid balance follows the 'INRA ideal protein pattern' (thr:lys 65%, M+C:Lys 60%, trp:lys 18% digestible basis.
- The protein level is set at 17%.

Table 4. An average modeled Western European pig feed formula.

		Average pig feed formula		
	Protein content feedstuffs (%)	Feed formula (%)	feed usage (mio tons)	protein content (mio tons)
soybean meal	45	14.0	12.3	5.5
rapeseed meal	34	5.0	4.4	1.5
sunflower meal	28	3.0	2.6	0.7
soybean whole seed	35	0.6	0.5	0.2
rapeseed whole seed	19	0.6	0.5	0.1
Pea	21	3.0	2.6	0.6
Wheat	11	25.3	22.3	2.4
Maize	8	10.0	8.8	0.7
Barley	10	25.0	22.0	2.2
Triticale	10	4.0	3.5	0.4
Oats	10	0.6	0.5	0.1
wheat bran	15	5.0	4.4	0.7
Skimmilk	34	0.1	0.1	0.0
Whey	10	0.1	0.1	0.0
Fishmeal	65	0.1	0.1	0.1
Premix	0	4.0	3.5	0
Total			88.4	15.2

Source: Van Cauwenberghe et al., 2003

In this formula 12.3 million tons soybean meal and 0.5 million tons of whole soybeans are used, providing 5.7 million tons of protein. This is nearly 38% of the total protein content of the pig feed.

Substitution of soybean and soybean meal in pig feed

Soybean meal is replaced in three alternative feed scenarios:
Scenario 1: substitution by rapeseed meal and sunflower seed meal
Scenario 2: substitution by pulses
Scenario 3: substitution by rapeseed meal, sunflower seed meal and pulses

The pig feed formula in Table 4 has been taken as a starting point. In case of a collapse of soybean meal imports a total of 5.7 million tons of protein will have to be provided by other feed ingredients.
For the substitution scenarios:

- total feed usage is kept constant at about 88 million tons
- protein content is kept at about 17%
- as soybean meal has a higher protein content then the substitutes, total feed usage increases when substituting. As this might increase the feed intake too much, total feed usage has been kept constant by decreasing the amount of cereals.
- all scenarios: 1 million ton of additional soybean meal produced in the EU has been included, because the increased inclusion of sunflower meal must be fortified with soybean meal
- oil meals inclusion rate have been maximized as specified in Table 3, Annex 4 at 15% for rapeseed meal and 20% for sunflower meal;
- Pea is used as an example for replacement by pulses, as it is the major feed pulse in the EU. Other pulses such as faba bean can be used as well.

In the substitution rations, amino acid requirement is not taken into consideration, and could be considered in future calculations, in order to maintain a good nutritional balance. It is therefore assumed that the pig feed conversion rate for the substitution rations are the same as in the reference ration. The compositions of the alternative feed scenarios are presented in Table 5, 6 and 7.

Table 5. Scenario 1: pig feed formula: an average European pig feed formula, and a formula in which imported soybean meal is substituted by oil meals.

		Average pig feed formula			Imported soybean meal, Substituted by oil meal				
	Protein content feedstuffs (%)	Feed formula (%)	Feed usage (mio tons)	Protein content (mio tons)	Feed formula (%)	Feed usage (mio tons)	Protein content (mio tons)	Change in feed usage (mio tons	Change in protein content (mio tons)
Soybean meal	45	14.0	12.3	5.5	1.1	1	0.5	-11.3	-5.1
Rapeseed meal	34	5.0	4.4	1.5	14.7	13	4.4	8.6	2.9
Sunflower meal	28	3.0	2.6	0.7	13.6	12	3.4	9.4	2.6
Soybean whole seed	35	0.6	0.5	0.2	0.0	0	0.0	-0.5	-0.2
Rapeseed whole seed	19	0.6	0.5	0.1	0.6	0.5	0.1	0.0	0.0
Pea	21	3.0	2.6	0.6	2.9	2.6	0.5	0.0	0.0
Wheat	11	25.3	22.3	2.4	25.1	22.2	2.4	-0.1	0.0
Maize	8	10.0	8.8	0.7	5.7	5.0	0.4	-3.8	-0.3
Barley	10	25.0	22.0	2.2	22.6	20.0	2.0	-2.0	-0.2
Triticale	10	4.0	3.5	0.4	3.2	2.8	0.3	-0.7	-0.1
Oats	10	0.6	0.5	0.1	0.6	0.5	0.1	0.0	0.0
Wheat bran	15	5.0	4.4	0.7	5.7	5.0	0.8	0.6	0.1
Skimmilk	34	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0
Whey	10	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0
Fishmeal	65	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Premix	0	4.0	3.5	0	4.0	3.5	0.0	0.0	0.0
Total			88.4	15.2	100.0	88.4	14.9	0.0	-0.3

Comments:
- Rapeseed meal inclusion within the limit of 15%
- Sunflower meal inclusion within the limit of 20%

Table 6. Scenario 2: Pig feed formula: an average European pig feed formula, and a formula in which imported soybean meal is substituted by peas.

		Average pig feed formula			Imported soybean meal, Substituted peas				
	Protein content feedstuffs (%)	Feed formula (%)	feed usage (mio tons)	protein content (mio tons)	Feed formula (%)	feed usage (mio tons)	protein content (mio tons)	Change in feed usage (mio tons	Change in protein content (mio tons)
Soybean meal	45	14.0	12.3	5.5	1.1	1	0.5	-11.3	-5.1
Rapeseed meal	34	5.0	4.4	1.5	5.0	4.4	1.5	0.0	0.0
Sunflower meal	28	3.0	2.6	0.7	2.9	2.6	0.7	0.0	0.0
Soybean whole seed	35	0.6	0.5	0.2	0.0	0	0.0	-0.5	-0.2
Rapeseed whole seed	19	0.6	0.5	0.1	0.6	0.5	0.1	0.0	0.0
Pea	21	3.0	2.6	0.6	39.6	35.0	7.4	32.4	6.8
Wheat	11	25.3	22.3	2.4	22.5	19.9	2.2	-2.4	-0.3
Maize	8	10.0	8.8	0.7	2.3	2.0	0.2	-6.8	-0.5
Barley	10	25.0	22.0	2.2	11.3	10.0	1.0	-12.0	-1.2
Triticale	10	4.0	3.5	0.4	3.2	2.8	0.3	-0.7	-0.1
Oats	10	0.6	0.5	0.1	0.5	0.4	0.0	-0.1	0.0
Wheat bran	15	5.0	4.4	0.7	6.8	6.0	0.9	1.6	0.2
Skimmilk	34	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0
Whey	10	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0
Fishmeal	65	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Premix	0	4.0	3.5	0	4.0	3.5	0.0	0.0	0.0
Total			88.4	15.2	100.0	88.4	14.8	0.0	-0.4

Scenario 2
Pulses: 5.2 million ton protein equals 24.7 million tons of peas (or other pulse)
Compare to the standard ration 32.4 million tons of peas have been included in order to achieve the protein content of 15 million tons. Inclusion of cereals was decreased to compensate for increase in total feed usage.
The inclusion rate of peas is nearly 40%, which is possible but not very likely.
It is not very likely that peas or other pulses will be used with such high inclusion rates.

Table 7. Scenario 3: Pig feed formula: an average European pig feed formula, and a formula in which imported soybean meal is substituted by oil meals and peas.

		Average pig feed formula			Imported soybean meal, Substituted by oil meals and peas				
	Protein content feedstuffs (%)	Feed formula (%)	feed usage (mio tons)	protein content (mio tons)	Feed formula (%)	feed usage (mio tons)	protein content (mio tons)	Change in feed usage (mio tons	Change in protein content (mio tons)
Soybean meal	45	14.0	12.3	5.5	1.1	1	0.5	-11.3	-5.1
Rapeseed meal	34	5.0	4.4	1.5	14.7	13	4.4	8.6	2.9
Sunflower meal	28	3.0	2.6	0.7	6.8	6	1.7	3.4	0.9
Soybean whole seed	35	0.6	0.5	0.2	0.0	0	0.0	-0.5	-0.2
Rapeseed whole seed	19	0.6	0.5	0.1	0.6	0.5	0.1	0.0	0.0
Pea	21	3.0	2.6	0.6	14.7	13.0	2.7	10.4	2.2
Wheat	11	25.3	22.3	2.4	20.9	18.5	2.0	-3.8	-0.4
Maize	8	10.0	8.8	0.7	5.7	5.0	0.4	-3.8	-0.3
Barley	10	25.0	22.0	2.2	22.6	20.0	2.0	-2.0	-0.2
Triticale	10	4.0	3.5	0.4	3.2	2.8	0.3	-0.7	-0.1
Oats	10	0.6	0.5	0.1	0.5	0.4	0.0	-0.1	0.0
Wheat bran	15	5.0	4.4	0.7	5.0	4.4	0.7	0.0	0.0
Skimmilk	34	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0
Whey	10	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0
Fishmeal	65	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Premix	0	4.0	3.5	0	4.0	3.5	0.0	0.0	0.0
Total			88.4	15.2	100.0	88.4	14.9	0.0	-0.3

Comments
Rapeseed: inclusion below max of 15%
Peas: inclusion rate at 15% (within acceptable range)
Inclusion of cereals was decreased to compensate for increase in total feed usage.

Table 8. Selected energy and feed crops, EU-27 average yields in 2005 and projections for 2020.

Crop	Average yield (tons/ha)	
	2005	2020
Cereal	4.5[1]	5.4
Soy	2.7[2]	3.2
Rape seed	3.0[2]	4.1
Sunflower	1.6[2]	2.2
Peas	3.1[3]	3.7

Projections based on OECD-FAO (2007)
Rapeseed and sunflower: yield increase of 38% in 2020 relative to 2005
Cereal, soy and pea: yield increase of 20% in 2020 relative to 2005
Sources:
[1] EC, 2007e
[2] ISTA Mielke, 2007
[3] COPA-COGECA, 2006

Table 9. Selected energy and feed crops, some characteristics.

Crop	Protein content[1] (%)	Oil extraction rate[2] (%)	Meal[2] (%)
Cereal	10	n.a	n.a
Soy	36	19	80
Rape seed	19	40	56
Sunflower	17	43	55
Peas	21	n.a.	n.a

Source:
[1] Van Cauwenberghe et al., 2003
[2] Fediol, 2007