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The Protein Puzzle: The Consumption and Production of Meat, Dairy and Fish in the European Union

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Grey Literature

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MAIN FINDINGS

Meat, dairy, eggs and fish are important components of the European diet

These animal products are not only important in terms of taste and tradition; they also provide essential nutrients such as proteins, iron, calcium and vitamins. Fish also provides essential fatty acids and vitamin D. Furthermore, livestock production and fisheries are important economic sectors for Europe's rural areas.

However, livestock production and fisheries have large environmental effects, both within and outside Europe

From a global perspective, impacts on terrestrial and marine biodiversity and emissions of greenhouse gases (GHG) and various forms of reactive nitrogen are most dominant. The large areas of land needed for grassland and feed production are an important cause of biodiversity loss. In the EU, about two thirds of the total agricultural area is used for livestock production. Around 75% of the protein-rich feed is imported, mainly from Brazil and Argentina where large areas of land are needed for its production.

Conversion of plant energy and proteins into edible animal products is a generally inefficient use of resource

These resources include land, water, fertilisers and fossil energy, among other things. This can be illustrated by the fact that, for each EU citizen, every day almost 3 kilograms of feed is consumed by EU livestock, 0.8 kilogram of which in cereals and 0.8 kilogram in grass (dry matter). This feed is converted into 0.1 kilograms of meat and 0.8 kilograms of milk,

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being the average EU consumption.

Livestock production is a source of greenhouse gas emissions and certain forms of reactive nitrogen

Around 10% of EU greenhouse gas emissions are caused by livestock production. Together, the beef and dairy sectors are responsible for two thirds of these emissions. A large quantity of nitrogen fertiliser is needed, each year, to sustain Europe's high production levels of grass, cereals and other crops. More than 80% of this nitrogen input is lost, leading to various environmental problems, including the loss of terrestrial biodiversity and algae blooms in coastal waters. There are large differences in greenhouse gas and nitrogen emissions between the various animal products and production practices.

Animal husbandry is associated with several ethical issues

These issues, among other things, are related to limited space, floor type and concentrated feeds, and to the breeds being used. Farm animals, especially when kept in conventional types of housing, experience various forms of discomfort. Animal diseases diminish not only animal well-being, but some animal diseases and the widespread use of antibiotics also cause human health risks. However, improving animal welfare generally leads to higher feed requirements and higher emission levels, thus implying a trade-off between animal welfare and environmental issues.

Many marine fish populations are overexploited. despite new fishing grounds, EU catches are declining rapidly

Catches in the main EU fishing areas have declined by a third since the early 1990s, partly because of EU regulation to prevent overfishing. EU aquaculture is growing, but at a much slower rate than in other regions. Worldwide, 40% of fish production comes from aquaculture, compared with about 20% in Europe. The EU, therefore, relies heavily on imports to meet its demand for fish.

Average EU consumption of animal protein per capita is about twice the global average

Meat consumption in Europe is twice the world average; for dairy produce it is even three times higher. Average EU consumption of meat, dairy and fish has increased strongly over the last 50 years. The total per-capita protein consumption (including vegetable sources) is about 70% higher than recommended. This, in itself, probably would have no adverse effects on human health, if not for the associated intake of saturated fatty acids, which lead to increased risks of cardiovascular diseases. The average intake of saturated fatty acids is about 40% higher than recommended. Thus, a reduction in the consumption of livestock products, notably in high-fat products, would reduce the European disease burden.

Global demand for animal products is expected to increase significantly, in the coming decades, as a result of a growing global population and increasing prosperity

As a consequence, cropland and grassland areas are expected to expand by 10% to 20% over the coming decades, leading to significant losses of terrestrial biodiversity, especially in South Asia, Sub-Saharan Africa and South America. Moreover, greenhouse gas and

nitrogen emissions related to agricultural production also are expected to increase. Globally, already around 30% of the total human-induced biodiversity loss is related to livestock production. Currently, about 80% of global commercial fish populations are being fully exploited or overexploited, leading to large impacts on marine biodiversity. Capture fisheries, therefore, are unlikely to be able to contribute to meeting the increasing fish demand.

Fish farming could be an option

Fish farming of predatory species, such as salmon, uses wild-caught fish as part of the fish feed. Further innovations in the composition of this feed, but also a switch to an increased consumption of herbivorous fish, would reduce the amounts of wild-caught fish required in fish feed. This would involve only a small increase in agricultural land used in the production of the feed for these additional numbers of farmed herbivorous fish. In this way, wild fish stocks would be protected, could recover and possibly provide higher catches in the future.

There are many options to reduce the impacts of livestock production

Main points of intervention are: shifts in consumption, reduction in food losses, changes in husbandry systems and animal breeds, feed conversion and feed composition, nutrient management, crop yields and land management. Modelling results demonstrate that significant reductions in environmental pressure are possible, at the global level, by improving crop yields and feed conversion and by a reduction in food losses along the food chain. The same results indicate that a reduction in the EU consumption of animal products would lead to a significant reduction in environmental impacts, mainly by reducing land conversion outside the EU. The fact that this would take place mainly outside the EU is partly a result of the current design of the Common Agricultural Policy (CAP), which stimulates European farmers to keep their land in agricultural production.

The options for the EU to reduce the impacts of livestock production can be grouped into three broad, partially complementary strategies: shifts in consumption, resource efficiency and producing with fewer local impacts

Consumption shifts, particularly a reduction in the consumption of livestock products, will not only have environmental benefits, but may also reduce the cardiovascular disease burden. This option is easy and robust, but changing consumption patterns is a slow cultural process. Improving production efficiency is already common practice, as there are many synergies between enhancing production and reducing costs. Further improvements along this route are certainly possible, especially regarding a better use of relatively cheap inputs (e.g. fertilisers) and reducing emissions. Producing with fewer local impacts may have negative environmental effects elsewhere, since production may be less efficient, such as in the case of improved animal welfare. More robust production systems with fewer local impacts, generally, lead to higher costs for farmers. However, if done properly, this would lead to lower societal costs by reducing local environmental impacts, animal suffering and public health risks.

Governments and actors in the food chain both could play a role in the implementation of the three strategies

Current policy and institutional setting mainly drive farmers and other actors in the direction

of cost price reductions, and thus primarily support the 'efficiency' strategy. Policies aimed at reducing consumption hardly exist, and policies regarding producing with fewer local impacts are usually secondary to economic and trade policies. Especially the EU, but also the national governments, have a large influence on the agriculture and fisheries sectors. Main policy instruments are the Common Agricultural Policy and the Common Fisheries Policy, which are currently undergoing a reform. Food and agriculture may play a role in EU initiatives, such as 'Resource Efficient Europe'. Individual consumers and actors in food production have many opportunities to reduce the impacts of livestock production, independently from government actions. Consumers could shift to the consumption of products with lower environmental or animal welfare impacts. Retailers could expand their assortment of these products, and could enter into agreements with farmers and other food suppliers to improve production techniques.

The full report can be downloaded for free from http://www.pbl.nl/sites/default/files/cms/publicaties/Protein_Puzzle_web_1.pdf.

Keywords: Consumption, livestock, fisheries, policy, environment, greenhouse gas emissions, nitrogen, biodiversity.

SUMMARY

1. INTRODUCTION

European diets have changed significantly over the last 50 years, and some of these changes have been in the direction of higher intakes of meat, dairy, eggs and fish. These higher intakes have been accommodated by the rapid development and implementation of new agricultural production techniques. These techniques have made food cheaper and allowed for a shift in the European workforce towards industry and services. However, the increased production and the techniques deployed have also aggravated a number of environmental and other impacts from agricultural production and fisheries. These include effects on biodiversity, animal health and welfare and emissions of greenhouse gases and reactive nitrogen.

The global production of food is expected to increase even further. The demand for food, in particular outside the EU, is expected to increase during the coming decades, due to a growing world population and increasing prosperity. This is most likely to lead to additional biodiversity loss and higher emissions of greenhouse gases and nutrients. Furthermore, in spite of increased global consumption and production, almost one billion people are still suffering from malnutrition today.

In Europe, security of supply, health consequences and environmental effects of food consumption and production are of growing concern, not only to governments, but also to many retailers, food companies, farmers and consumers. The question therefore is: are European diets sustainable and healthy, and, if not, what improvements could be made and how?

1.1 Focus on Consumption and Production of Meat, Dairy and Fish

The focus of this study is on the consumption and production of animal products (meat, dairy and fish), for a number of reasons. There are concerns about animal welfare, greenhouse

gas emissions, biodiversity loss, and resource use due to inefficient conversions of plant proteins into animal proteins. Meat and fish are partly interchangeable, in culinary as well as in nutritional terms, both being suppliers of protein. Regarding fisheries, there are concerns over the depletion of fish stocks and impacts on marine biodiversity. From the perspective of public health, many Europeans consume too many calories and saturated fats, mostly from animal origin. According to dietary recommendations, many people should consume more fish, fruit and vegetables. As meat, dairy and fish all are important sources of protein, and because they are partly interchangeable and can be replaced with vegetable protein sources, the problems may be framed as 'the protein puzzle'. The fact that Europe is importing large quantities of protein-rich feed from North and South America, is another aspect of the same protein puzzle.

1.2 Focus on EU Food System in Global Context

A further focus of this study is primarily on the EU food system, as the EU has a single market for food products. Moreover, there are many EU policies regarding food, agriculture and fish. The most prominent are the Common Agricultural Policy and the Common Fisheries Policy, both currently being reformed. Other EU policy areas, such as environmental policies and economically-oriented policies, for example on trade regulation and cohesion, also have an important effect on food consumption and production. Given the trend towards globalisation and the ongoing concentration of players in the food chain, food and retail companies also play a crucial role.

1.3 Aim and Approach of This Study

The central aim of this study is to stimulate an informed discussion about the future of the EU food system in a global context, focusing on the consumption and production of meat, dairy and fish, and their environmental consequences. The global and European food systems are very complex with many relationships and feedbacks. In order to support the discussion on the future of the EU food system with facts and Figures, this study analyses the current EU food system and explores the effects of a number of possible pathways to reduce negative effects. A brief analysis is made of the global situation, followed by an analysis of the present EU consumption and production of meat, dairy and fish, based on an analysis of statistical data and literature reviews. The effects from a number of theoretical options regarding the consumption and production of meat, dairy and crop products are quantified by means of a combination of economic and integrated assessment models. The study concludes with a brief exploration of how the EU food system could be adjusted towards a more sustainable production and consumption of food.

2. GLOBAL PERSPECTIVE AND OUTLOOK

2.1 Global Meat Consumption Is Expected to Increase Strongly

Presently, around 16% of the global meat consumption takes place in the EU27. Compared to the EU, the consumption of animal protein in less wealthy regions is a factor of four to five lower. Many people in these regions do not consume sufficient proteins, which has adverse effects on human health and potential. The demand for proteins from animal products is projected to increase by more than 50% by 2030, compared to that of 2000 (Figure 1), due to population growth and increasing wealth. Whether this projection becomes reality will depend on many factors, including environmental, economic and policy feedbacks.

Large areas of grassland and cropland are already needed for present levels of meat and dairy consumption. Given the projected increase in meat and dairy consumption, much more feed will be needed in the future. Crop production is projected to increase by more than 60% over the 2000-2030 period including the feed required in livestock production (Figure 2). The additional amount of cropland needed for this production also will depend on increases in the crop yield. In the past, around 70% to 80% of the additional crop output was produced in higher crop yields. For the 2000-2030 period, cropland and grassland areas are projected to increase by 10% to 20%. The projected need for additional cropland and grassland areas implies risks of deforestation and conversions of semi-natural grasslands. This will not only lead to loss of biodiversity, but also to CO2 emissions.

2.2 Large Impact of Agriculture and Fisheries on Global Environment

Presently, global livestock and fish production both have a large effect on the environment:

- Global livestock production is responsible for around 12% of global greenhouse gas emissions. These emissions stem from animals and manure, from feed production and from land conversion, for example, from forest into pasture and from pasture into arable land.
- Around 30% of total terrestrial biodiversity loss may be attributed to livestock production. Livestock production also leads to substantial emissions of nitrogen in various forms (ammonia, nitrates), which in turn lead to losses of terrestrial and aquatic (including marine) biodiversity.

Because of the projected growth in global livestock production, all of these problems are expected to aggravate over the coming years, notably in Asia and South America. Furthermore, in spite of growing prosperity and food production, malnutrition is not expected to be eradicated over the next decades.

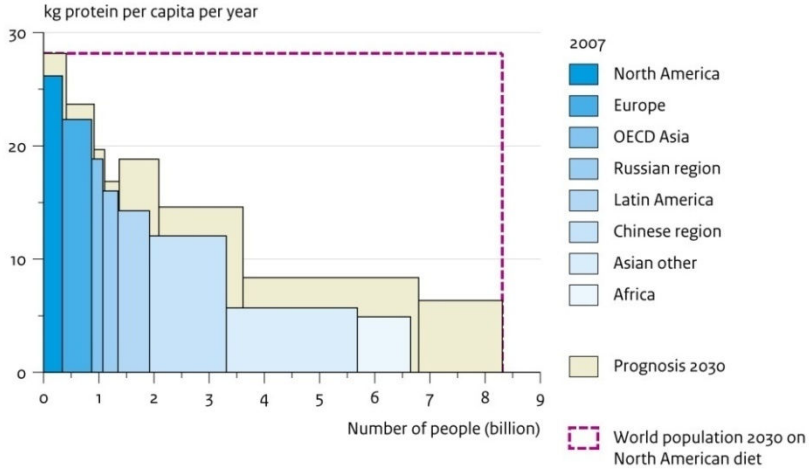

Fig. 1. Global consumption of animal protein per region

The global consumption of meat, fish and dairy products will increase due to increases in population and prosperity. Source: Based on (FAO, 2006, 2010).

3. EU CONSUMPTION AND PRODUCTION OF MEAT, DAIRY AND FISH

3.1 Average EU Consumption of Animal Products Twice the Global Average

The average per-capita EU consumption of animal proteins in the form of meat, fish and dairy produce is about twice the global average. Within the EU, this consumption ranges from around 10 kilograms per person, per year, in Bulgaria and Slovenia, to 22 kilograms in France and Denmark. The main source of animal proteins is meat, of which the average consumption in Europe is about 52 kilograms (corresponding to 85 kilograms in carcass weight). Dairy is the second source of animal protein; average dairy consumption in the EU is equivalent to 300 kilograms in milk, and consists of milk and milk products, such as cheese, butter and ice cream. On average, only 10% of animal proteins consumed are from fish.

3.2 Strong Increase in EU Consumption of Animal Products over the Last Fifty Years

The per-capita consumption of animal products in Europe has increased by around 50% over the 1961-2007 period, mainly due to increased welfare and relatively lower prices. The per-capita consumption of poultry, in particular, has quadrupled since the 1960s, due to availability, reduction in price and the convenience trend, as poultry products are usually quicker to prepare. Pig meat consumption also increased, by 80%. Both kinds of meats increased without a corresponding reduction in any of the other meats.

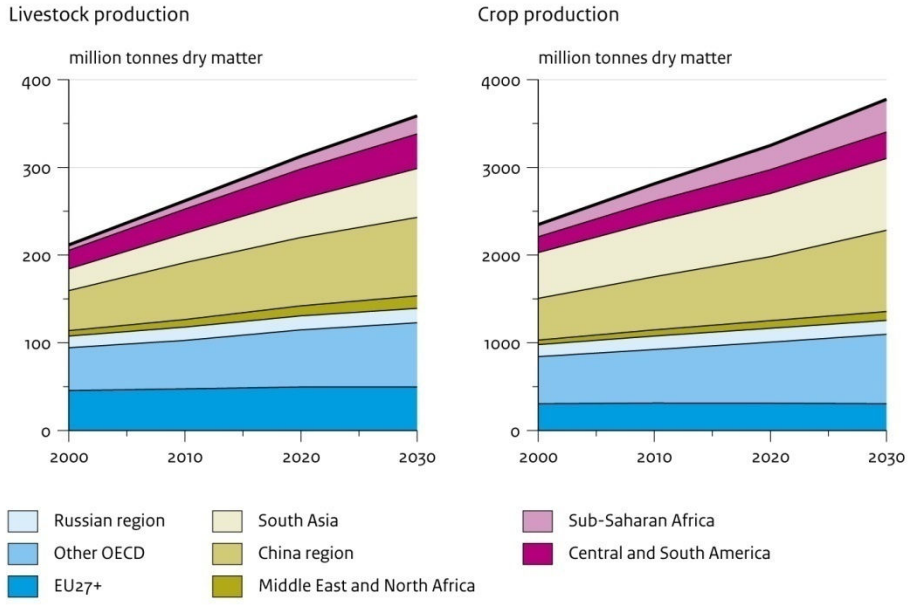

Fig. 2. Global livestock and crop production, based on LEITAP calculations
Source: Woltjer, 2011

3.3 Animal Products Have Positive and Negative Health Effects

Meat, fish and dairy produce are rich sources of vitamins, in particular vitamin B12, iron, calcium, zinc and other compounds. They are also primary sources of energy and protein in

the EU. However, the energy intake and protein intake from animal and vegetal products in the EU are higher than recommended in WHO guidelines – for protein by as much as 70% (Figure 3).

There are, however, also public health risks related to eating too many animal products. A high consumption of red meat is related to an increased risk of cancer. Red meat consumption in EU, currently, is twice as high as recommended by the World Cancer Research Fund. In addition, WHO guidelines recommend that the consumption of saturated fats be limited, due to the increased risk of cardiovascular diseases. For saturated fats, EU consumption levels, currently, are on average 40% higher than the maximum recommended amount (Figure 4). Around 80% of saturated fats originate from animal products. A diet with lower amounts of meat and dairy would potentially increase human health and life expectancy. The consumption of fatty fish is related to a decrease in the prevalence of cardiovascular diseases; however, Europeans consume only about half of the recommended amount of fish.

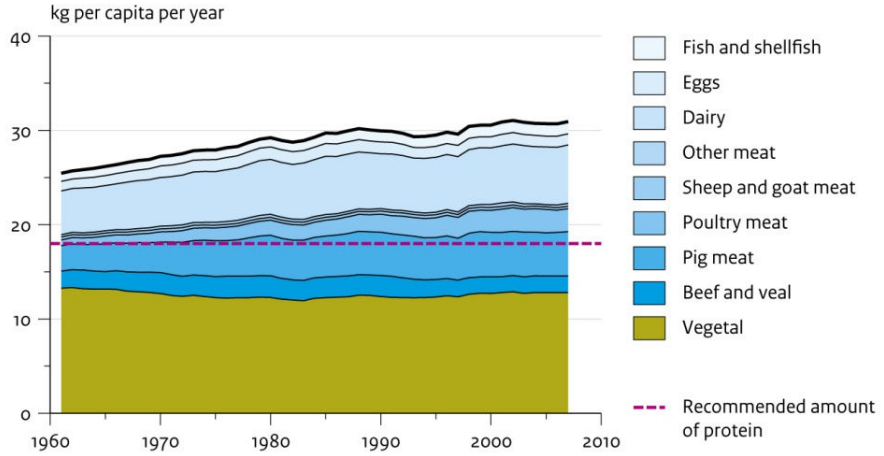

Fig. 3. Per capita intake of protein in EU27

The increased consumption of animal products means that the total protein intake has increased over the last 50 years. The consumption of proteins per person is around 70% higher than recommended. Source: PBL analysis, based on (FAO, 2010; Gezondheidsraad, 2001; NEVO, 2010; Schmidhuber, 2007; Voedingscentrum, 2008; WHO, 2003, 2007). More information on the methodology can be found in the online Annex at www.pbl.nl

4. EU FISHERIES AND AQUACULTURE

Fish and shellfish originate from both catches and aquaculture. Since EU catches are declining and the increase in aquaculture production compensates only half of this decline, imports of fish into the EU27 are increasing.

4.1 EU Catches Are Declining Rapidly, Despite New Fishing Grounds

Catches by EU fisheries are declining (Figure 5). This is partly due to the EU Common Fisheries Policy (CFP), which dates back to 1983 and was last modified in 2002. It comprises instruments for fleet reduction, a quota system, and management plans for

several fish populations. However, despite the efforts made, overfishing has not been solved, as also stated in the EU Green Paper 'Reform of the Common Fisheries Policy'. The most important fishing areas for the EU fisheries are the North-east Atlantic Ocean and the Mediterranean Sea and Black Sea. Catches in these waters have dropped by a third since the early 1990s. Although EU fishing boats are travelling ever further and fishing ever deeper to find their catches, this compensates the declining catches from European waters only to a limited extent.

Marine and freshwater biodiversity is under threat and wild fish stocks are in decline. Globally, marine fish populations have declined by 24% since 1950. About 80% of commercial fish populations are fully exploited or overexploited. In waters where the EU fishing fleet is active, the exploitation level is even higher than average.

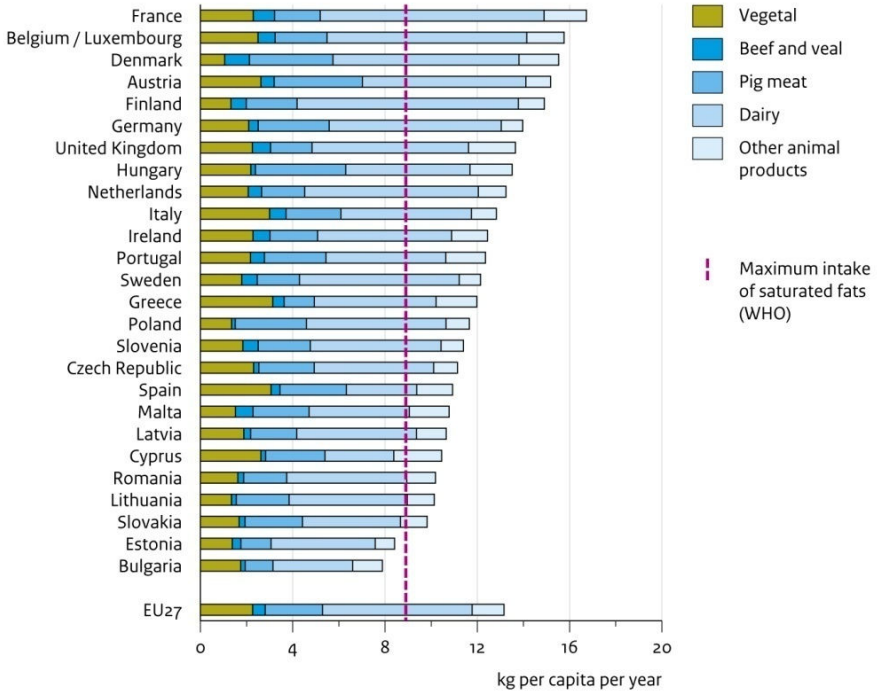

Fig. 4. Intake of saturated fats in EU27 in 2007.

In most countries, the consumption of saturated fatty acids is more than the recommended maximum amount. Source: PBL analysis based on (FAO, 2010; NEVO, 2010; WHO, 2003; Voedingscentrum, 2010). More information on the methodology can be found in the online Annex at www.pbl.nl

4.2 Aquaculture: Possibilities as Well as Problems

Smaller catches and growing fish consumption are driving the demand for aquaculture. Aquaculture production of fish in Europe has almost tripled since 1980. This has mainly been due to aquaculture in Norway; aquaculture in the EU27 has not even doubled and the increase has now stagnated. Globally, however, aquaculture has increased tenfold. Aquaculture production in the EU27, therefore, is growing much more slowly than it is worldwide.

A further increase in the cultivation of fish and shellfish could help to close the gap between growing demand and stagnating supply. Worldwide, around 40% of the produced fish currently originates from fish farms; The EU27 lags behind, at around 20%. However, aquaculture is not without its drawbacks, the most significant of which is the use of caught fish as fish feed. Other main problems are the conversion of coastal ecosystems and the nutrient pollution of coastal and inland waters. Furthermore, agricultural land is needed to produce crops, such as soy beans and cereals, for feed.

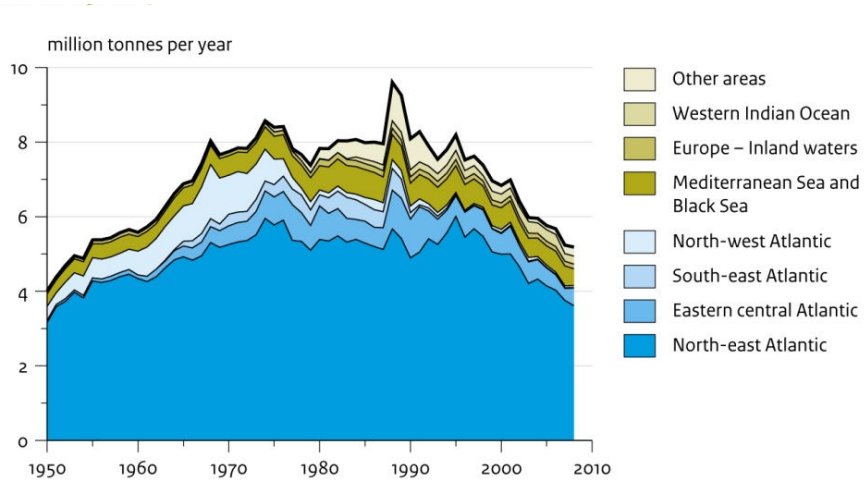

Fig. 5. Catches by EU27.
After a peak around 1990, catches made by EU countries declined rapidly, despite a trend to fish further away, for example, in the Indian ocean. Source: (Eurostat 2010; FAO, 2009)

5. THE EU LIVESTOCK SECTOR

5.1 EU More or Less Self-Sufficient in Livestock Products

The EU is a net importer of beef and sheep meat and a net exporter of pig meat and dairy products. However, quantities of both export and import are relatively small compared to EU production, thus, the EU is more or less self-sufficient in animal products. The analysis of the consequences of European diets, therefore, focuses on EU livestock production.

5.2 The EU Livestock Sector Is Diverse in Type and Size of Farms

The total production value of the EU livestock sector is more than 140 billion euros. Milk (35%), beef and pig meat (each around 20%) are the sectors with the highest production value. The total EU27 meat production is around 44 million tonnes. The European livestock sector is diverse and can roughly be divided into two types. The first type is the sector with ruminants, such as cattle, sheep and goats, which graze for at least part of the year on most farms. The second type mainly consists of pig and poultry farms, where the animals usually are kept indoors, permanently (intensive livestock production). Across the EU27, these farms vary largely in size, number of livestock per hectare, and animal origin (farm-reared or purchased), and in composition of the feed that they use.

5.3 Feed Is a Key Factor in the Environmental Effects of Livestock Production

Feed production requires large quantities of land, water and other inputs, and leads to significant emissions of greenhouse gases and nitrogen. The EU livestock sectors annually use around 500 million tonnes of animal feed. About 40% of this quantity is in grass (expressed in dry matter), 28% in cereals, and the rest consists of a range of products. About 60% of EU cereal production is used in animal feed. The dairy sector is the largest consumer of feed, with around 220 million tonnes, annually (Figure 6), followed by the beef sector and the pig sector. For beef and dairy, grass is certainly not the only feed type. In the dairy sector, the share of grass in total feed is even below 50%.

Feed can be roughly divided into three types: grass, feed crops such as cereals, and by-products. It is often argued that livestock production is a very efficient way of transforming products not suitable for human consumption, such as grass and by-products, into high-value products such as dairy and meat. However, this is only true to a limited extent. It is estimated that only 4% of dairy production and around 20% of beef production is connected to feed that comes from high nature value grasslands. Most of the grass in the EU originates from intensively managed grasslands, stimulated by fertiliser application. Extensive, high nature value grasslands have low yields. Moreover, some of the grasslands are temporary grasslands on land that could also be used for crop production.

On average, by-products only have a limited share in the total feed composition. Soybean meal is not a by-product of oil production, since the economic value of the meal is higher than that of the oil. Without the huge demand for feed, global soy production would be lower. The EU annually imports around 35 million tonnes in soybean meal equivalents, mainly from Brazil and Argentina. The EU is largely dependent on imports for the protein-rich feed component, as about 75% of protein- rich feed is imported, mainly in the form of soy products.

5.4 Development of the Livestock Sector Strongly Influenced by the Common Agricultural Policy

Domestic production, and import and export of both livestock and feed are significantly influenced by EU policies, notably the Common Agricultural Policy (CAP). Although the CAP has evolved over the last decades, it still has a strong effect, particularly through market protection and income support (Single Farm Payments). Import tariffs still exist for many livestock products. Given the fact that production costs within the EU are often higher than in countries such as Brazil and the United States, a reduction in EU import tariffs may lead to an increase in imports and, consequently, to a reduction in EU livestock production. Production quotas still exist for milk, but will expire in 2015. Other regulations, such as sanitary measures, also have an important effect on imports and on production systems abroad

The EU livestock sector has grown over the last decades. The former EU12 showed the strongest growth in the 1961-1985 period, when milk production increased by 70%, pig production by 120%, and poultry by 300%. Beef and milk production stagnated after 1985, mostly as a result of changes in policies. Pig and poultry meat production continued to grow by around 4%, annually.

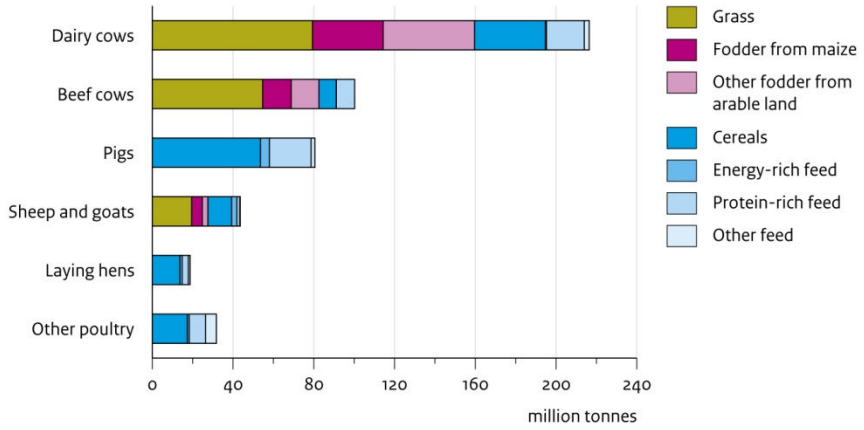

Fig. 6. Feed use per livestock sector in EU27 in 2005.

Around 65% of the feed in the EU is used in dairy and beef production: part of this is in the form of grassland products, but many crops are also being grown as feed. In total, 500 million tonnes of animal feed are used, annually, equivalent to around 1 000 kilograms per EU citizen. Source: Calculations based on Miterra-Europe (Lesschen et al., 2011; Velthof et al., 2009).

6. ENVIRONMENTAL IMPACT OF EU LIVESTOCK PRODUCTION

Livestock production has a large impact on the environment; directly due to animal husbandry, and indirectly as a result of feed production. This study looks at the effects on biodiversity (as a consequence of land use and nitrogen emissions in the form of ammonia and nitrate) and climate change (through greenhouse gas emissions). Most of the environmental effects of EU livestock production occur within the EU itself, except for those from the cultivation of soy beans. These last effects are felt in the producing countries – mainly in Brazil and Argentina.

6.1 Over Two Thirds of Agricultural Land Use in the EU27 Is Related to Livestock Production

Since good agricultural land is a scarce resource, the land area needed in agriculture is a key indicator of its environmental impact. A grassland area of around 65 to 70 million hectares is needed to produce feed for the EU livestock sector. In addition, a similar amount of arable land is needed to produce other feed, mainly in the form of cereals and forage, such as maize silage. About one third of this arable land is used to feed the animals in the European dairy sector. Grasslands are very diverse in terms of management, yield and biodiversity value. They range from semi-natural grasslands with low yields and high biodiversity values to heavily fertilised monocultural grasslands.

6.2 Significant Amounts of Land Are Needed Outside the EU to Produce Protein-Rich Feed

EU livestock production also has an effect outside the EU through the import of feed. In Brazil and Argentina, most soy is grown on originally semi-natural grasslands, which have been converted into arable land. This in itself already has a negative effect on biodiversity.

Furthermore, such expansions have also displaced livestock farmers and thus indirectly stimulated the conversion of Amazon forests into pasture for livestock farming that is being pushed out. In physical terms, about 20 million hectares outside Europe is needed to produce the protein-rich feed components. Since soy beans are cultivated for both oil and protein-rich meal, around 12 million hectares outside Europe may be attributed to European livestock production (for comparison: the arable land area used within the EU is around 120 million hectares).

6.3 Livestock Production Plays a Pivotal Role in Reactive Nitrogen Losses

Crops and grass need nitrogen to grow, while animals need proteins in which nitrogen is an essential element. Since the invention of industrial nitrogen fixation, around 1910, it has been possible to produce nitrogen fertilisers at relatively low cost. The use of these fertilisers has boosted EU crop production and, consequently, its animal production. However, crops and animals do not absorb all the nitrogen input. The output/input efficiency of European agriculture is only 19% (Figure 7).

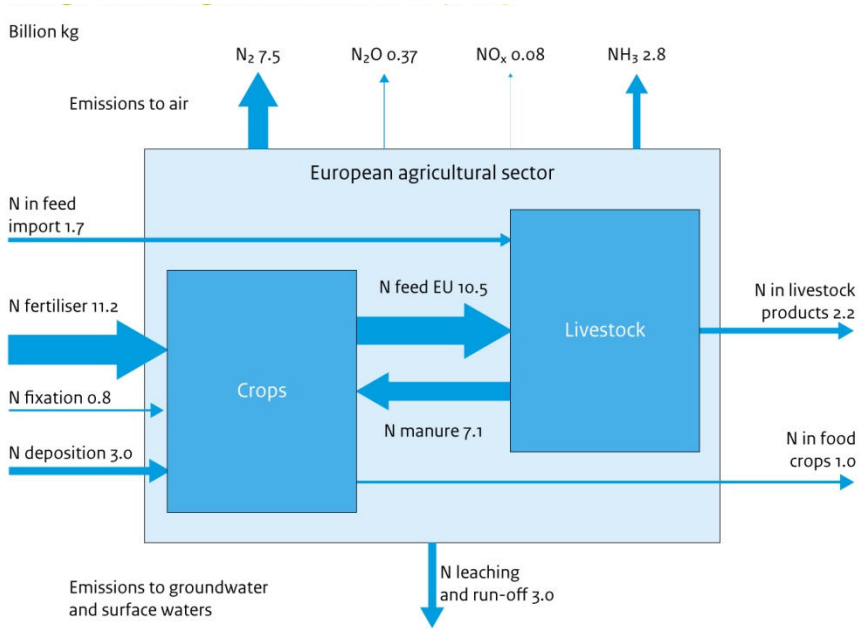

Fig. 7. Nitrogen flows in agricultural sector in EU27, 2005.
The EU agriculture has a nitrogen efficiency of 19%. The livestock sector is one of the main causes of nitrogen losses to the environment. These losses occur in various chemical forms, such as ammonia (NH_3), nitrate (NO_3), nitrous oxide (N_2O) and the harmless N_2. Source: Miterra-Europe(Lesschen et al., 2011; Velthof et al., 2009).

The rest of the nitrogen is lost; the livestock sector is the main source of nitrogen emissions. Most of the losses are in the form of harmless N2, but large losses in ammonia and nitrate also occur, both potentially leading to the eutrophication of ecosystems. In many areas in Europe, nitrogen deposition levels are above the critical values. In general, agriculture is responsible for 50% to 80% of the total nitrogen load in watersheds; the rest mainly comes from industries and households. This nitrogen also negatively affects biodiversity in coastal

zones. EU policy objectives for the quality of groundwater and surface waters are set in the EU Nitrate Directive and the Water Framework Directive. Stimulated by national and European policies, farmers have significantly reduced fertiliser use and nitrogen losses over the last 20 years while maintaining or even increasing production, and have thus increased nitrogen efficiency.

6.4 Effect of EU Livestock Production on Biodiversity

EU livestock production is influencing biodiversity in a number of ways, most prominently through the use of agricultural land and emissions of nutrients (e.g. nitrogen) and pesticides. The impact of this land use on biodiversity is diverse. On the one hand, extensive livestock production, usually in the form of traditional farming systems, has led to a special kind of land management and corresponding rich biodiversity, albeit different from the pristine situation. The grasslands used in these farming systems are defined as High Nature Value Farmlands and are considered to be part of Europe's cultural heritage. They make up approximately 30% of grasslands in the EU15. Most of which are Natura 2000 sites. Discontinuation or intensification of the present management system would lead to a loss of this type of biodiversity. On the other hand, many farm animals are fed on products from either arable land or intensively managed (and fertilised) grasslands. The intensive cultivation of these areas negatively affects local biodiversity, for example, because of the loss of landscape elements. A second main pressure of livestock production on biodiversity is being caused by the emission of reactive nitrogen and other nutrients (e.g. phosphorus) and residues of pesticides.

6.5 EU Biodiversity Target

Concerning biodiversity, the European Council in March 2010 agreed on 'a headline target of halting the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, and restoring them in so far as feasible, while stepping up the EU contribution to averting global biodiversity loss'. This would indicate that the biodiversity value of the High Nature Value Farmlands, which contain many European biodiversity hotspots, has to be ensured by the continued, extensive use of these areas. For more intensively used agricultural areas, the challenge is to maintain production at a relatively high level, while also augmenting local biodiversity values.

6.6 Greenhouse Gas Emissions: about 10% of EU27 Emissions Related to Livestock Sector

The livestock sector in the EU27 currently contributes more than 10% to the total greenhouse gas emissions from the EU27. This Figure takes into account both direct emissions from animals and manure and those related to feed production, including land use. Main sources are enteric fermentation (methane) and soil emissions (nitrous oxide). Together, the beef and dairy sectors account for more than 70% of greenhouse gas emissions from livestock farming, while pig production accounts for around 13%. The contribution from poultry (4%) is small compared to its share of 25% in EU meat production, as poultry has low digestion emissions and a better feed conversion. The policy objective of the EU is to reduce total greenhouse gas emissions by at least 20%, by 2020, compared to 1990 levels.

6.7 Animal Welfare and Animal Health

Although, strictly speaking, animal welfare and animal health are no environmental issues, they are very relevant to society and there are many links with environmental issues. Conventional types of animal housing lead to discomfort for farm animals. This discomfort is caused by poor air quality in stables, too smooth and often wet floors, the lack of stimulus offered by the environment, concentrated feed (leading to boredom), and disease. Some animals are also routinely subjected to interventions, such as beak cutting, tail docking, tooth clipping and castration. Concerning the relationship between the risks to animal health and human health, one of the main areas of concern is the development of resistant bacteria strains. Humans infected with these resistant bacteria may develop severe health problems. Furthermore, various EU Member States have faced serious problems over the last 10 to 15 years, due to outbreaks of animal diseases such as BSE (mad cow disease), foot and mouth disease, classical swine fever and avian influenza (bird flu).

7. ENVIRONMENTAL EFFECTS OF PRODUCTS AND DIETS

Livestock products deliver important components in the European diet, but they also form a significant share of the environmental impact from consumption. The EU consumption of meat and dairy produce is responsible for about 10% of all EU greenhouse gas emissions from consumption. It also represents about one third of the total land use related to household consumption in the EU27. Most of the land is located in Europe, but also elsewhere, when related to imported products, such as beef and dairy, and imported feeds used in the production of European meat and dairy. Some of the greenhouse gas emissions that are related to European consumption are emitted outside Europe.

In general, food products of animal origin cause more environmental impact than do plant-based protein-rich products. This is mainly due to inefficient conversions of feed protein and energy into animal protein and energy. Moreover, only around 50% of the total animal is fit for human consumption.

The highest environmental impact is found for meat, in terms of land use and greenhouse gas per kilogram of product, with beef having the highest impact, followed by pig meat. Poultry meat causes the lowest impact, because of the higher feed conversion of poultry. Expressed per kilogram of protein, the impact of milk is in-between the ranges of pig meat and poultry.

Land use for ruminant meat production – such as beef and sheep meat – can be high, but this is mainly grassland, especially in extensive systems. Some of these grassland regions are not suitable for arable farming, and ruminant farming systems are the only systems possible. Furthermore, the land-use impact of grassland on biodiversity usually is lower than the impact of arable land. However, in addition to higher land use, beef production also has the disadvantage that it emits methane, a powerful greenhouse gas.

Generally, land use and greenhouse gas emissions related to farmed fish are within the same range as those of poultry. The impact on marine biodiversity depends on the use of forage fish in the feed; this is relatively high for predatory species, such as salmon, but low for herbivorous species, such as tilapia. Wild-caught fish, especially, has an impact on marine biodiversity. However, bottom-trawling fishing methods generally also emit high greenhouse gas emissions because of their high energy use.

Differences in impacts also exist within production categories, such as of beef or pig meat. This variation is mainly due to differences between production systems, although transportation is also an important factor for some products, especially in the case of air transport. The differences are partly due to differences in production circumstances, but in some cases efficiencies also could be improved. There are various opportunities, both within and between the various product categories, for reducing the environmental impact from the European diet and for mitigating climate change.

Although such changes in diets would be favourable, both to sustainability and health, there is some ambivalence related to fish. Although increasing fish consumption would be beneficial in terms of human health, it would have an unfavourable impact on marine biodiversity. In order to achieve the amounts of fish recommended for a healthy human diet, innovation is needed in aquaculture.

In summary, opportunities do exist for changing human diets to be more healthy and sustainable, but further steps are required.

8. OPTIONS FOR REDUCING NEGATIVE EFFECTS OF THE EU FOOD SYSTEM

8.1 Many Points of Intervention along The Food Chain to Reduce Negative Effects

There are many possible points of intervention to reduce the negative effects caused by the present EU food system, ranging from shifts in consumption patterns, to adaptations of husbandry systems, raising crop yields to reduce the land area needed, and improved management of manure and land (Figure 8). For each point of intervention, multiple options exist. Examples are increased feed conversions or reductions in food waste. In some cases these options are directly related to possible policy measures, such as raising minimum standards of space required per animal in husbandry systems. In other cases, such as those of consumption shifts and increases in crop yields, policy measures or interventions by other actors will be less directly connected to these physical options.

8.2 Innovations in Aquaculture Could Reduce Effects on Marine Biodiversity

For the effects on marine ecosystems to be reduced, it is important to reduce the use of wild-caught fish as feed in aquaculture. Fish farming of predatory species, such as salmon, uses relatively large amounts of wild-caught fish as fish feed. However, a relatively small increase in agricultural land could be enough to produce feed for more farmed herbivorous fish, so that wild fish would be protected, could recover and possibly provide higher catches in the future. This would need to be combined with a switch in consumption from predatory to herbivorous species. Direct consumption of caught herbivorous fish instead of using them as feed for other fish, would also help. Another option – which is already ongoing – is to reduce the amount of wild-caught fish in fish feed. This could be achieved by replacing fishmeal and fish oil with additional vegetable ingredients and by improving the feed conversion. Furthermore, there are other options for farmed fish, which are similar to those for meat and dairy (Figure 8).

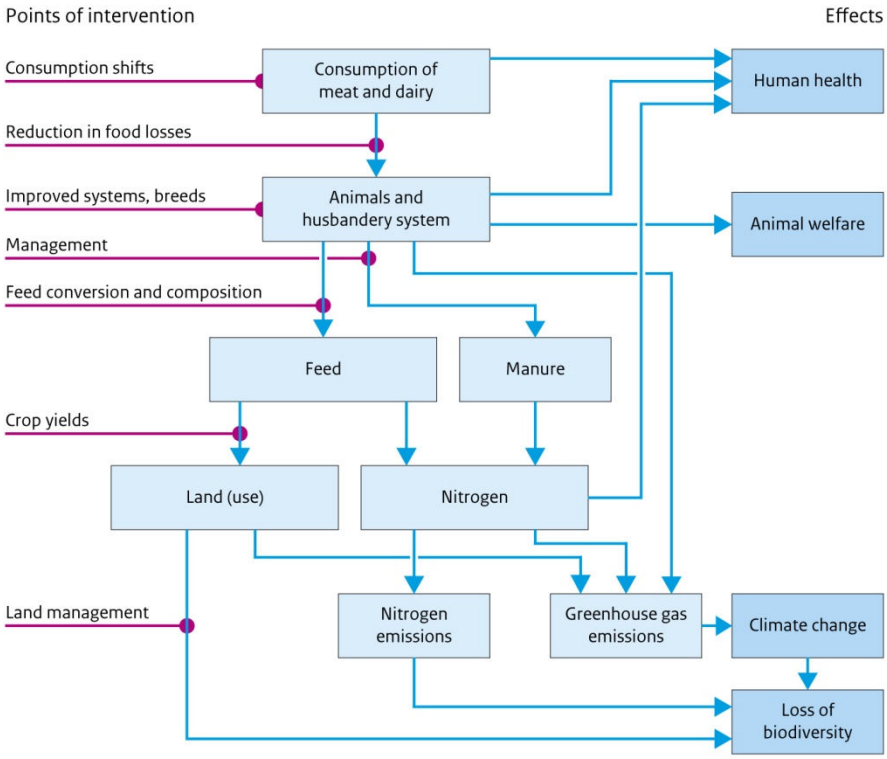

Fig. 8. Causal diagram of effects of meat and dairy consumption and points of intervention

There are many potential points of intervention at which negative effects of livestock consumption and production on human health and the environment could be addressed. Positive or negative side effects will always occur, due to the complex relationships within the food system.

8.3 Often Trade-Offs between Improvement in Animal Welfare and Environmental Issues

A number of options for reducing certain negative effects simultaneously lead to improvements for other issues, as well (synergy), but they may also lead to the aggravation of others (trade-offs). In many cases there are synergies, for example, because several problems have the same origin. Reduction in the demand for animal products, in particular, will benefit biodiversity and human health, as well as reduce nitrogen and greenhouse gas emissions. The same synergies occur in the case of increased feed efficiency.

One of the most important trade-offs lies between animal welfare and environmental effects. To improve animal welfare, farm animals need more space and perhaps outdoor access. Different breeds are also needed, which sometimes grow less quickly, as in the case of broilers. These improvements would all lead to higher feed demand per unit of produce and more emissions from housing systems. Improved welfare conditions would lead to an additional feed use of around 10% for pigs and laying hens and 25% for broilers; in the case of organic production the additional demands would even be higher. This reduction in feed

efficiency could be compensated either through innovation or by a shift in the consumption of animal products.

8.4 Quantification of Effects from Different Options

In order to explore effects, an assessment of several options was made, using PBL's Integrated assessment model IMAGE in combination with two agro-economic models (the IMPACT model of IFPRI and the LEITAP model of LEI) for comparison. The economic models were used for calculating responses by consumers and producers in different world regions. Because of feedbacks and non-linearities in the food system, a simple upscaling of results from life-cycle assessments (LCAs) or simple extrapolation ('crop yields plus 10% means land area minus 10%') would not yield valid results. Two sets of options were developed, one for implementation at the global level, the other at EU level. The combined models enabled a quantification of, among other things, effects on food demand, regional crop and livestock production, land use and greenhouse gas emissions.

8.5 Global Options Would Have Significant Effects on Land Area Needed

The options defined on a global level mainly aim at increasing usable production, while minimizing land area and greenhouse gas emissions. These options are:

- producing more efficiently (e.g. higher crop yields than assumed in the Reference Scenario, more livestock products per kilogram of feed);
- reducing supply chain wastes and losses with consequential decreases in demand and production.

All evaluated global options would result in less additional arable land and grassland needed compared to that in the Reference Scenario. Lower production costs and less waste would result in lower commodity prices, in turn leading to an increase in food consumption, which may mean less malnutrition. This reduction in arable land and grassland area, compared to that in the Reference Scenario, would also result in lower biodiversity loss and lower emissions of greenhouse gas and nitrogen.

8.6 Options at EU Level Would Mainly Have Effect on Land Use outside the EU

Seven options have been defined at EU level. These options are mainly aimed at reducing environmental impacts and human health risks by reducing or altering consumption of livestock products. Two of these options were defined to improve animal welfare. The options analysed are:

- changing human consumption patterns (e.g. switching within a food category, such as meat, to products with less environmental impact, or from animal products to vegetal products (Healthier diets, Substitution of red meat (with poultry meat), Reduced consumption of livestock products (10%, 20% and 50% less);
- shift to different production systems (Animal friendly and Organic).

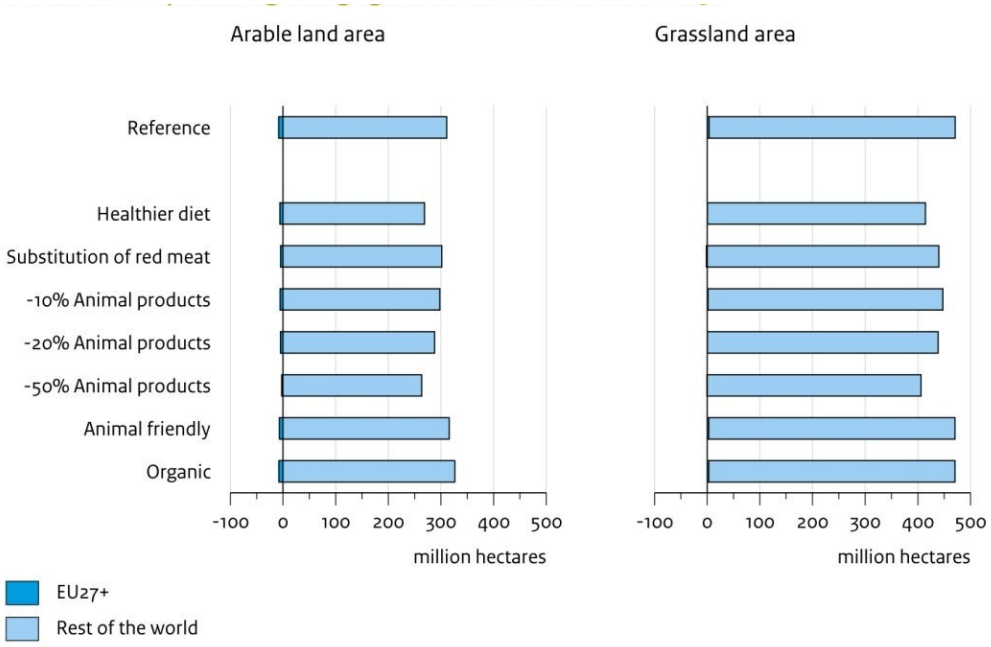

Fig. 9. Effects of EU options regarding agricultural land use, 2000-2030.
Globally, both cropland and grassland areas are projected to increase, between 2000 and 2030, as a consequence of the growing global food demand. If the EU were to reduce the consumption of livestock products, the expansion of arable land and grasslands would be considerably smaller than in the Reference Scenario. In the options that include increased animal welfare, slightly more arable land would be needed. Source: (Stehfest et al., 2011; Woltjer, 2011)

The EU options presented some counter-intuitive results, especially those regarding dietary changes. Although, in these options, reduced demand for animal products would lead to a decrease in their EU production, it would still lead to a somewhat higher export of dairy, and pig and poultry meat, and to a reduction in beef imports. In the EU, decline in livestock production would result in some extensification of land use (i.e. lower yields) and in an increase in biofuel production. In addition, as the EU demand for feed would decrease, this would result in higher cereal exports. As a consequence, some non-EU countries would face a reduction in the demand for their products, which in turn would lead to a relatively greater reduction in agricultural area in those countries than would have occurred in the EU, where yields and livestock densities usually are much higher than outside the EU. Both a shift to a healthier diet and a 50% reduction in the consumption of animal products would lead to an actual reduction in, or avoided expansion of total arable area of 45 million hectares, which equals one third of the EU arable area. The same options would also result in an avoided expansion of grassland use outside the EU of around 60 million hectares, being about equal to the total EU grassland area (Figure 9).

The fact that EU options would mainly influence land use outside the EU, may be partly explained by the design of the EU Common Agricultural Policy, which stimulates agricultural use of land by coupling the Single Farm Payments to the requirement to keep the land in 'good agricultural and environmental condition'. An additional explanation would be that land-use changes within the EU would mean land abandonment, while outside the EU this

would result in less conversions from natural areas into agricultural land. The options Animal friendly and Organic both would lead to somewhat higher commodity prices and a larger increase in cropland than in the Reference Scenario, as a result of increased feed demand in both these options, and lower EU crop yields in the Organic option.

Environmental effects would be in line with those on land use. Especially the options Healthier diet and reduced consumption of livestock products by 50%, would lead to substantial reductions in biodiversity loss, and to lower emissions of greenhouse gas and nitrogen.

The model results suggest that, usually, less than 50% of theoretical environmental benefits are actually achieved, because of feedbacks related to consumption and production. For example, price decreases would lead to an additional increase in consumption on the one hand, and to less efficient production, especially leading to lower yields, on the other. To some extent, these effects of rebounds and leakage may benefit other policy targets: lower food prices would mean a better affordability of food, and, hence, a potential means to reduce malnutrition. Extensification of production may also improve local environmental quality.

9. FROM OPTIONS TO STRATEGIES

9.1 Three Strategies to Reduce Impacts

Along the food chain, there are a number of points of intervention to reduce the impacts from consumption and production of animal products (Figure 8). For each point of intervention numerous opportunities exist. For example, higher crop yields may be achieved through better crop management and higher inputs, or by introducing new varieties. These opportunities can be grouped into three broader strategies:

(i) *consuming less or different animal products*,
(ii) *increasing resource efficiency*, and
(iii) *producing with fewer local impacts*.

These strategies are partly complementary to each other.

Consuming less or different animal products would reduce the size of livestock production, which in turn would lead to lower environmental pressure. This would include a shift towards more animal-friendly or less environmentally harmful production systems. In general, this strategy would lead to health benefits – human and animal. Increasing resource efficiency involves of a more efficient use of resources, such as land, water, and inputs such as nitrogen and phosphate. Examples would be higher yields per hectare, higher feed efficiencies, better management of manure and fertilisers, and reductions in food wastes. Producing with fewer local impacts focuses on mitigating local impacts, improving animal welfare and reducing animal health risks. Examples of opportunities related to this strategy are improving animal housing systems and breeds, and improved land management. Organic farming also falls within this strategy, and certain elements could also be applied in other farming systems, as well.

Consuming less or different animal products would lead to an increase in resource efficiency and a reduction in local environmental impacts. This, therefore, would be a robust strategy to follow. Increasing resource efficiency might lead to adverse local impacts, such as

biodiversity loss and high emissions of nitrate in regions with high production levels. This means that increasing resource efficiency might be contrary to the strategy to reduce local impacts. The benefit of this strategy, however, is that, globally, less land and resources would be required. On the other hand, the Producing with fewer local impacts strategy may result in a less efficient use of resources, both at the European and the global level. Examples are poorer feed efficiencies due to increased animal welfare, and lower yields if large land areas would be reserved for ecological set-aside.

9.2 What Role Could The EU and National Governments Play to Put These Strategies into Practice?

Current policies and institutional setting mainly drive farmers and other actors in the food chain in the direction of cost price reduction. This stimulates an efficient use of resources with an economic price that reflects their scarcity, but the current setting does not stimulate an equally efficient use of non-priced resources. Regarding the strategy Consuming less or different animal products, policies are practically non-existent, and with respect to the strategy Producing with fewer local impacts, policies are usually secondary to free market policies. By means of the Common Agricultural Policy and the Common Fisheries Policy, the EU has a large influence on the livestock and fisheries sectors. Food and agriculture may also play an important role in initiatives such as 'Resource Efficient Europe'. Policies could include financial instruments, such as 'getting the price right', legislation (e.g. on environmental and/or animal welfare), and encourage institutional changes, innovations and behavioural changes.

9.3 Actors in the Food Chain May Act Independently from Governments

Consumers and other actors in the food chain could initiate and implement the strategies ahead of changes in policies and international institutional changes. Consumers could shift to products that have lower environmental impacts or are more animal friendly. However, they will probably only do so if they are well informed, by food companies and retailers, and if there are real choices to be made. The fact that 'sustainable' diets, in general, are healthier as well, may serve as another convincing selling point. Retailers could enlarge their assortment of animal products that are produced under higher standards, as well as offer food products that serve as alternatives to meat and fish. In addition, retailers could enter into agreements with farmers and food suppliers, in order to develop new labels and improve production techniques.

9.4 Globally, Improving Food Security while Limiting Environmental Impacts Is a Major Challenge

Improving food security while limiting local and global environmental impacts is a major challenge, especially in developing countries. The development of the agricultural sector is vital for a reduction in poverty in rural areas. Assisting in creating a strong agricultural sector should however not lead to the export of westernised diets. Improving efficiencies, such as higher yields, in theory, would benefit food security and the global environment. Increasing food production alone, however, does not guarantee an improvement in food security. In order to reduce hunger and malnutrition, a more targeted, pro-poor approach would be needed, based on local physical and socioeconomic conditions.

The 'protein puzzle' is not easy to solve, and many questions remain unanswered, on more technical issues, as well as on how to change the institutional setting to initiate changes in production and consumption. Human consumption will always impact the environment, but there certainly is scope for increasing global food availability while limiting impacts on biodiversity, climate, animal welfare, and animal and human health.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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