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Food security risks for Austria caused by climate change

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Project abstract

Food security is an upcoming challenge. Major risks that will affect agricultural production and food supply in Austria are:

1) Climate change: Changing climatic and extreme weather conditions will affect agricultural production in Austria/Europe. Effects on yields are limited in general until 2050.
2) Import of energy: Austria is dependent on imports of crude oil, diesel, natural gas, as well as on nitrogen fertilizer produced by natural gas.
3) Import of inputs (phosphate fertilizer): Austrian agriculture is dependent on imports of phosphates.
4) Import of high-protein feedingstuffs: Austrian life stock production is dependent on imports of soy bean meal and vegetable oils.
5) Suspicion about technical progress: Public suspicion about technical progress (e.g. biotechnology in agriculture) may hinder potential increases in yields or plant and animal health.
6) Biofuels and biofibres: Uncontrolled expansion of areas farmed for biofuels and biofibres may limit the area needed for food and feed production.
7) Agricultural policy: Political targets towards a low input agricultural policy may reduce production potential.

Calculations in order to derive scenario-specific assumptions for the simulation models show that the largest positive changes in crop yields are due to technical progress. Largest negative changes in yields are generally due to lower intensity levels of inputs. Lower intensity levels may be the result of shortages in input supply or due to political presuppositions. In a scenario assuming a relatively high level of agricultural productivity the acreage necessary to meet present-day food security demands of Austria decreases by -29% (–297.000 ha) in 2050, relative to 2015.

In a scenario assuming a relatively low input level and an uncontrolled demand for biofuel and biofibres the acreage needed to meet present-day food security demands of Austria increases by +109% (+1.1 Mio ha) in 2050.

Environment-friendly agriculture and more acreage used for biofuel and fiber production align if technical progress is not prohibited. In a scenario assuming a medium input level, expanded areas farmed extensively and more acreage used for biofuel and fiber at the same time self-sufficiency rates and the acreage required to meet present-day food security demands of Austria stay stable, if technical progress is accepted.

Executive Summary

Problem Statement

Food security has been recognized as a threat by the UN, the US and the EU since 2008. Relating to Austria, climate change will influence agricultural production potentials in the country itself and in regions from which Austria imports food and feedingstuffs. Beyond that the resilience of Austrian food supply could be affected by threats of political conflicts, as well as social and political rebellions for food, feed and water. Additionally, the global competition for agricultural commodities, agricultural land and energy, all of which are needed for agricultural production, also presents a potential hazard to Austria's food supply.

Research Questions

Up to now there is no available common assessment, which takes into account all the effects of climate change on agricultural production in Austria and its food resilience regarding imported feed, food, energy and all other inputs relevant for agricultural production. Food resilience is not only affected by the effects of climate change on global agricultural production, but also by socio-economic influences and security policy risks. The main task of the project is to identify the major hazards, threats and risks that could affect agricultural production and food supply in Austria.

Aim and results

The aim of the project is to analyse potential food security risks for Austria in 2030 and 2050 taking into account climate change as well as political and socio-economic risks.

Based on the concept of supply balances, this study simulates the impacts of various risks on Austria's food self sufficiency, allowing for the deduction of risk management options as well as political recommendations regarding communicating and managing food security risks.

Project design

Project results were derived in two stages, relying on a forecast and a risk assessment (National Resilience) in the first stage and then using a second risk assessment with the help of threat scenarios analysed with Monte-Carlo-Simulations.

For the years 2030 and 2050, data on production, acreage and livestock, consumption, trade balances and self sufficiency rates (SSR) in Austria were simulated. The underlying dataset is based on historical data (2000 to 2010) and forecasted data (2011 to 2020, based on the OECD-FAO agricultural outlook 2011 for for the EU-27). In 2015, Austria is supposed to be a net exporter of sugar, beef and veal. The country's production of cereals (wheat and coarse grains), starch crops, pork and milk is quite self-sufficient. Austria is a net importer of oilseeds, oil seed meals, vegetable oils, fruits, vegetables, poultry meat, eggs, butter and fish. The protein component of oilseed meals is essential for Austrian pig and poultry production. Thus the SSRs for pork and poultry meat are more or less dependent on the foreign protein supply. Most food (sector) imports originate from EU-member states. With SSRs of 9% for soybeans, 49% for oil seed meals and 46% for vegetable oils, the EU-27 has comparable shortages in the own production of relevant agricultural products as Austria.

In addition, Austrian agricultural production depends on imports of energy (crude oil, diesel, natural gas) and agricultural inputs (phosphate, potassium, pesticides, vitamins, essential amino acids). The production of nitrogen fertilizers is again dependent on energy imports. Certain inputs were not taken into account for further risk analysis, for example inputs that the EU industry could assumably substitute extra-EU imports with its own short term production and products not necessary for food security (e.g. bananas). Supply risks regarding energy and inputs were assessed by taking into account the National Resilience (NR) expressed by the Social Resilience (SR) and the Political Resilience (PR) of the respective exporting countries.

Austria is heavily dependent on imports of high strategic importance originating from non-EU countries. These are energy (crude oil, natural gas), phosphate fertilizer and protein feedingstuff, especially soy.

The main crude oil suppliers to Austria are (in descending order with respect to amount) Kazakhstan, Libya and Nigeria. Gas is mainly imported from Russia and Norway. In Central Asia, Kazakhstan can be expected to be a stable trading partner for oil- and gas exports to Austria in the near future, leading up to 2050. In North Africa, Libya's future development is highly uncertain due to the physical and political devastation caused by the regime change in 2011. Internal as well as external threats can impede the reliability of hydrocarbon exports from Libya to Austria in the next few years, possibly even over several decades. In West Africa, Nigeria will remain a highly potent, but also an uncertain exporter of hydrocarbons to Austria until 2015 and most probably beyond that. Russia has no imminent internal or external risk factors in the near-term and can continue to be viewed as a stable exporter of crude oil and gas for Austria until 2015. In the mid-term there will be an increasing demand from Asian parties for these commodities, i.e., Austria will have to be prepared to face increasing competition. Norway, one of the most stable Scandinavian countries, has extensive proven as well as newly discovered oil- and gas reserves. This will enable its industry to supply hydrocarbons to Austria with high reliability until 2050.

Morocco is by far the largest phosphate supplier worldwide, accounting for more than 90% of all imports to Austria. Within the global phosphate market, Morocco will become the most important global player in the 21st century. Morocco's monopoly position will lead to a highly global competitive situation, which Austria will have to prepare for in order to ensure uninterrupted exports for its agriculture sector. Further internal and external security threats, as well as demographic, societal and environmental pressure, threaten Morocco's stability in the short- as well as in the long-term.

Austria is heavily dependent on reliable soy exports from the Americas, originating from Brazil, USA and Argentina.Though it still suffers from problems with poverty, corruption and crime, Brazil is a success story of a country rising in regional and international importance, reflecting its high internal stability and lack of major external threats in the short- and long-term. These characteristics reduce the likelihood of Brazil failing to live up to its commitments as reliable soy exporter to Austria also until 2050. The future of the United States as a reliable soy supplier is uncertain. Its hitherto dominance as the only global superpower will be questioned by other uprising nations. Further, the USA will have to deal with an aging population, diabetes and strong immigration from Mexico. Argentina's farm belt is larger than the territory of France. This implies that the country is and will remain a key exporter of agricultural products in general, and of soy in particular. Neither its policy uncertainty, nor its chronic labor disruptions will change this status significantly in the long term.

Efforts to increase agricultural production must be multiplied in the years be able to guarantee an adequate diet and nutrition for all of the world's population at accessible prices and not only for those people living in countries with sufficient purchasing power. As we doubt that agricultural production will increase sufficient, more competition and higher prices for food and inputs will be the consequence.

Food security risks for Austria in 2030 and 2050 are addressed by establishing two simple (non-economic) simulation models based on historical and forecasted data. To account for uncertainties, Monte-Carlo simulations are employed. Three different scenarios are analysed with each simulation model: a "best case", a "most-probable case" and a "worst case" scenario based upon a "base line" scenario. These four scenarios take into account the impacts of climate change on Austrian crop yields (per hectare), technical progress and supply risks (in terms of shortages of phosphorus (P-) fertilizer as well as less imports of protein feedingstuffs). Shortages in energy supply and relatively high energy prices, respectively, were considered the worst case scenario via a significant expansion of areas used for bioenergy and fibers. The scenarios are comprised of political presupposition. The best case scenario accounts for a sustainable intensification of agricultural production. The worst case scenario considers an extensive agricultural production as a presupposition all over the country. The most-probable case scenario follows more or less the current political trend towards a more ecologically sound agriculture.

Both simulation models calculate product-specific self-sufficiency rates for 2030 and 2050, given the underlying scenario assumptions. The first simulation model solves for the acreage needed to guarantee the required production (taking trade balances as given). The second simulation model solves for the required net imports or possible net exports (taking acreage and livestock as given).

Results

Major risks identified in this project that will affect agricultural production and food supply in Austria:

1) Climate change: Changing climatic and extreme weather conditions will affect agricultural production in Austria/Europe. Effects on yields are limited in general until 2050.
2) Import of energy: Austria is dependent on imports of crude oil, diesel, natural gas; dependency on nitrogen fertilizer produced by natural gas (Haber-Bosch-process)
3) Import of inputs (phosphate fertilizer): Austrian agriculture is dependent on imports of phosphates
4) Import of high-protein feedingstuffs: Austrian life stock production is dependent on imports of soy bean meal and vegetable oils
5) Suspicion about technical progress: Public suspicion about technical progress (e.g. biotechnology in agriculture) may hinder potential increases in yields or plant and animal health
6) Biofuels and biofibres: Uncontrolled expansion of areas farmed for biofuels and biofibres may limit the area need for food and feed production
7) Agricultural policy: Political targets towards a low input agricultural policy may reduce production potential.

Besides a baseline scenario, the other three scenarios developed for the simulation models can be described as follows:

1. The best case scenario assumes a relatively high level of agricultural productivity. All possibilities offered by technical progress (including biotechnology) are used. The intensity level of inputs increases relative to 2015. There are no shortages in energy, inputs and imports of feedingstuffs. Demand for biofuel and biofibres increases up to 10% of the acreage of the respective crops.

2. The most probable case scenario assumes a medium input level and expanded areas farmed extensively (25%). Technical progress as well as normal breeding efforts but also shortages in phosphate and high-protein feedingstuffs are taken into account. Demand for biofuel and biofibres increases up to 12% of the acreage of the respective crops. The scenario assumes that the share of extensive agriculture is higher. The most probable case scenario mirrors more or less the current political focus.

3. The worst case scenario assumes a relatively low input level (100% organic agriculture). Shortages in fossil energy, phosphate fertilizers and high-protein feedingstuffs are also taken into account. In this scenario, demand for biofuel and biofibres increases up to 40% of the acreage of the respective crops.

Given a set of different assumptions, the largest positive changes in crop yields per hectare (relative to 2015) are due to technical progress. However, the largest negative changes in yields are generally due to lower intensity levels of inputs. Lower intensity levels may be the result of shortages in input supply or due to political presuppositions.

Model 1: Virtual acreage needed

In the **best-case scenario** the required total acreage to meet present-day food security demands of Austria decreases by -19% (-191,000 ha) in 2030 and by -29% (–297,000 ha) in 2050, relative to 2015 of the total arable acreage considered in the project (1,032.7 mio ha, forage cropping was not included).

In the **most-probable case scenario** the required acreage to meet present-day food security demands of Austria increases in 2030 by +1% (+10,000 ha) in 2030 and decreases by -6% (-60,000 ha) in 2050, relative to 2015.

The most-probable case scenario indicates that more extensive agriculture and more area used for biofuel and fiber production is possible if technical progress is not prohibited.

In the **worst-case scenario** the acreage needed to meet present-day food security demands of Austria increases by +99% (+1,025,000 ha) in 2030 and by +109% (+1,128,000 ha) in 2050, relative to 2015.

Model 2: Self Sufficiency rates (acreage is taken as given)

If the acreage is taken as given in the **best-case scenario** the SSRs change as follows (in %age points relative to 2015):

SSR Best-case scenario	**2030**	**2050**
Wheat	+30%	+52%
Coarse Grains	+24%	+45%
Protein Crops	+5%	-3%
Sugar	-3%	+16%
Beef & Veal	+1%	-1%
Sheep Meat	+5%	+4%
Pork	+6%	+4%
Poultry	+3%	+2%
Raw Milk	+6%	+5%

In the **most-probable case scenario** absolute changes in SSRs (in %age points) relative to 2015 are as follows:

SSR: Most-probable case scenario	**2030**	**2050**
Wheat	+4%	+8%
Coarse Grains	+8%	+21%
Protein Crops	-5%	-15%
Sugar	-11%	+3%
Beef & Veal	-12%	-15%
Sheep Meat	-2%	-3%
Pork	-4%	-5%
Poultry	-3%	-4%
Raw Milk	-3%	-5%

In the **worst-case scenario** the product-specific SSRs change in the following way (in %age points relative to 2015):

SSR Worst-case scenario	**2030**	**2050**
Wheat	-44%	-45%
Coarse Grains	-44%	-46%
Protein Crops	-28%	-36%
Sugar	-63%	-67%
Beef & Veal	-26%	-28%
Sheep Meat	-9%	-10%
Pork	-14%	-15%
Poultry	-10%	-11%
Raw Milk	-13%	-14%

The project team defined risk management options, recommendations and a communication strategy:

Recommendations

Based on the findings and results of this project, the following recommendations may assist decision makers in meeting Austria's future food security:

<u>Climate change and agricultural production in Austria</u>

All specific scientific research on climate change indicates that agriculture has to adapt to it. Following the 5th report of the IPCC on climate change, Austria will have to face more and more extreme weather situations, which will especially influence agricultural production. Yields, sale volumes of farms, prices of agricultural products and farmers' income may fluctuate strongly year by year. Feed and food markets will be more volatile.

Therefore we recommend

- State financed storage of key agricultural products to stabilize markets and guarantee supply in years with low yields.
- Subsidized assurances, either with respect to production or based on the average yearly farm income, to sustain the economic viability of farms (investing power) and farmers' incomes.
- Enhancing research and plant breeding particularly regarding drought and heat tolerant varieties.
- Market support policy that stabilize prices and farming systems that increase yields.

<u>Dependency on imports of crude oil, diesel, natural gas; dependency on nitrogen fertilizer produced by natural gas.</u>

Austria is heavily dependent on imports of high strategic importance originating from non-EU countries. These imports include energy (crude oil, natural gas), phosphate fertilizer and protein feedstuffs, especially soy.

The main **crude oil** suppliers to Austria are (in descending order with respect to amount) Kazakhstan, Libya and Nigeria. **Natural gas** is mainly imported from Russia and Norway. Kazakhstan can be expected to be a stable trading partner for oil- and gas exports to Austria in the short-term and in the subsequent period leading up to 2050. Libya's future development is highly uncertain due to the physical and political devastation caused by the regime change in 2011. Nigeria will remain a highly potent, but also an uncertain exporter of hydrocarbons to Austria until 2015 and most likely beyond that. Russia has no imminent internal or external risk factors in the near-term and can continue to be viewed as a stable exporter of crude oil and gas for Austria until 2015; in the mid-term Austria will have to be prepared to face increasing foreign competition for Russian oil and gas. Norway will be able to supply hydrocarbons to Austria with high reliability until 2050.

Worldwide reserves of petrol as well as natural gas are already limited and prices are relatively high, when compared to output prices of agricultural production. Different economic sectors in Austria are heavily competing with respect to petrol and natural gas based energy use. Most of the competitors have higher values added than agriculture, which finally could result in the situation that agriculture will not have access to affordable and economically justifiable energy.

We recommend

- raising Austria's self-sufficiency rate in the energy sector
- limiting the use of petrol and natural gas based energy to those sectors, where no other energy use is technically or economically possible (e.g. energy for mobility)
- replacing fossil energy (natural gas) by alternative energy sources (wind power, solar energy) for the production of nitrogen fertilizers

- enhancing fertilization efficiency and fostering research to develop methods and/or plants to fix nitrogen by plants (due to the dependency on imports of fossil energy for the production of nitrogen fertilizer)
- increasing the production of biofuels as well as of biogas. Agriculture should be able to produce the energy needed for agricultural production and food logistics. Using bio-waste, which accumulates year by year in Austria and originates from households, gastronomy and the food industry, it should be possible to reduce the demand for area. Austria should foster investments and research to enhance energy efficiency and eventual development of new generations of biofuels
- diversifying suppliers of crude oil and doing so, minimizing the risk of getting cut off from supply in the short and medium term.
- assisting in building up stable political institutions in exporting countries Austria is depending on.

<u>Dependency on imports of phosphates and other inputs</u>

Concerning **phosphate,** Morocco (by far the largest phosphate supplier worldwide, accounting for more than 90% of all imports to Austria) will be in a monopolistic position in the 21st century. Austria will have to prepare how to ensure an uninterrupted export for its agriculture sector from only one dominant exporter who is threatened by internal and external security threats as well as by demographic, societal and environmental pressure.

We recommend

- limiting the use of phosphor to the minimum demand of soil based crop production
- enhancing recycling of phosphor from any source available, e.g. sewage treatment plants (laundry detergents) or extracts from bones in abattoirs
- enhancing scientific research on the mobilization of phosphates in agricultural soils, even that only postpones the problem
- assisting in the building of stable political institutions and peace-keeping actions in phosphate exporting countries
- ensuring technical and legal facilities to produce vitamins, essential amino acids and pesticides in Europe. Problems according to lacking supply of pesticides may be crucial as crop pests and invasive pathogens already have a high impact on yields. Climate change may intensify the risks.

<u>Dependency on imports of high-protein feedingstuffs</u>

Austria depends on feed imports, especially vegetable oils and soy bean meals. The protein component in oil seed meals is essential for Austrian pig and poultry production. In spite of successfully raising the supply rate for oil seed meals by reinforcing domestic oil plant cultivation, the protein supply situation remains crucial. Soy products are particularly important to ensure high quality protein feeding components for pigs and poultry. Throughout the last decades, there have been strong efforts to increase soy bean production, but it seems difficult to achieve the necessary level of production. Planting in more areas is restricted by a lack of varieties adapted to Austrian climate conditions (yield) and difficulties in weed.

Consequently, the good or at least relevant self-sufficiency levels for pork and poultry meat are more or less superficial and very sensible to shortages of the protein supply from abroad.

Actual per capita consumption of meats in EU and Austria is double the world level. Enforcement of oil crops cultivation within the last decade and industrial use of cereals in Austria have been lowering protein imports, but only gradually.

With SSRs of 9% for soybean, 49% for oil seed meals and 46% for vegetable oils EU-27 exhibits similar shortages in the home production of relevant agricultural products as Austria.

We recommend

- enhancing the cultivation of soy beans for feed production in central Europe (Austrian protein strategy, "Danube soya")
- enhancing research and debate possible methods and technologies to solve weed control problems in soy cropping
- raising protein feed production by using more low quality wheat for protein production
- considering the use of animal offal and meat and bone meal for feeding of non ruminants
- re-evaluating hygiene provisions to facilitate feeding of food waste to animals

- promoting responsible use of meat in human diets. For Austria effects of reducing meat consumption in diets on food security may be limited as around 70% of Austrian farm land can only be used by meat production due to geography (alpine grassland) or climatic or natural limitations (crops grow only in feeding quality crop rotation).

- promoting the consumption of meat less dependent on high quality protein feedingstuffs and using feed from grassland and meadows (ruminants)
- assisting in building up stable political institutions in exporting countries Austria is depending on.
- With regard to soy, Austria should strengthen its relationship with Brazil as soy supplier bearing in mind that its other two main soy suppliers, Argentina and the US, may have problems in meeting Austria's demands in the long term.

Technical progress

We recommend

- intensifying scientific and applied research programs in plant and animal breeding. The final objectives should be to raise yields in crop production as well as to increase the transformation rate in animal production
- informing the public on food security issues and present-day agricultural production methods and enable an unbiased dispute on technologies and measures to enhance productivity.

Biofuels und biofibres

The increased use of biofuels and biofibres is an important pillar of the bioeconomy. Fossil energy resources will will decrease within the next decade and may end anytime. Prices will rise. Political risks may disturb markets even earlier.

We recommend

- enhancing the use of biofuels and biofibres to moderate prices for fossil energy and to steer demand and supply (in addition to other alternative energy sources)
- preventing an unlimited expansion of areas farmed for biofuels and biofibres, by steering the demand for food, feed, fibers and fuel.

We have to keep in mind that higher farm prices in developing countries increase incomes in agriculture, lead to rising investments, and at the same time favor productivity in the sector. There are still about 1.4 billion people living on less than US$1.25 a day. At least 70% of the world's very poor people are rural. 80% of rural households farm to some extent, and typically it is the poorest households that rely most on farming and agricultural labor.[1] 90% of the worlds extremely poor are small-scale farmers.[2] Higher agricultural prices, even if they are results of biofuel production, may reduce poverty and boost investments in a long term.[3]

Policy presuppositions

A low input agriculture may be more environmental friendly. Extensive low input agricultural production needs more area to produce the same amount of food. Extensive low input agricultural production in Austria is factually an export of virtual area to developing countries. Dependencies grow strongly.

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[1] IFAD, Rural Poverty Report 2011, 5, http://www.ifad.org/rpr2011/index.htm

[2] FAO (2012): Livestock sector development for poverty reduction, Rome; XIII

[3] Farming Systems and Poverty, Improving farmers' livelihoods in a changing world

A high input agriculture may harm the environment and interfere with animal welfare believes. SSR may be increased significantly.

We recommend

- balancing reasons between political presupposition towards a low input agriculture (e.g. organic farming) and a high input agriculture. Sustainable agricultural intensification (more intense production taking into account envirnomentalö aspects) may be a solution
- limiting the consumption of agricultural area by construction of e.g. building, roads or reforestation and other use.

1. Technical and Scientific Content, Objectives and Applied General Methodology of the Project

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1.1. Hypotheses to be tested

Climate change will influence agricultural production potentials in Austria and in regions from which Austria imports food and feedingstuffs. Beyond that the resilience of Austrian food supply will be affected by threats caused by political conflicts, by social and political riots for food, feed and water as well as the global competition for agricultural commodities, agricultural land, energy and fertilizer needed for agricultural production. The project analyses these food security risks by carrying out the following activities:

- International data collection with regard to pertinent literature, compilation and review of literature, assessment of models, studies and expert assessments. Expert assessments are performed in data workshops and focus groups.
- Risk analysis of threat scenarios. The impact of the threat scenarios are analysed using mathematical simulations.
- Development of recommendations on crisis mitigation.

1.2. Starting point

Austria depends heavily on imports of energy, fertilizer, oilseeds, fruits and vegetables. Austria has a self-sufficiency rate of above 100% only in the cases of sugar, wheat, beef and veal meat, pork and milk. These data are misleading as the high self-sufficiency rate of meat heavily depends on imports of protein feedingstuffs. There are also particularly significant imports of soybean meal, amounting to 500,000 tons per year. Soybean meal is essential in pork and poultry production. Without imports of soybean meal the self-sufficiency rate for pork and poultry would decrease dramatically. In addition, Austrian agriculture depends highly on imports of energy (crude oil, diesel and gas) and phosphate fertilizer for agricultural production (Phosphorus is essential for plant growth and thus for agricultural crop yields and food production: Cooper et al 2011). It is mostly excavated in mines and processed with Nitrogen and Potassium to mineral fertilizers (Cordell et al. 2009).

It is evident that there are risks for food security, if production potentials in Austria and central Europe are affected through climate change and other supply risks, e.g. import shortfalls of crude oil, diesel, gas, phosphate fertilizers or feedingstuffs. Supply risk may be caused by political or socio-economic conflicts as well as the global competition for agricultural commodities, agricultural land and energy and fertilizers needed for agricultural production. Due to climate change there could arise a new competition for exported feed or even shortages of food in exporting countries. This study aims to contribute to the literature on food security risks for Austria.

To ensure the future food supply – and therefore the national security –different policies and strategies were chosen by some states. One of these solutions is the acquisition of agricultural land in foreign countries through private firms, formation of national organizations or use of private investors. The 4th IPCC report acknowledges the worldwide effects of climate change and reasons why these effects will increase over the next decades. Measures to mitigate climate change as well as measures to adapt to changing conditions due to climate change will become more important in the future. In June 2008 the U.S. Military Advisory Board classified for the first time the risk of climate change on U.S. national security as being higher than the risk of a military conflict during the Cold War and other global risks. The European Union has also recognized climate change as a risk for food security. In the debate on the CAP post 2013, concerns about food security while world's population is rapidly increasing, good land management, the problem of climate change and balanced development of rural areas are addressed as key issues. Until now, the EU Council only identified food security risks for developing countries. In the United Kingdom an intensive scientific debate on national food security has already started. Under these changed premises the UK is the only member state to accomplish a national food security assessment until now. The Austrian Lebensmittelbewirtschaftungsgesetz 1997 provides measures to securing food supply in emergency situations in Austria. Agrarmarkt Austria may be mandated by the Federal Ministry for Agriculture, Forestry, Environment and Water Management with this responsibility. Food security as a general issue is in the initial phase of political discussion. Up to now real data on forecasts regarding food security risk in Austria are unavailable.

1.3. Project Objectives

Risk analyses on food security risks for Austria and development of data collection on the resilience of food supply mark a sensible starting point for the following efforts towards further research and political discussion:

- Identification and characterisation of hazards and threats to agricultural production caused by climate change in Austria in 2015 and for 2030 and 2050.
- Identification and characterisation of hazards and threats to agricultural production caused by climate change and by socio-economic developments, population growth and political conflicts in exporting states regarding food and feed supply resilience as well as for fertilizer and energy supply needed for agricultural production in Austria in 2015 as well as 2030 and 2050.
- Simulation of risks and their impacts on Austrian food balances
- Assessment of identified and characterised food security risks. Description of food security risks by threat scenarios. Assessment of their consequences and description of their impacts on Austrian food security in 2015 and for 2030 and 2050.
- Development of risk management options and recommendations to implement political strategies for ensuring food security in Austria (risk management concerning food security risks).
- Development of a communication strategy concerning food security risks for target groups like policy decision makers, producers and consumers.

1.4. Background 1: Climate Change and Agricultural Production

In agricultural crop production, it is rarely realized that, for the past few decades, the underlying biophysical conditions for agro-ecosystem resources and functions (i.e., that agro-climatic conditions remain stable long-term) have been significantly altered by climate change (e.g., Assad et al. 2004, Perarnaud et al. 2005, Oberforster 2009). In recent years scientific research, scientific research has made several attempts to assess future climate-based agricultural risks in crop production and searching for adaptation measures for agricultural systems. Global warming is expected to modify the plant response and agricultural activity. For the determinant herbaceous crops, the increase of temperature could shorten the cycle and result in decreased yield. The accumulation and extension of periods of drought and the appearance of new invasive species will increase the risks for agricultural production and yields significantly. Rainfed summer crops are, as many simulation studies show, in general at a higher yield risk under most climate scenarios (Eitzinger et al., 2009). For example, significant negative yield effects for several crops and additional water demand for irrigation might be expected in southern Europe (e.g. Marrachi et al., 2005) as well as in regions with low soil water availability (Tubiello et al., 2000). The opposite will happen for crops with indeterminate cycle if the irrigation water availability will increase. For tree crops, the temperature increase could expand the suitable area for plants requiring high temperature, such as the grapevine (Olesen and Bindi, 2004). The conditions for cropping could become more favourable within the area of the Commonwealth of Independent States (CIS- former Soviet-Union). Therefore, in addition to mitigation measures, agricultural adaptations to climate change will become more important in the future. European and Austrian agricultural production will be affected seriously by climate change.

1.5. Background 2: Climate Change, Political Conflicts and Feed and Food supply

The current and the future climate have impacts on eco-systems, social systems and the economy. Global population growth and climate change will influence the demand and availability of food, feed and biomass for energy as well as energy and fertilizer for agricultural production. Austria and most EU member states currently depend heavily on imports of protein feedingstuffs, oilseeds, fruits and vegetables and on fuel and fertilizers for agricultural production. The data are misleading as the high sufficiency rate of meat heavily depends on imports of protein feedingstuffs. There are particularly significant imports of soybean meal, amounting to 500,000 tons annually. Soybean meal is essential for pork and poultry production. Without imports of soybean meal the self sufficiency rate for pork and poultry will shrink dramatically. Due to climate change there could be a new competition for exported feed or even shortages of food in exporting countries. In 2008 leading markets, like the European Union and the USA, concluded that climate change and its consequences threaten our security policies, eco-systems and social systems (EU security doctrine, Brussels, March 2008). Leading politicians expressed their concern that future competition for food will deepen conflicts and could provoke wars and social and political riots, e.g., Lee Hsien LONG, Prime minister, Singapore, 2008. In 2008 the first indications of social riots occurred in Asia, Africa and the Carribean. Included among the consequences of these riots were numerous deaths, the fall of Haiti's government, and the announcement of food export-restrictions (e.g. rice from some Asian countries in 2008). As a result of these facts, this project will, with a detailed focus on Austria, take a scientific assessment of the risks of climate change on agriculture and food industry systems while also considering its global consequences on food security. To ensure the future food supply – and therefore national security – several different solution statements were already chosen by some states. One of these solutions is the acquisition of agricultural land in foreign countries for example through acquisition by private firms, formation of national organisations or use of private investors, such as:

- South Korea: Hyundai Heavy Industries buys farmland in Siberia; Daewoo Logistics plans to lease 50% of the whole farmland of Madagascar.
- Japan: Mitsui Industries has bought 100,000 ha of farmland in Brasilia.
- China (p.R.): Acquisition/Leasing of 2.0 million hectare of farmland in foreign countries.
- Saudi-Arabia: $ 4.3 billion land for rice farming in Indonesia.
- Gulf Cooperation Council: Acquisition of agricultural areas in Europe, Latin America, Sudan, Pakistan, Cambodia.
- Black Earth Farming (S), Heartland Farms (UK), Trigon Agri (DK): Acquisition of agricultural areas in Russia

- Morgan Stanley (USA): Acquisition of agricultural areas in Ukraine
- P. Heilberg Investment (USA): Acquisition of agricultural areas in Sudan

As a further consequence of climate change (environmental-), an increased number of refugees will present an imminent security problem. The combination of increasing occurrences of storm and flood catastrophes, increasing number of heat waves and forest fires, the loss of freshwater availability and the loss of food production will increase environmental migration. If climate change will occur according to predicted dimensions, security-related risks to food and animal feed supply are inevitable.

1.6. Improvement of Existing Solutions and Degree of Innovation

Existing data sets or studies are forecasts on the development of agricultural production (FAO 2003, FAO 2006) or assessments of agricultural production potentials (Erb et al IFF 2009). These models take into account probable effects of climate on agriculture (partly only until 2030 as FAO 2003) and the competition for agricultural products ranging from food to fuel. Up to now there has been no common assessment available, which takes into account the effects of climate change on agricultural production in Austria and the food resilience of imported feed, food and energy for agricultural production. Food resilience is not only affected by the effects of climate change on global agricultural production, but also by socio-economic impacts and security policy risks. The innovative factor of this project is the combination of agricultural production scenarios with global socio-economic trends and security policy risks considering climate change scenarios. The study focuses clearly and specifically on the assessment of Austrian food security risks.

1.7. Description of Scientific Uncertainties

There have already been several studies from UN organizations, universities and scientific institutes on the question of food security. Only a few of them considered the 2050 time horizon. For this project we focused on studies with the 2050 horizon.

On the other hand, a lot of studies also used the same FAO – studies (Table 1) and data as a basis for their work. These studies were mostly focused on commodity prices, rather than on the question of population growth, production and demand, which minimized their weight in the analysis.

Having said this, it is clear why the following studies have been selected:

Table 1: literature search

Author	Titles list
ALEXANDRATOS, N. (2009)	World Food and Agriculture to 2030/2050
BRUINSMA, J. (2003)	World Agriculture:towards 2015/2030
Cooper, J.; Lombardi, R.; Boardman, D.; Carliell-Marquet, C. (2011)	The future distribution and production of global phosphate rock reserves. Resources, Conservation and Recycling 57, 78-86.
EUROPEAN COMMISSION (2010)	Situation and Prospects for EU Agriculture and Rural Areas
ERB, K-H et al. (2009)	Eating the Planet: Feeding and fuelling the world sustainably, fairly and humanely – a scoping study
FAO (2006)	World Agriculture: towards 2030/2050
FAO (2011)	The State of Food and Agriculture 2010 – 2011
FAOSTAT (2011)	http://faostat.fao.org/site/291/default.aspx
FORESIGHT (2011)	The Future of Food and Farming
HLPE (2011)	Price volatility and food security
NELLEMANN, C. (2009)	The environmental food crisis – The environment's role in averting future food crises
OECD-FAO, (2010)	OECD-FAO Agricultural Outlook 2010 – 2019
UN Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects, (2011)	The 2010 Revision
WORLD BANK (2010)	World Development Report 2010

The final results of the analyses of the above papers, studies and reports are described in the following chapters.

1.8. General Methodology

1.8.1. Risk Analysis and Scenarios

Author: AGES: Johann Steinwider

Project results were derived into two stages. The first was comprised of a forecast for production, areas, consumption, trade balances and SSRs, and a risk assessment (National Resilience). The second was based upon a risk assessment using threat scenarios analysed by means of Monte-Carlo-Simulations.

Based on the assessment of forecasts of production, area, consumption, trade balances and SSR for 2030 and 2050 and a risk assessment (National Resilience) of exporting countries, scenarios were developed in expert workshops.

National Resilience (NR) Levels are assessed using a combination of various indices, based on a wide spectrum of parameters. These parameters describe the current situation in quantitative manner, using arbitrary units.

NR<2: Countries featuring a National Resilience Level lower than 2 can be considered highly reliable trading partners. Unforeseen interruptions in supply of food, feed or energy are very unlikely.

NR<4: Describes countries of medium National Resilience. Imports from these countries may be interrupted for limited duration before they resume again normally.

NR≥4: These countries should be viewed as highly vulnerable. In light of the rather large potential negative consequences due to additional stress, the disruption of exports for an undefined time period is more probable than not.

Agricultural production prognoses, hazards and threats regarding the resilience of food and feed supply as well as the supply with energy and phosphate fertilizer as described in WP 1 and WP2 were analysed and assessed for this reason. The scenarios were separately calculated with the Monte Carlo simulation. With the Monte Carlo simulation input criteria and the calculated consequences of several hazards and threats can be combined to calculate an overall risk, which describes the impact on Austrian food supply and the self-sufficiency rate. The results of the simulations of different scenarios for the 2030s and for the 2050s are evaluated separately against today's demand for food and feed (2015).

1.8.1.1. Definitions

There are several definitions of risk analysis or risk assessment which are quite similar but with semantic differences. The following definitions are listed according to ISO standards.

Definitions according to ISO/DIS 31000 and ISO 49.000

<u>Risk</u>

Risk is the combination of the probability and impact of an event. Risk involves chance and threat potential. It estimates the probability and impact of a scenario (ISO 49001).

Risk = probability of event x impact

<u>Risk Assessment</u>

According to ISO/DIS 31000, Risk Assessment is the overall process of risk identification, risk analysis and risk evaluation.

- Risk identification: The aim of this step is to identify sources of risk, areas of impacts and their potential consequences.
- Risk analysis: The second step is to analyse the risk to provide input on risk evaluation. It involves consideration of the causes and sources of risk, their consequences and the likelihood that those consequences can occur.
- Risk evaluation: Risk evaluation involves comparing the level of risk found during the analysis process with risk criteria established when the context was considered.

Scenario Development

As a method of risk assessment scenarios are developed and evaluated with the likelihood and impact of the threats. A scenario is the concrete representation of the opportunities and threats (ISO 49.000)

Risk aggregation

A Monte Carlo simulation is an effective method to determine the interaction of several different, uncorrelated individual risks to an organization's overall risk (ISO 49.000).

Risk management

Risk management is a series of coordinated activities to be carried out to manage and control risks. Risk management is comprised of the system definition, risk assessment (risk analysis and risk evaluation), risk treatment (risk avoidance, reduction of probability, limitation of consequences, risk optimization, risk transfer, risk retention), risk acceptance, risk monitoring and risk communication.

According to ISO/DIS 31000, risk management should ensure that organizations have an appropriate response to the risks affecting them. Risk management should thus help avoid ineffective and inefficient responses to risk.

Definition according to the general principles and requirements of food law **(EC) No 178/2002**

Food security is not the same as food safety, but food security is a prerequisite for food safety. We assume that the result could be relevant for food safety risk assessment, so for the sake of completeness we describe here the definition of risk assessment in the Regulation (EC) No 178/2002 by laying down the general principles of food and feed safety in Europe.

"Risk" means a function of the probability of an adverse health effect and the severity of that effect, consequential to a hazard;
"Risk analysis" means a process consisting of three interconnected components: risk assessment, risk management and risk communication;

“Risk assessment" means a scientifically based process consisting of four steps: hazard identification, hazard characterisation, exposure assessment and risk characterisation;
"Risk management" means the process, distinct from risk assessment, of weighing policy alternatives in consultation with interested parties, considering risk assessment and other legitimate factors, and, if needed, selecting appropriate prevention and control options;

The definitions of this regulation are specifically focused on hazards for the health on plants, animals and humans.

1.8.1.2. Methods

Risk Assessment in this project

A requirement for risk assessment is a detailed characterisation of the hazards and threats of climate change on food security and the global supply of food, feed and energy. This work was done in work package one and two, which is described in detail in chapter 2 to 5.

Figure 1 shows the project structure:

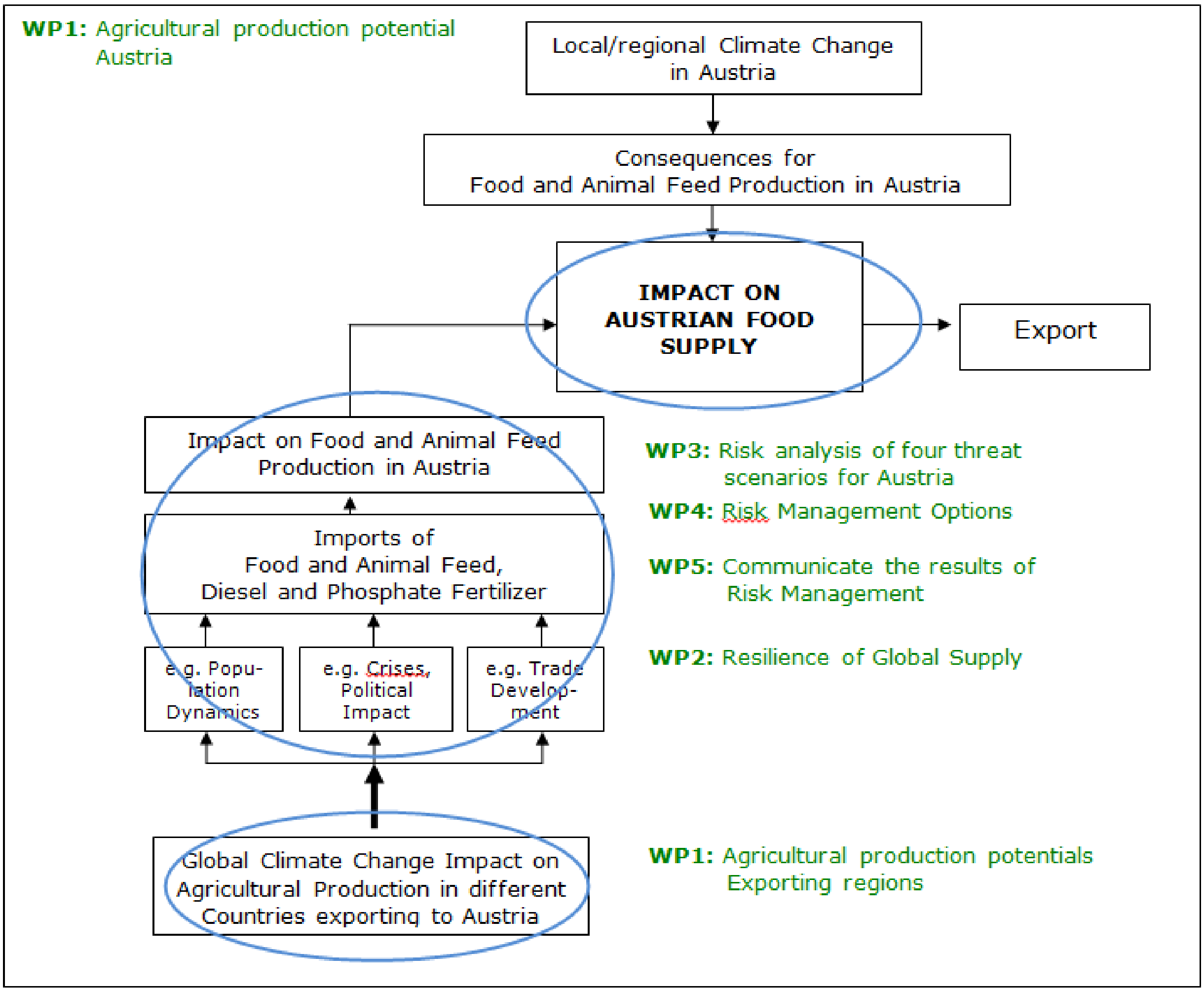


Figure 1: Structure of the analysis of security risks caused by climate change

1.8.1.3. Development of scenarios

Based on the assessment of the results of WP1 and WP2, scenarios were developed in expert workshops. Included in the discussion and aggregation of scenarios were agricultural production prognoses, hazards and threats regarding the resilience of food and feed supply, as well as the supply of energy and phosphate fertilizer as described in WP 1 and WP2.

ISO 49.000 defines a scenario as a detailed description of a specific threat with causes, courses and consequences. The scenario has one or more threats as a starting point and includes a sequence with different impacts on an organization or a system. As a method of risk assessment scenarios are developed and evaluated with likelihood and impact of the threats.The consequences are results of the models of this project.

We will explain here the structure of the discussion on the example of phosphate fertilizer.

The largest phosphate supplier worldwide is Morocco, accounting for more than 90% of all imports to Austria. Internal and external security threats in Morocco can lead to an interruption of phosphate exports (see chapter 5.1.9).

The lack of phosphate reduces agricultural production significantly, but there is a deposit of phosphate in the soil, which lasts for several years. Therefore a short interruption of phosphate fertilizer supply would have a marginal effect and could be neglected, but a long term interruption of the supply would have a critical impact on production. Because of the fact that the supply of phosphate fertilizer was analysed as critical in the long term, an assumption was made regarding the likelihood for the reduction of production for several scenarios (seeTable 2).

- The likelihood of the several scenarios regarding the threat of lack of phosphate was used to categorise the scenarios as most probable, best and worst case. The highest probability was used for the most probable case, then the better option was used for the best case, leaving the worse option for the worst case. The assumptions of today were used for the baseline scenario, but with the added impact of climate change.
- The assumptions were re-discussed in the next meeting to carry out a reality check – a confirmation of the assumptions against different sources in order to define parameters and variables for the simulation. The input levels for the threats used in the simulation models are described in detail in chapter 6.3.
- This process was done for all the other threats in the scenarios. Finally the descriptions of the scenarios were implemented as the input criteria for the Monte Carlo simulation.

Table 2: Expert evaluation of identified threats on a scale from 1 (not likely) to 10 (very likely)

	Likelihood	**Used for Scenario**
Climate Change		
Climate Change regarding model	10	used for all scenarios
Technical progress		
As before	8	most-probable case
Higher than before	6	best-case
Lower than before	6	worst-case
Input level affecting yields		
As before (Medium input level)	10	most-probable case
High input level	6	best-case
Low input level	6	worst-case
Phosphorus fertilizer		
As before (no shortage)	6	best-case
Medium impact of shortage	8	most-probable case
Total impact of shortage	5	worst-case
Demand as before	6	best-case
Medium increase in demand	8	most-probable case
High increase in demand	6	worst-case
Imports of protein feedingstuff		
No import restrictions	5	best-case
Medium import restrictions	8	most-probable case
High import restrictions	5	worst-case

The results of the assessment were used to develop several scenarios (they are already shown in the above table).

- Baseline scenario
- Best case scenario
- Most probable case scenario
- Worst case scenario

Table 3: Expert evaluation of identified threats on a scale from 1 (not likely) to 10 (very likely) – total likelihood points out of 60.

	Threat	baseline scenario	best-case scenario	most-probable case scenario	worst-case scenario
impact of climate change		Yes			
Likelihood			10	10	10
technical progress		as before	higher than before	as before	lower than before
Likelihood			6	8	6
input level affecting yields		as before	high input level	medium input level	low input level
Likelihood			6	10	6
phosphorus fertilizer		no shortage		medium impact of shortage	total impact of shortage
Likelihood			6	8	5
bioenergy		as before	low increase in demand	medium increase in demand	high increase in demand
Likelihood			6	8	6
imports of protein feedingstuff		no import restrictions		medium import restrictions	high import restrictions
Likelihood			5	8	5
Total likelihood (points of 60)			**39**	**52**	**28**

The aggregated likelihood of the different threats is 52 points out of 60 in the most probable case, 39 in the best case and 28 in the worst case. This was also discussed in the second expert workshop, where it was concluded as reasonable.

1.8.1.4. Monte Carlo simulations

Scenario results were calculated using a simulation model (Monte Carlo simulation). Monte Carlo simulations enable an analysis of the impact of input criteria and assumed risks of the scenarios on Austrian food supply balances and the respective self-sufficiency rates. The results of the scenario-specific simulations for 2030 and for 2050 are evaluated separately relative to supply balances in 2015.

1.8.2. Description of Questions to be addressed

A necessary review of pertinent literature starts with studies on agricultural production and agricultural production scenarios now and in future, taking climate change into account. In working package 1 as the first step in agricultural production and demand for 2015, 2030 and 2050 on the basis of agricultural statistics and forecasts of the FAO (FAO-Stat 2009, FAO 2003, FAO 2006), the UN medium population forecast (UN 2007) and Climate Change Model A1b Scenario will be taken as baseline. Useful climate reports and relevant studies will be analysed and taken into consideration.

In detail the analyses will comprise of:

- agricultural production potential under changed climatic conditions (Austria, EU and worldwide regions exporting food and feed to Austria or the EU)
- production hazards with regard to drought and plant and animal health under the effects of climate change
- supply resilience of imported food, animal feed and energy for agricultural production
- this analysis is conducted separately for Austria, the EU and regions worldwide, which are able to export food and feed to Austria or the EU

The project will not develop a new model for agricultural production potentials. The project team, particularly AGES and LKO experts, will assess global models, global production and demand scenarios in data workshops and focus groups from an experts point of view in order to gain a relevant data framework regarding the impacts on Austria.

For the 1st task it is necessary to quantify the Austrian production of food and animal feed, imports and exports of food and animal feed and energy imports for maintenance of agricultural production in 2015, 2030 and 2050. Self-sufficiency rates and import dependencies in 2030 and 2050 will be estimated. The EU was only considered as a whole entity due to limited resources and data.

The effects of climate change, population growth and land use change are taken into account. The second task is to consider the resilience of the food and feed supply from global markets. Sources of imported food, animal feed and energy for agricultural production have to be quantified and described. An assessment of the actual risks of supply and of possible alternative sources concludes this task. A global demand and supply scenario, taking into account and climate change, is then developed for 2030 and 2050.

A data framework describing the agricultural production and export potential of traditional or future suppliers will be the basis for working package 2. In working package 2 political and socio - economic threats caused by climate change as well as existing threat scenarios (developed by the Austrian Federal Ministry for Defence, U.S. Military Advisory Board) are analysed. Issues are e.g. the impacts of political and social riots in exporting countries on food and feed supply to Austria, the predicted worldwide global competition on international commodity markets for feed, food, fibre and fuel, the availability of phosphate fertilizers or acquisition of agricultural land in foreign countries, conflicts through water supply shortages and refugees according to increasing sea level, etc.

A risk analysis is performed in Work Package 3: agricultural production prognoses, hazards and threats regarding the resilience of the food and feed supply and the supply with energy and phosphate fertilizer as described in WP 1 and WP 2 are analysed and assessed. Three different scenarios (best case, most probable case, worst case scenario) based upon a baseline scenario are developed. These scenarios are separately completed through an assessment of possible consequences in terms of possible food security risks for Austria. Risk is derived from the probability of a certain threat to occur (threat scenario development) and the resulting consequences [risk = probability of threat x impact]. The risk analysis is comprised of an analysis of the impact of the above developed scenario assumptions (e.g., regarding imports of food, feed, fertilizers and energy for agricultural production) on Austrian food supply and the self sufficiency rates. These consequences are analysed using mathematical simulations on the base of product.

Work Package 4 will develop risk management options concerning food security risks and political strategies for ensuring food security. It shall be possible to interact between adaption and mitigation strategies. Implementing and proposing management measures regarding food security are taken into account. Based on the risk analysis, recommendations for ensuring food security in Austria and a communication strategy are developed. At the end of Work Package 5, the results of the project will be communicated to the target groups' policy decision makers, producers and consumers.

1.8.3. Anticipated Project Results

Austrian agriculture is highly dependent on imports of protein feedingstuffs, diesel for agricultural production and phosphate fertilizer. Austria has a low self sufficiency of fruits, vegetables and oilseeds. It is evident that there are risks for food security, if production potentials in Austria and Central Europe are affected by climate change and supply risks production of feedingstuffs and diesel for agricultural will be placed under pressure or even cut. The project will deliver:

- a framework of agricultural production data and supply data for Austria and regions, which are relevant for the Austrian supply of feed, food and energy for agricultural production in 2015, 2030 and 2050
- self sufficiency rates for Austria in 2015, 2030 and 2050
- analysis of political and economic threats caused by climate change and global competition on international commodity markets, which may have impacts on imports
- risk analysis and systemic interactions of scenarios (worst case and most probable case) regarding food security risks for Austria
- evaluation of implementing and proposed management measures concerning food security risks as well as political strategies

- recommendations for ensuring food security, e.g. alternative crop rotations, optimized national agricultural production, intended self-sufficiency rates, enhancing trade relations with secure supply regions
- communication strategy.

Due to the lack of suitable data in combination with limited personal and financial ressources, we were not able to calculate self sufficiency rates for European Union in 2030 and 2050.

1.8.4. Importance and Relevance of the Project

In 2008 the US military graded climate change’s risk on national security higher than the risks of a cold war or other global risks for the first time. The effects of climate change will be extensive on social and ecological processes. Several climate change scenarios indicate irreversible and drastic global changes. Regional areas of nature and the global ecosystem could restructure radically. Therefore, the terms of human development would change dramatically and the adaptability of social systems and international agriculture and food systems would be overburdened. Climate change could trigger global dynamics which will transform the international patterns of trade, demand and supply of agricultural raw materials and food and feedingstuff. Therefore it is advantageous to be able to be proactive on modified boundary conditions concerning food security. Climate change presents several threats to food supply. One of the important threats is the competition for agricultural land. Recently, some institutions in various countries have bought land in other countries to serve for their own food supply. Climate change in Country A causes damages of production, then Country A restricts exports to Country B to produce agricultural products and food for their own use. For this reason it is very essential to assess the consequences and define the derived consequences for Austria and the implications for its trading partners. Further competition for agricultural land is presented by the production of food or renewable products. Declining production of food through climate change is a high challenge in the mean-time. However, there is additional global competition for agricultural area, namely the production of bio fuel and other renewable resources which could intensify these constellation of conflicts. The awareness of climate change as the central challenge for the 21th century has increased globally in the last few months. Hence it is indispensable to develop risk management strategies in a timely manner for future years. How Austria handles these consequences on agriculture and food systems will have a lasting impact on Austrian food supply.

1.8.5. Applicability and Use of the Project Results - User Value for Austrian Scientific Community

The project strengthens Austria’s interdisciplinary capacity and its development of production and supply models. The project strengthens the capacity for climate research by raising understanding of regional impacts on agriculture and understanding the impacts on food supply in Austria. The project identifies research gaps regarding regional and local impacts on agriculture and food supply. The project supports the Austrian scientific community in catching up to the international level on food security research.

1.8.6. User Value for Policy Makers

Governments have a key position regarding mitigation and adaptation measures regarding climate change on national and international levels. The issue of food security is of rising importance. The end report of the Food Security Project will be a basic paper to prepare policy makers for upcoming challenges regarding food security risks in Austria. The development of scenarios will facilitate raising awareness. The risk analysis performed in the project will provide with a first assessment of food security risks for Austria on a scientific method. The project will develop management options and recommendations to facilitate and support further political discussions. The term policy makers is not focused on government and members of parliaments, it includes all stakeholders like chambers, farmers associations consumer associations, trade unions, environmentalists etc.

1.8.7. User Value for Private Companies and Consumers

The results of the project are useful for agriculture, the food industry and retailers for long term eco economic planning. Agriculture is highly dependent on weather conditions and vulnerable to climate change impacts. The results are very useful to farmers, so they are able to adapt their production and take measures to mitigate the impacts. For farmers it is very important to know about future developments to take careful decisions for long term investments. For the food industry and retailers it is important to know if they can rely on traditional suppliers, if they will get food at all and from where they can get it risk-free in the future. The assessment will also be important regarding land use priorities (food, feed and biomass production in Austria), supporting long term policy decisions in agricultural and energy policy. The assessment of food security risks is important for consumers in every way.

2. Climate Change and Agricultural Production in 2030

Authors: BOKU: Josef Eitzinger, Herbert Formayer, Martin Schlatzer

2.1. Methodology

Worldwide agricultural production and demand for 2015, 2030 and 2050 on the basis of agricultural statistics and the forecasts of the Statistics Austria, EUROSTAT, OECD, FAO (FAO-Stat 2009, FAO 2003, FAO 2006) and FEDIOL (a member of primary food processors) and the UN medium population forecast (UN 2007, if available also latest updates will be used) were taken as baseline in WP 1. Relevant studies and useful climate reports were analysed and taken into consideration. A ten year interval (2000 to 2009) for the relevant product groups (Figure 36 and Figure 37) formed the basis of the assessment of production and demand of food and feed 2015 for EU27 and Austria based on trend analysis and experts opinions. Due to compatibility in data aggregations of various agricultural statistics, product groups, as given in Figure 36 and Figure 37, are chosen for this study.

The team of BOKU_Met focused their work on the influence of climate change on global yields and those of the EU and Austria. The data used within Work Package 1 is based on the GAEZ (Global Agro-ecological Zones) system. The GAEZ methodology has been developed and refined over more than 30 years by IIASA (International Institute for Applied Systems Analysis) and the FAO (Food and Agriculture Organization) of the United Nations.

GAEZ is an integral part of an advanced modelling framework that combines the FAO/IIASA Global Agro-ecological Zone model and the IIASA World Food System model. The GAEZ approach covers the availability of digital global databases of climatic parameters, topography, soil and terrain, land cover, and population distribution. These data sets have not only enabled revision and improvements to AEZ calculation procedures, but have also allowed crop suitability and land productivity assessments to be extended to temperate and boreal environments. The GAEZ modeling framework has been used for the spatial assessment of biofuel feedstock potential in a global study of biofuels and food security.

GAEZ v3.0 provides one of the most ambitious assessments, which is publicly accessible from the IIASA and FAO Web sites (http://www.iiasa.ac.at/Research/LUC/GAEZv3.0/ resp. IIASA/FAO, 2012).

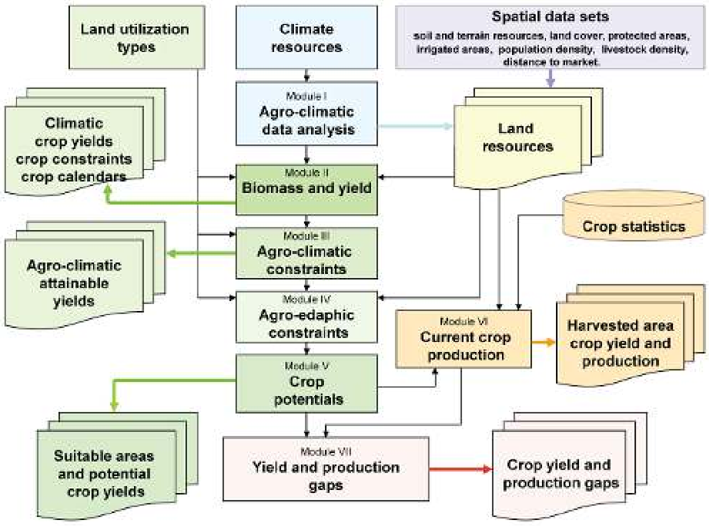


Figure 2: GAEZ model strucutre and data integration (IIASA, 2012)

The selected criteria for the data were the following:

- agro-ecological suitability and productivity: cultivated, unprotected land
- suitability and potential yields for up to 280 crops/land utilisation types under alternative scenarios
- management for historical, current and future climates
- rain-fed agriculture
- intermediate scenario (medium scenario, better management, partly market orientated, between low and high input scenario)
- CO2-fertilizer effect
- Hadley CM3 A2 scenario
- time horizons: 1961-1990; 2020-2030 and 2030-2050

Three input level selection options were available: high level inputs, intermediate level inputs, and low level inputs. The choice was made for the intermediate-level inputs/improved management scenario. Under the intermediate input, improved management assumption, the farming system is partly market oriented. Production for subsistence plus commercial sale is a management objective. Production is based on improved varieties, on manual labor with hand tools and resp. or animal traction and some mechanization. It is medium labor intensive, uses some fertilizer application as well as chemical pest, disease and weed control, adequate fallows and some conservation measures (Tóth et al., 2012). Regarding the Climate Change Scenario, the Hadley CM3 A2 Scenario was selected. Therefore, the Global Circulation Model used, was HADLEY CM3 (Hadley Centre Coupled Model, Version 3) under the IPCC emission scenario A2. The HADLEY CM3 represents a coupled atmosphere-ocean general circulation model (AOGCM) which was developed by the Hadley Centre in the United Kingdom. HadCM3 has been used extensively for climate prediction, detection and attribution and other relevant climate sensitivity studies. Furthermore it was one of the major models used in the IPCC Third and Fourth Assessment Report (Met Office, 2013).

The A2 scenarios out of the four SRES (Special Report on Emissions Scenarios, report by IPCC) scenario families stem from of a more divided world (IPCC, 2000). The A2 scenario family represents a differentiated, heterogeneous world which is characterised by a a) continuously increasing population, b) world of independently operating, self-reliant nations and c) regionally oriented economic development. The possible range of the projected global average surface warming until the end of the century is in between 2.0°C to 5.4°C (for further details see IPCC, 2000). The SRES scenarios, however, do not encompass the full range of possible futures, which means that emissions may change less or more than the scenarios imply.

After selecting the criteria and choosing the items and the regions resp. country, the changing rates for each item had to be calculated. Changing rates of the year 2015 were based on the calculations in relation to 1975 (for the period 1961-1990) and the projections for 2020-2030 (with 2025 as reference year). Changing rates for 2030 are based on the year 2015. The spectral changing rates of the time spans from 2015 to 2030 and 2030 to 2055 were finally calavulated for the world regions (USA, Europe, Asia, Africa, Australia and South America, subdivided) and Austria.

20 selected crops investigated:

Wheat
Barley
Millet
Oat
Rye
Maize
Wetland rice
Dryland rice
Soy
Rapeseed
Olive Oil
Sunflower
Potatoes
Sweet Potatoes
Cassava
Yam and Cocoyam
Phaseolus bean
Kidney bean
Sugar cane
Sugar beet

Indicator plants for the main world regions

As a next step, indicator plants for the different world regions were defined (Table 4). Data could be determined for the main world regions. Regarding the commodities, where limited or no data was available, indicator plants were chosen. Taking a look at some of the main commodities in focus of the project (cereals, roots and tubers, sugar, pulses and oil) it was recognized that the categories in the data set often were more explicit.

Therefore, the most important crops in each region had to be chosen. For instance, in the case of sugar, data was available for sugar cane and sugar beet. The same applied to oil plants, where indicator plants had to be defined for each region. Between grain used for the human consumption and grain for animal feed, no differentiation was possible within the data set.

Table 4: Indicator plants for different world regions (author's own compilation)

Regions/ Indicator Plant	Cereals	Roots and tubers	Sugar	Pulses	Oil
North America	wheat maize	potatoes	sugar beet, sugar cane	phaseolus bean	soy, rapeseed, sunflower
Europe, Russia	wheat maize	potatoes	sugar beet	phaseolus bean	soy, rapeseed, sunflower, olive
Pacific OECD	wheat, maize	potatoes, sweet potatoes, cassava, yam and cocoyam	sugar cane	phaseolus bean	soy
Africa, Sub-Saharan Africa	wheat, maize, millet	potatoes, sweet potatoes, cassava, yam and cocoyam	sugar cane	phaseolus bean	soy, sunflower
Latin America	wheat, maize	potatoes, sweet potatoes	sugar beet, sugar cane	phaseolus bean	soy, sunflower
North Africa, Near East	wheat	potatoes	sugar beet	phaseolus bean	olive, soy, sunflower
East Asia	rice, wheat, maize	potatoes, sweet potatoes, cassava	sugar beet, sugar cane	phaseolus bean	soy, sunflower
South- and Southeast Asia	rice, wheat, maize	potatoes, sweet potatoes, cassava, yam and cocoyam	sugar cane	phaseolus bean, kidney bean	soy
Rest of World	rice, wheat, maize, millet	potatoes, sweet potatoes, cassava, yam and cocoyam	sugar beet, sugar cane	phaseolus bean	soy, rapeseed, sunflower, olive
Developed Countries	rice, wheat, maize, millet	potatoes, sweet potatoes, cassava, yam and cocoyam	sugar beet, sugar cane	phaseolus bean	soy, rapeseed, sunflower, olive
Developing Countries	rice, wheat, maize, millet	potatoes, sweet potatoes, cassava, yam and cocoyam	sugar beet, sugar cane	phaseolus bean	soy, rapeseed, sunflower, olive
World	rice, wheat, maize, millet	potatoes, sweet potatoes, cassava, yam and cocoyam	sugar beet, sugar cane	phaseolus bean	soy, rapeseed, sunflower, olive

Within the group of pulses, phaseolus bean, which includes kidney beans and chickpeas, (India as a main grower) were selected. The whole rates and indicators served as the basis for the calculation of scenarios of Work Package 3.

2.2. Global Impacts

On global scale, climate change will have a positive impact on agricultural production till 2030 in most of the regions. Most of the crops will benefit till 2030 under the selected scenario. There are some regions where negative impacts can be seen when examined until 2050. For the changing rates of main indicator plants in world regions due to climate change till 2050, see Table 8.

Table 5: Changes of the yield of major indicator plants due climate change in main world regions from 2030 till 2055 (decadal rates of yield change). The changes are significantly positive (green fields), significantly negative (red fields) or not significantly positive or negative (yellow fields) (data base: GAEZ, 2013).

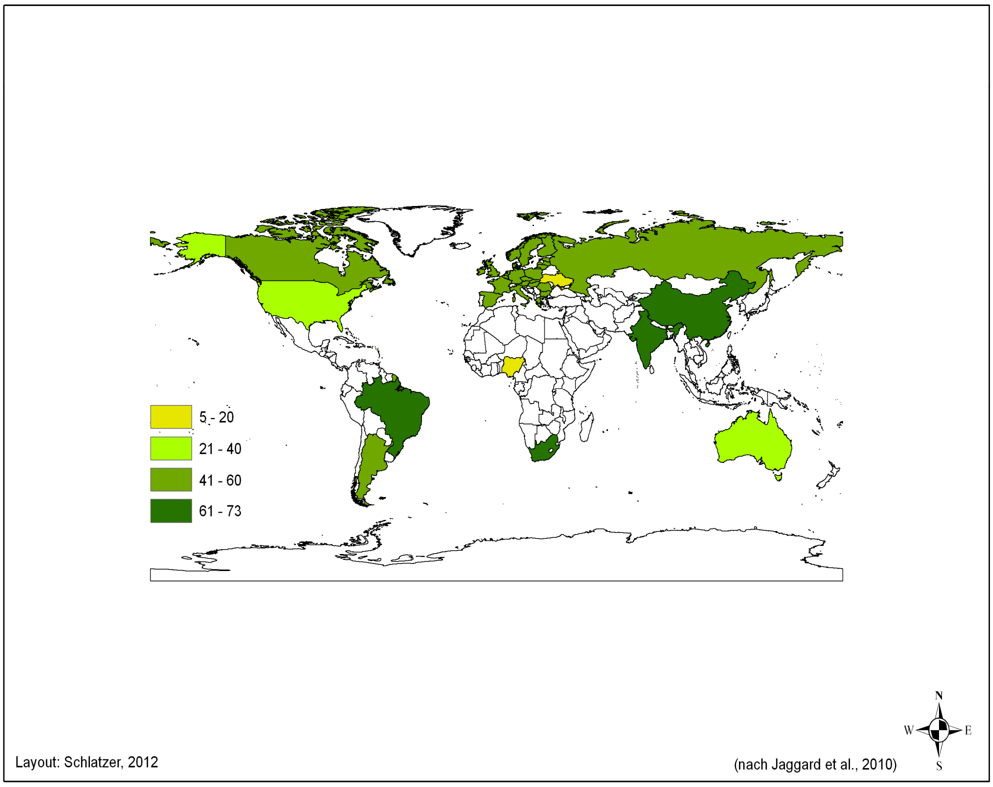
Region/ Indicator Plant	Cereals	Roots and tubers	Sugar	Pulses	Oil
North America	wheat 1.1	potatoes -1.8	sugar beet -4.3	phas.bean -5.8	soy -4.1
Europe Russia E+R	wheat 0.6 1.1 0.8	potatoes 0.9 0.0 0.4	sugar beet -0.9 0.1 -0.4	phas.bean -4.0 -4.2 -4.1	soy 0.7 5.9 3.3
Africa Sub-Saharan Africa A+SSA	wheat 4.7 2.3 3.5	potatoes 0.3 2.3 1.3	sug. cane -1.2 -1.0 -1.1	phas.bean -5.0 -4.3 0.4	soy 0.9 -0.6 0.2
Latin America	wheat 2.3	potatoes 2.3	sugar beet 0.1	phas.bean -8.1	soy -0.3
North Africa	wheat -1.6	potatoes -1.6	sugar beet -0.7	phas.bean -2.6	olive 1.4
East Asia	rice -1.6	potatoes -1.6	sugar beet 0.1	phas.bean 0.8	soy 2.4
South- and South East Asia SA SEA	rice 1.9 0.4 1.2	potatoes 2.2 -2.2 0	sug. cane 1.1 -0.1 0.5	phas.bean -1.2 -1.0 -1.1	soy -2.7 -0.3 -1.5
World	rice -0.3 wheat 1.2	potatoes -0.1	sugar beet -0.8 sug. cane 0.2	phas.bean -3.9	soy -0.4

SEA= South East Asia, SSA= Sub-Saharan Africa

The fertilizing effect of CO_2 represents the crucial factor in terms of the higher benefits regarding 2030 compared to 2050. Data for cultivated, unprotected land was taken into account under the Hadley CM3 A2 Scenario. Further criteria for the data set of the suitability and potential yields were a) rain-fed agriculture, b) an intermediate scenario (medium scenario, better management, partly market orientated, between low and high input scenario) and c) CO_2-fertilizer effect (for further details, see methods).

To illustrate the deliverable changing rates, wheat was chosen as an important indicator plant for many regions in Austria, the EU and worldwide. On a global scale, the annual changing rate of the wheat harvest will be 0.06% from 2015 to 2030. By 2050, the annual changing rate of the wheat harvest will be at 0.12%.

Under the chosen conditions resp. scenario, (see chapter of methods) global wheat production will benefit under climate change. According to Jaggard et al. (2010), these changing rates will generally be moderate as prior and follow up studies have shown (see Figure 3).



Ertragsänderungen von Weizen (%) aufgrund des Klimawandels im Zeitraum von 2007 bis 2050 (nach Jaggard et al., 2010)
Anmerkungen: Szenario Geringes Wachstum (=+0,7%/a); mit CO2-Effekt (+15%) und O3-Effekt (-9%); maximale Ertragsmöglichkeit von +10%, d.h. bei Weizen von 80 auf 90%)

Figure 3: Changes of yields due to climate change in world regions between 2007 and 2050

Source: Jaggard et.al., 2010

During the study many studies were cited, collected and analysed. Results, critical points and deliverables for other work packages were discussed within the work package as well as with other work packages and the study team as a whole. Moreover, many graphs (with ARG GIS mapping[4]) were created to show the effects of future climate change on yields in major world regions, including the European Union. Data from Austria was analysed as well. In order to have a comprehensive data set, the FAO GAEZ model was chosen. This made comparisons possible, both between different world regions and on a country level .

Under the chosen conditions (for further details see methods), the annual changing rate of the wheat harvest is at 0.1% from 2015 to 2030. By 2050, the annual changing rate of the wheat harvest will be at 0.16%. This means the wheat harvest in Austria will benefit more in comparison to the world rates.

2.3. European Union

Under the chosen conditions (see chapter methodology), wheat production within the European Union (because no data was explicitly generated for the European Union, the average of the values obtained from the regions North, Western and South Europe were taken into account) will increase slightly raise about 0.06% per year from 2015 to 2030. By 2050, the benefits will be a little lower, around 0.4% per year.

[4] Esri's ArcGIS is a geographic information system (GIS) for working with maps and geographic information which is used for: creating and using maps as well as compiling geographic data. For further details see www.arcgis.com

3. Global Agricultural Production and Consumption

Authors: ÖVAF: Martin Maria Krachler, Martin Weigl

3.1. Objectives, Methodology and Data

Production and demand/consumption[5] data, which was taken out of the studies listed below, were used as a base for the calculations. To mirror the development of the ratio between production and demand, production data and demand/consumption data (per capita food consumption in kcal/person/day) were calculated with the following growth factor for the time periods under question.

Growth factor $y_n = (1+z/100)^n$ and **$(1+z/100) > 1$**

Production or Demand in year x_n = Production or Demand in year x_0 multiplied with the growth factor of the respective period, $x_n = x_0 * y_n$

z = yearly yield growth in %s

n = number of years of a specific period

x_0 = Production/demand in base year

x_n = Production/demand in year n of a specific period

The base year for production and demand is the average 1999/01 as used in the FAO study Global Perspective Studies Unit (2006): World Agriculture: towards 2030/2050; Interim Report, Prospects for food, nutrition, agriculture and major commodity groups, Rome.

Concerning demand, data was taken from the following source: http://faostat.fao.org/site/452/default.aspx, last visited 09 February 2012, with the following population data:

2000	2015	2030	2050
6,122,769,000	7,284,293,000	8,321,382,000	9,306,131,000

Table 6: World population

Growth factors of demand/consumption have also been estimated using the same formula as used for production because of the necessity to include the cumulative curve of age classes. This is a must, especially for countries with the highest growth rates and the

[5] These two terms are used interchangeably. All kinds of use are included (food, feed, industrial use, but also waste and losses) With respect to waste and losses also see: Nellemann, C. et alt. (2009), page 30. Industrial use includes bio fuel and biomass use too.

lowest average age with respect to their population. These countries will have higher food demand to avoid malnutrition and hunger.

Input data of production and demand were adapted to three different scenarios:

- non intensive scenario
- intensive scenario and
- intensive scenario taking climate change effects on production into account.

Non intensive scenario: No major efforts are made to boost production and change diets in high consumption countries.

Intensive scenario: Efforts are made to raise yields - not only by applying better techniques including green biotechnology - but also to take more land under agricultural production, without destroying forests of high biodiversity value or even already protected areas. On the other hand where possible, there should be more land taken under irrigation and not only used for rain fed production. In animal production, breeding efforts should be intensified to need less input per kg of meat and milk. There are still high potentials for boosting average yields in Eastern Europe, Africa in general and most parts of Asia.

In most of the regions with possibilities to brush up their average yields on croplands significantly, substantial investments in machinery, fertilizers, pest control and often also in irrigation would be inevitable to put these possible gains in yields in practice.

In most of developing countries, the correct employment of organic farming as well as the implementation and use of crop rotation could brush up yields. This can be assumed because the nutrient status of cropland is often very poor in these countries, which ignore, among other things, crop rotation principles. These countries' yields could therefore be increased by the correct application of basic production standards.

Intensive scenario taking climate change effects on production into account:

This scenario is based on the same assumptions as the one above. Consumption/demand as well as production data for meat and dairy products are the same, but concerning plant production climate change influence was taken into account. The time horizon running up to only 2050 shows climate change to have only slight influence on yields. A range of differing opinions exist within the international meteorological scientific community. Anyhow, it is a fact - already proven by laboratory experiments - that the higher amounts of CO_2 in the air is positive for plant output, which could positively influence yields per unit of area. On the other hand there is - more or less - consensus on the effect of climate change concerning natural disasters like droughts, floods, etc.!

3.2. Data Sources

Data was taken from the following sources, where more detailed information than provided by the following chapters of this report can be found:

- Bruinsma, J. (2003): World agriculture: towards 2015/2030, an FAO Perspective. Rome, FAO.
- FAO - Global Perspective Studies Unit (2006): World Agriculture: towards 2030/2050; Interim Report, Prospects for food, nutrition, agriculture and major commodity groups, Rome.
- Bruinsma, J. (2009): The Resource Outlook to 2050; By how much do land, water and crop yields need to increase by 2050, Expert Meeting on How to Feed the World in 2050. Rome, FAO.
- Alexandratos, N. (2010): Expert Meeting on how to feed the World in 2050, Critical Evaluation of Selected Projections, Rome.
- OECD - FAO (2010): Agricultural Outlook 2010 - 2019; Highlights, Rome.
- FAO (2011): The State of Food and Agriculture 2010 - 2011, Rome, FAO.
- OECD - FAO et alt. (2011): Agricultural Commodity Markets Outlook 2011 - 2020; A comparative analysis, Rome.
- OECD (2013): Global Food Security: Challenges for the Food and Agricultural System, OECD Publishing, Paris.

For data used in the scenarios for which calculations were made also see Annex 14.1.

3.3. Population development and nutrition habits

Already in 1798 Thomas Malthus published his proposition that sooner or later population would get checked by disease, widespread mortality and famine. Undernutrition and malnutrition are widespread in the poorest countries (IMechE, 2011). Figure 2 shows the typical s-shaped pattern of projected population size over the course of demographic transition. Between 2010 and 2100 in the case of Europe a 20% decline is expected from 0.73 to 0.59 billion. However, in the UK a rise of 14% (additional 8 million people) is anticipated, from 62 million, the present figure, to 70 million by 2100 (United Nations, 2004).

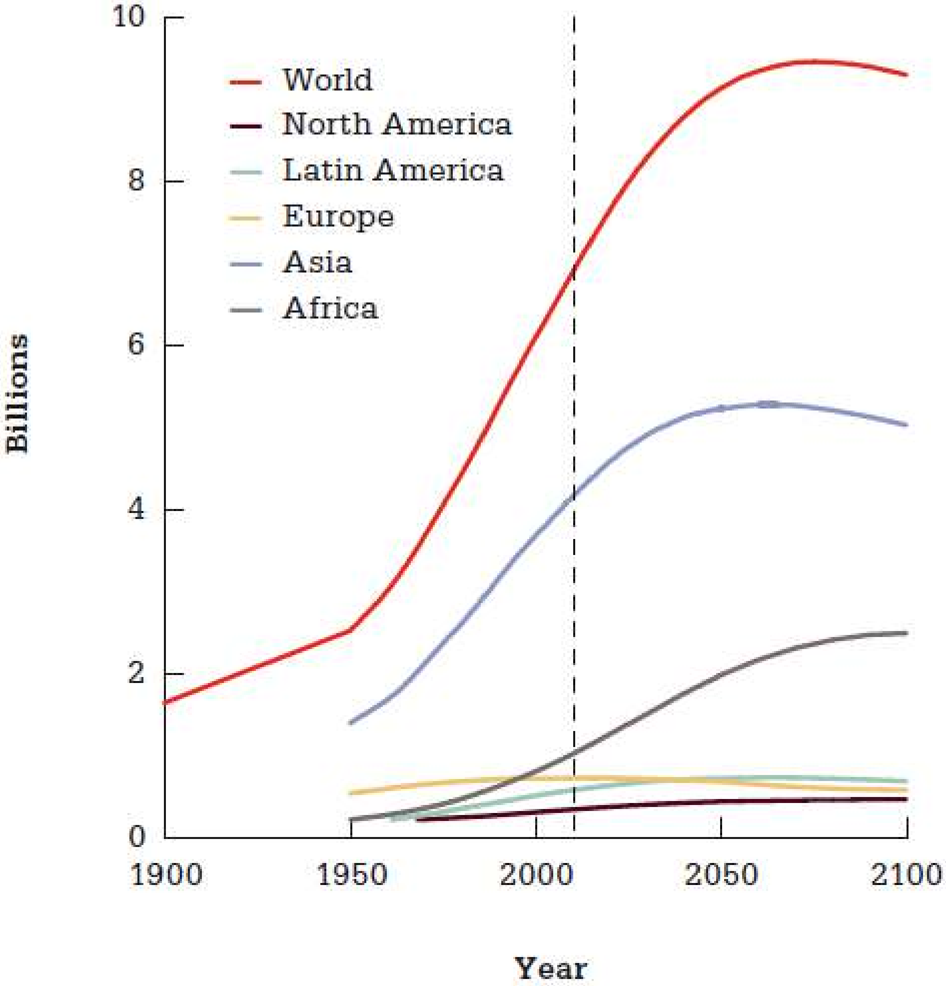


Figure 4: Population projections by region

Source: United Nation World Population to 2300

In 2050 more than 70% of the world`s population is expected to be urban. Sustainable solutions are needed for this situation. Today one billion people are undernourished due to political or social problems of poverty. The UN's Millenium Development Goals recognized this issue but the solution process has been hampered by the global financial crisis (United Nations, 2004). Tudge C. (2004) estimates that by 2050, livestock will be consuming more food than was consumed by the human population in 1970. The provision of sufficient food will be an even greater challenge with a rapidly growing population in the 21st century. Developing countries like Argentina, Brazil, Columbia, Costa Rica, Ecuador are expected to remain much less urban but could have over 50% of their populations living in urban areas in 2050. In 2010 Latin America had a population of 0.59 billion and the projected growth trend is 0.74 billion in 2065. World Bank estimates an 85% increase in meat production between 2000 and 2030 compared with the rise in cereal demand. One billion people are starving, while the unhealthy western lifestyle of increased consumption results in excess weight gain and obesity (IMechE, 2011).

Nevertheless urbanization will bring with it changes, e.g the implementation of a recommended diet. The share of meat, dairy, fish, vegetables and fruits will be increasing, those of grains and other staple crops will be on the decline (IMechE, 2011).

The Institution of Mechanical Engineers recognises four main areas in which population growth will significantly challenge society in the provision of basic human needs, and predicts increased pressure on current resources and the environment (IMechE, 2011).

- Food: In 2050 the increased consumption of meat and changes in dietary habits will double demand for agricultural production. Uncertain impacts of climate change on global food production will increase this pressure on food security.
- Water: Not only the increasing requirements of food production will increase the pressure, also the worldwide demand for water is projected to rise 30% by 2030, due to a growth in demand for drinking water and industrial processing.
- Urbanisation: The Institution of Mechanical Engineers estimates a growth up to three billion urban inhabitants by 2050. According to the Institute, solutions are needed to relieve the pressures of overcrowding sanitations, waste handling and transportations if we are to provide comfortable, resilient and efficient places for all to live and work.
- Energy: By mid-century, population growth and rising affluence will create increased pressure on current resources, environment, food- and not least on the energy supply. The latter is estimated at more than double the current demand on the sourcing and distribution of energy by 2050 (IMechE, 2011).

3.4. Agricultural production and consumption 2015, 2030 and 2050

Whenever we are talking about developments with time horizons this far in the future, like 2050, which is the case of this study, we must keep in mind that each modeling looks into the far future based on historical data and provisions. Such an attempt can always be criticized, may be full of errors, but is the only way to show politicians and people in general what may happen as long as there are no decisions taken or measures implemented to change basic parameters of possible developments.

Having said this we can say that in the period 2005/2007 the world average of per capita availability of food - after subtracting animal feed, non food uses and waste - rose to 2,770 kcal/person/day. This number looks quite good, meaning that there was sufficient food for all. But, the real picture is not that idyllic. There are still some 0.5 billion people who have only less than 2000 kcal available to them per day, while 2.3 billion people live in countries with daily availability of 2000 to 2,500 kcal. On the other extreme there are 1.9 billion people living in countries with a daily consumption of more than 3,000 kcal. It has also to be mentioned that these numbers are average numbers, which means that even not all of those living in countries of 2,000 to 2,500 kcal per day have this average available! Wars, terrorism, natural disasters, etc., present another group of facts. These events make access to sufficient food on a regular basis impossible for more and more people. In the following chapter use of energy production is not taken into account, because this kind of use depends on a lot of different factors, which may change day by day. The EU may serve as an example of this. At the moment the European Parliament is discussing how to change European legislation with respect to the %age of bio fuels mixed with fuels on petrol basis to much lower rates, as is now foreseen up to the 2020 horizon. Under these political circumstances we prefer to leave use of production out of this, saying that production, which exceeds world consumption of food and feed, may be used for this purpose.

Even though there have been calculated different commodities - production and consumption as well as the relevant numbers for different country groups following the FAO - scheme - in this chapter we shall limit the discussion of results to those of the overall world. Therefore quantities of world total is more than summing up quantities of all the cereals used in the calculations. One good example is millet. Like some other cereals, millet is not traded regularly and in quantities of importance on World markets but in some of developing countries it is of extremely high importance in the daily diet. On the other hand a lot of countries' statistics do not really include all production - especially production that is directly used for farm household consumption or sold without declaration on local and regional markets. One example from a so called developed country: Greece didn't have agricultural statistics until joining EEC in 1981 when they received 350 million ECU over 15 years, in order to finally know something about their agricultural sector. The only trustable information about Chinese agriculture is taken from international trade statistics even though FAO has to work with official Chinese data. Compared to Greece, it is not a problem of quality but of the availability and political will of China.

3.4.1 Scenarios covering production and demand in 2015, 2030, 2050 for selected products

In this part the results of the period 1999/01 to 2015, 2015 to 2030 and 2030 to 2050 are presented and briefly discussed. These results are based on calculations, which have taken all limitations - already mentioned above - into account.

3.4.1.1. Non intensive scenario

Cereals

As shown in Figure 5 cereal demand for all uses will be much higher than production, but with differences between main cereals. The biggest lack exists for coarse grains, which include maize. The USA is using a lot of maize for sugar substitutes and bio fuel production. The gap between production and demand is lowest for wheat and rice. For both of them, levels of production and demand in 2030 would nearly be balanced.

During 2030 and 2050 - mostly because of highest population growth during this interval - demand will once again be significantly higher than in the decades before.

Following the growth rates foreseen for world population without higher yields and/or expansion of cultivated area, as well as taking into account that world economic crisis will not last for too long, the gap between production and demand will widen again.

Higher incomes for more parts of the population means changes in diets - less proteins from plants and more proteins from animal products. Higher consumption of meat, milk and dairy products will decelerate the share of world population with access to sufficient food.

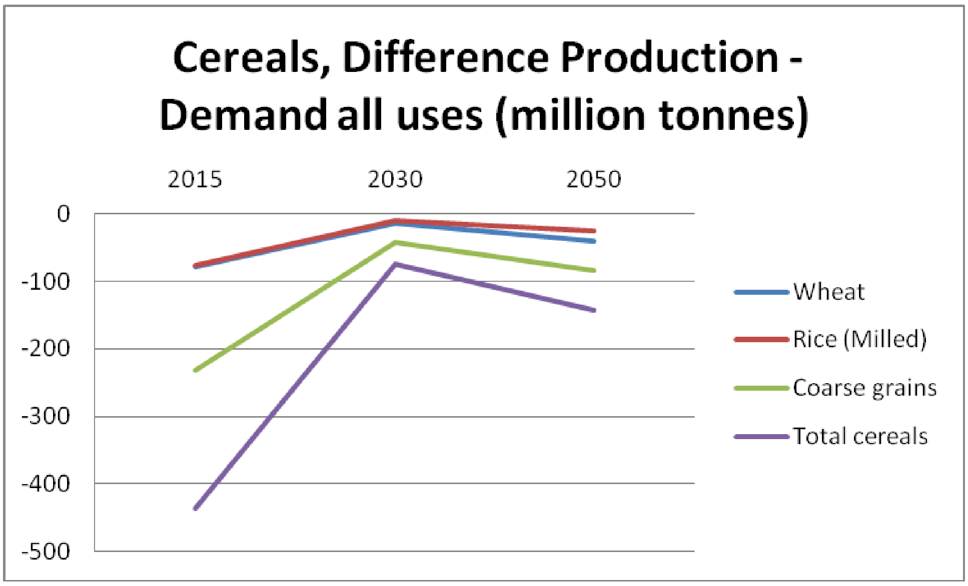


Figure 5: Cereals, Difference Production – Demand all uses (million tonnes)
Source: ÖVAF calculations, 2012, Vienna

Taking the results by country groups as basis - see Figure 6 - indicates that only North America is producing much more than will be demanded. Concerning the results for Europe and Russian Federation, the difference between production and demand will mostly depend on what cereals will be used for. In Latin America production will cover demand. The widest gap between production and demand will occur in developing countries because demand is growing more rapidly than production.

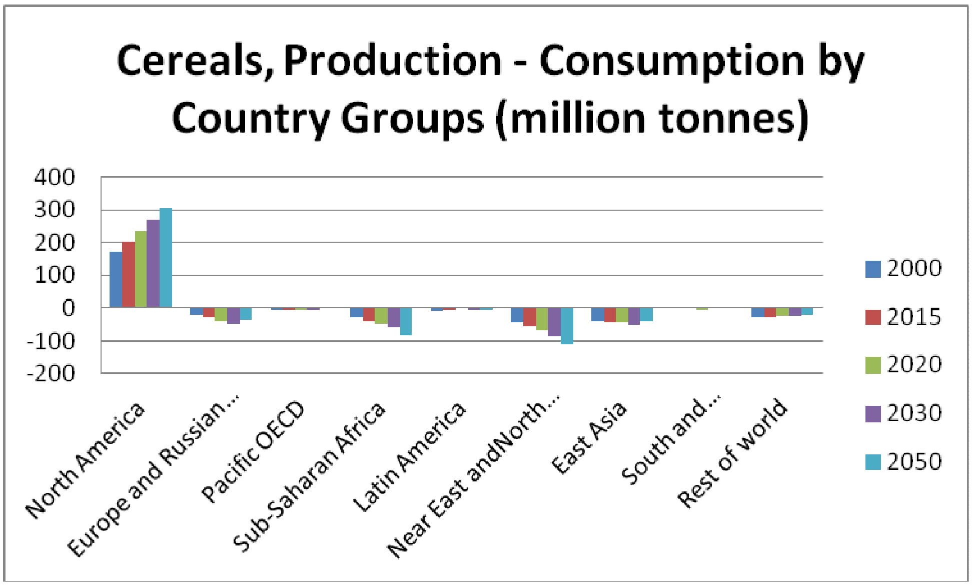


Figure 6: Cereals, Production – Consumption by Country Groups (million tonnes)
Source: ÖVAF calculations, 2012, Vienna

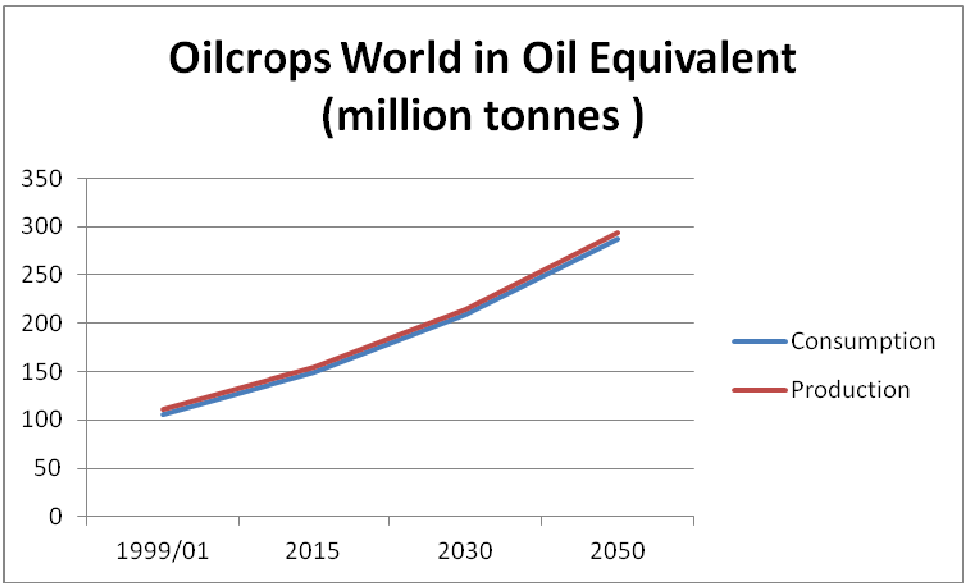


Figure 7: Oilcrops, World in Oil Equivalent (million tonnes)

Source: ÖVAF calculations, 2012, Vienna

The situation for oil crops as shown in Figure 7 is totally different to that of cereals. Production and consumption will increase significantly and parallelly. As has already been the case for cereals, there exist significant differences between country groups. In the case of oilseeds, developing countries as a whole are those who will have the highest growth rates with respect to oilseeds production, while there still exists great difference within this country group as shown in Figure 8. Some of these countries are already important exporters of palm oil, soybeans and rapeseed.

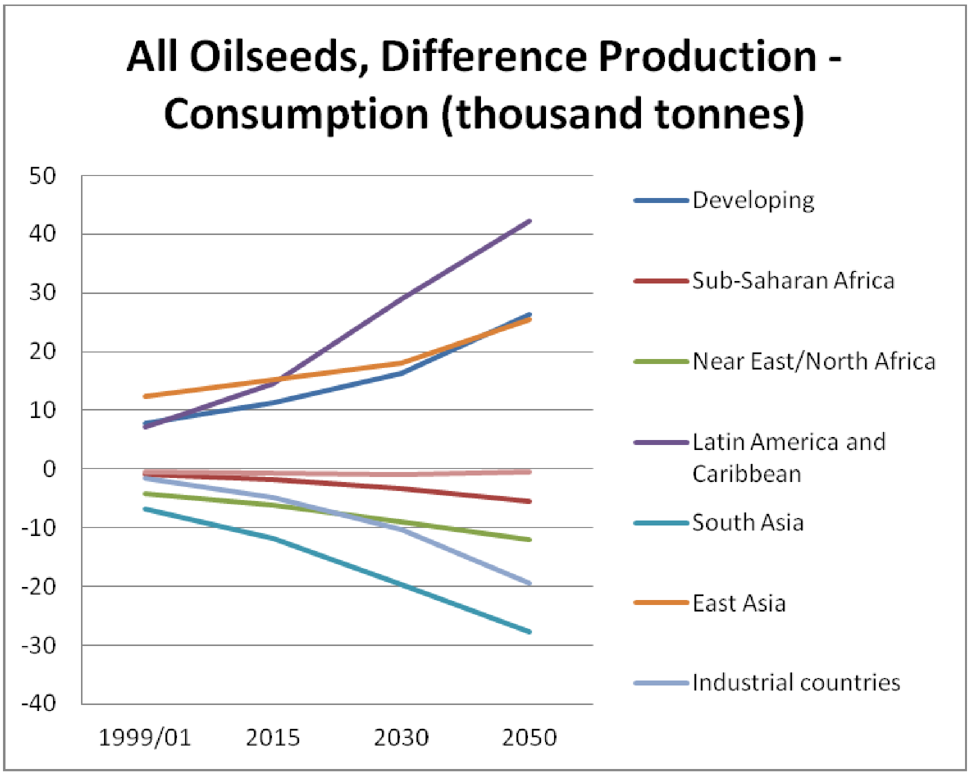


Figure 8: : All Oilseeds, Difference Production – Consumption (thousand tonnes)

Source: ÖVAF calculations, 2012, Vienna

Meat

We have already mentioned above that one of the factors highly influencing meat consumption is the economic situation, which dictates the purchasing power of individuals. Other factors include dietary habits, tradition and religion based exclusion of pork and bovine meat.

Even under the non intensive scenario, total world meat production will more than answer demand, even though levels will no longer reach the high levels of the 1999/01 period.

The advance of Islam and higher purchasing power in China as well as parts of India raises demand for poultry meat. In developed countries, consumption is increasing because of dietary aspects. On the other hand poultry needs less input of cereals per kg than meat production, which is another positive aspect.

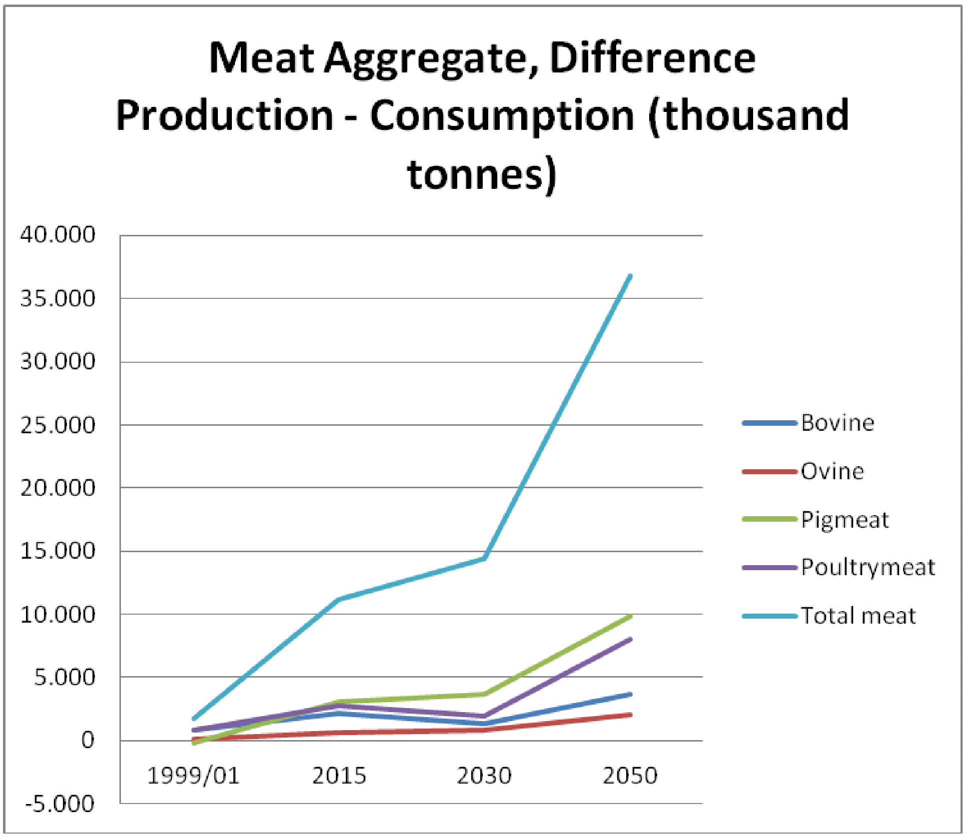


Figure 9: Meat Aggregate – Difference Production - Consumption (thousand tonnes)
Source: ÖVAF calculations, 2012, Vienna

Milk and dairy products

Concerning milk and dairy products, it must be mentioned that the following different serious scientific studies show that a high %age of the world population is lactose intolerant - estimates go up to 75% of world population - and cannot consume milk nor dairy products without serious health problems.

Source: http://de.wikipedia.org/wiki/Laktoseintoleranz, last visited 1 June 2012

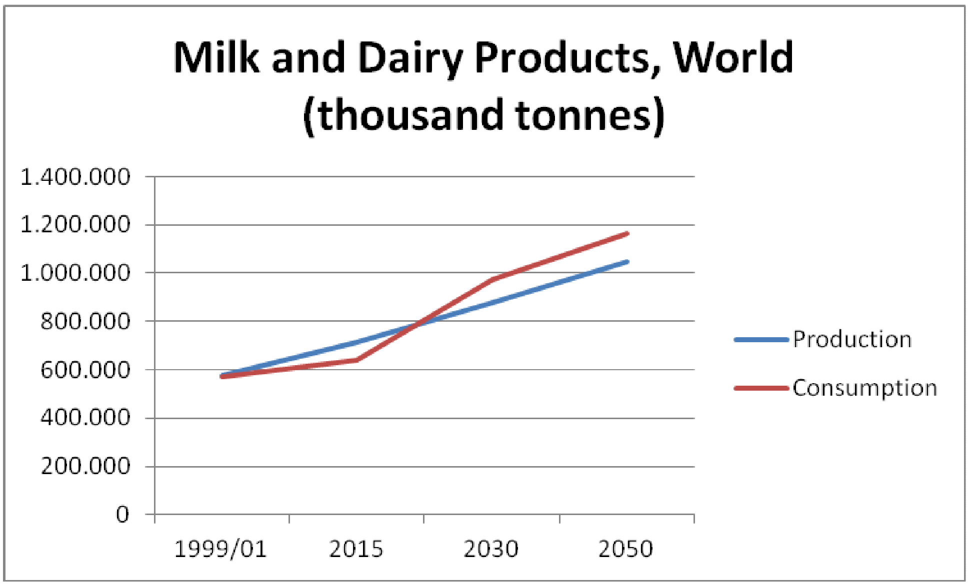


Figure 10: Milk and Dairy Products, World (thousand tonnes)

Source: ÖVAF calculations, 2012, Vienna

Following the results of the production demand ratio as shown in Figure 8, production will, like consumption, increase further. Between 2015 and 2020, consumption will start to be higher than production.

If lactose intolerance were taken under consideration, the picture would be totally different than shown in Figure 11 below. Real consumption refers to those consumers with lactose intolerance who are absolutely not using milk and dairy products in their diets.

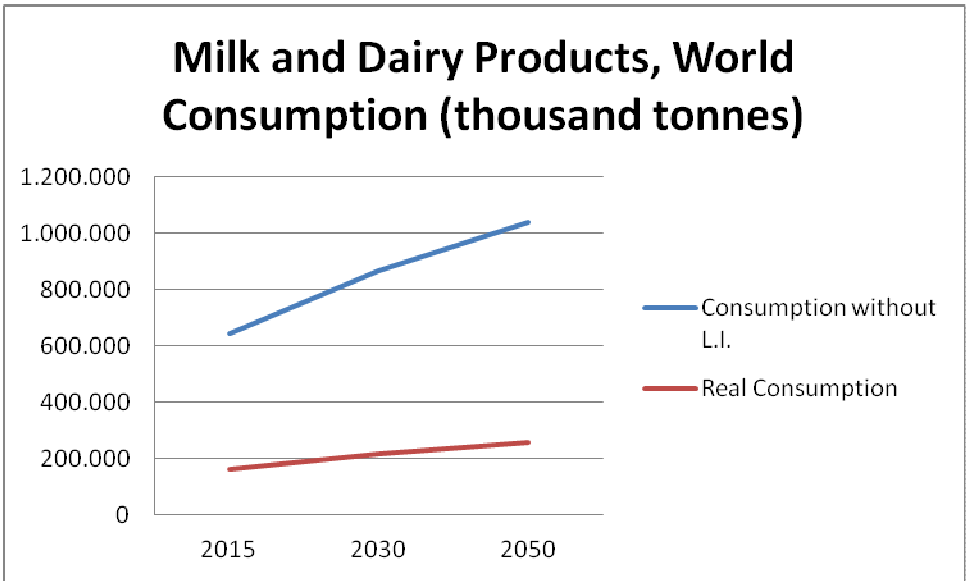


Figure 11: Milk and Dairy Products, World Consumption Comsumption (thousand tonnes)

Source: ÖVAF calculations, 2012, Vienna

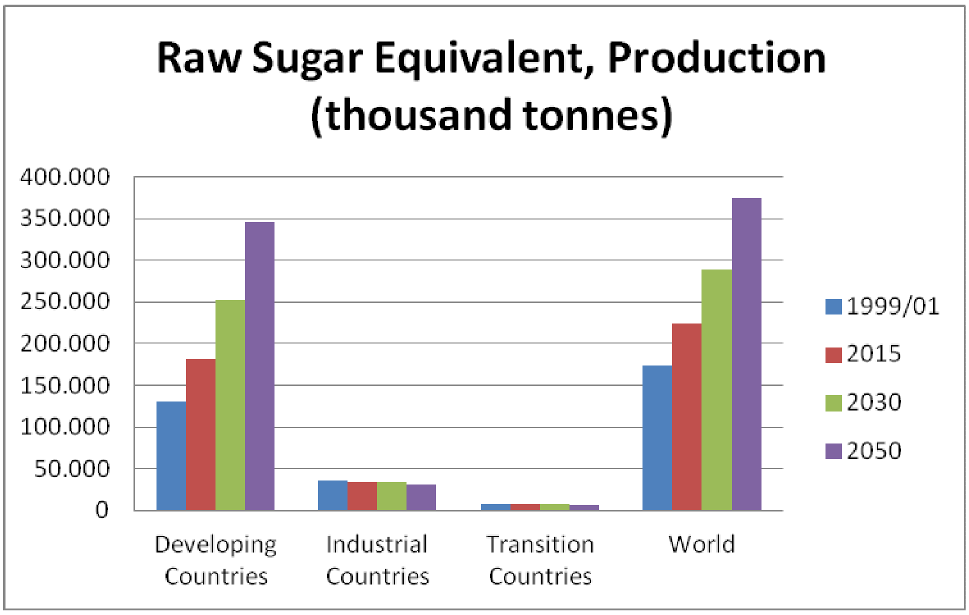


Figure 12: Raw Sugar Equivalent, Production (thousand tonnes)

Source: ÖVAF calculations, 2012, Vienna

Following chart 12 it becomes clear that the main producers of raw sugar are developing countries. This will continue while Industrial and Transition Countries go on to reduce their production of sugar. In 2015 Brazil alone will produce 67.3% of sugar for non food use! Nearly all of the sugar for non food use is distilled to ethanol and mixed with fuel - Brazil was one of the pioneers in doing so.

As shown in Figure 13, even under the non intensive scenario, sugar production will also be higher in 2050 than sugar consumption. The only question will be, what will sugar be used mainly for - food or non food use.

Since the 1999/01 period sugar production is going up, meanwhile sugar used for food is especially and significantly decreasing in developed countries and rising in developing countries. The latter is mostly based on the substitution of sugar by corn-based sweeteners in the United States of America.

Imports of ethanol derived from sugar to the EU may also go down significantly, because of discussions within the European Parliament to change the respective directive on what % of ethanol have to be added to petrol based fuel by 2020. At the moment it seems that this will happen soon, which would also influence European Ethanol Industry strongly.

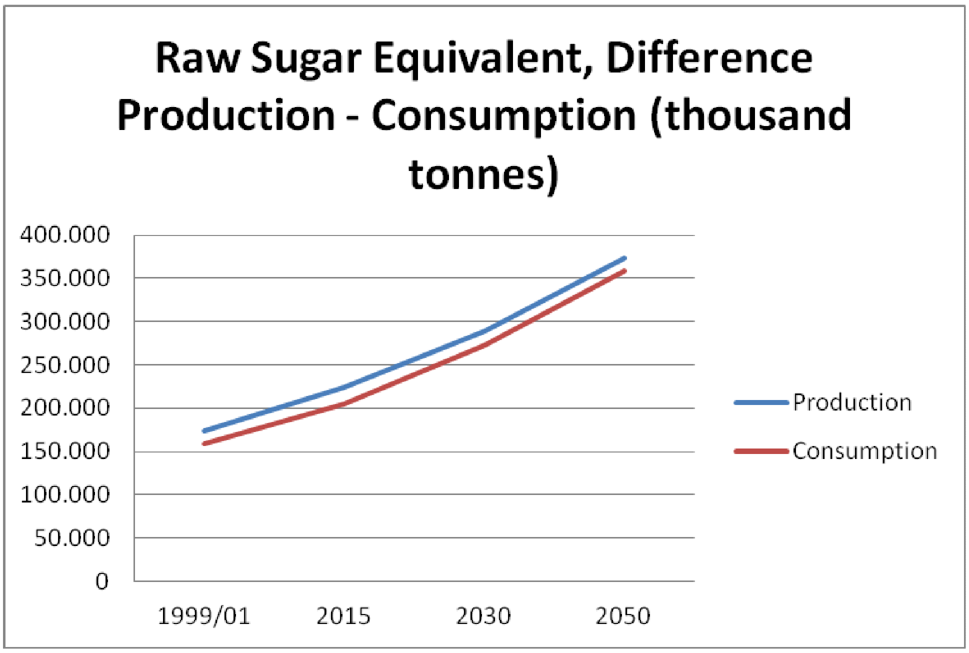


Figure 13: Raw Sugar Equivalent, Difference Production - /Consumption (thousand tonnes)

Source: ÖVAF calculations, 2012, Vienna

3.4.1.2. Intensive scenario

This scenario is based on data and assumptions taken out of the FAO studies already listed above. Data was calculated with the same formula as above. In this scenario FAO assumptions used in the *FAO - Global Perspective Studies Unit (2006): World Agriculture: towards 2030/2050; Interim Report, Prospects for food, nutrition, agriculture and major commodity groups, Rome,* were adapted to the data used in *Bruinsma, J. (2009): The Resource Outlook to 2050; By how much do land, water and crop yields need to increase by 2050, Expert Meeting on How to Feed the World in 2050. Rome, FAO* and revised using the more recent *FAO ESA Working Paper No. 12-30, Alexandratos, N. and Bruinsma, J. (2012): World Agriculture towards 2030/2050: The 2012 revision, Rome, FAO.*

Use of agricultural products for bio fuel production is neither calculated nor shown as an extra part of this scenario, because by logic and under the main aspect of this study - Food Security - only those quantities not necessary to nourish the whole population worldwide should be used for that purpose. This in fact means that quantities for bio fuel production will be left over after subtracting world consumption from world production of all agricultural shipments used in bio fuel industry. It also has to be kept in mind that in none of the scenarios presented and discussed in this chapter did we include the gross estimate of the global picture of losses, conversion and wastage at different stages of the food supply chain as published in *Nellemann, C. et alt. (2009): The environmental food crisis - The environment's role in averting future food crisis. A UNEP rapid response assessment. United Nations Environment Programme, GRID - Arendal*.

Cereals

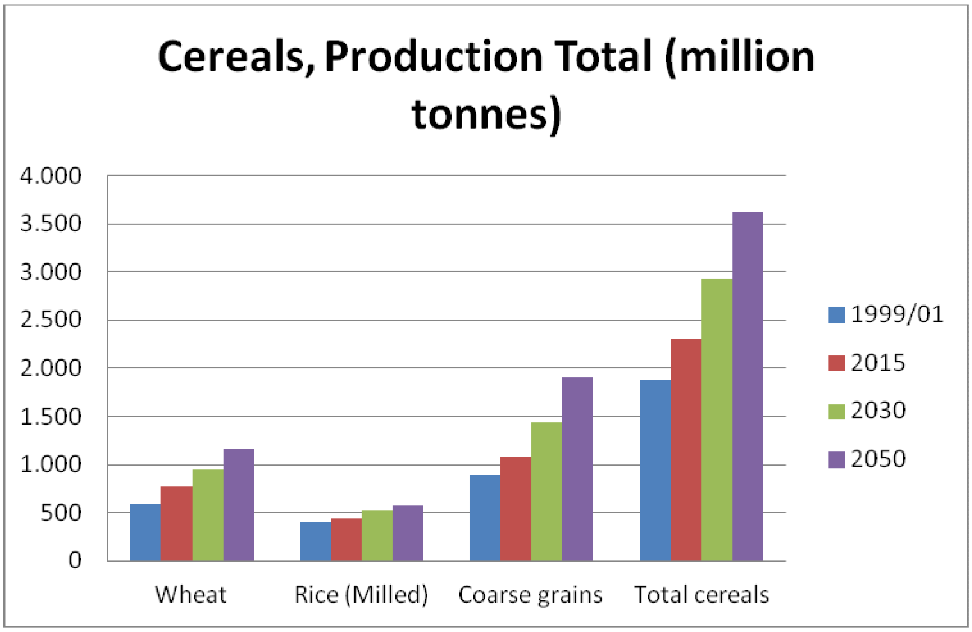


Figure 14: Cereals, Production Total (million tonnes)

Source: ÖVAF calculations, 2012, Vienna

Following Figure 14 above it can be deducted that, under the assumptions of the intensive scenario, which is based on a moderate increase of yields and area used for cereals production there will be a constant increase of production with respect to all cereals. We have to also take in mind that there has already been a lot of progress concerning plant breeding to adapt cereal seeds to changing weather conditions.

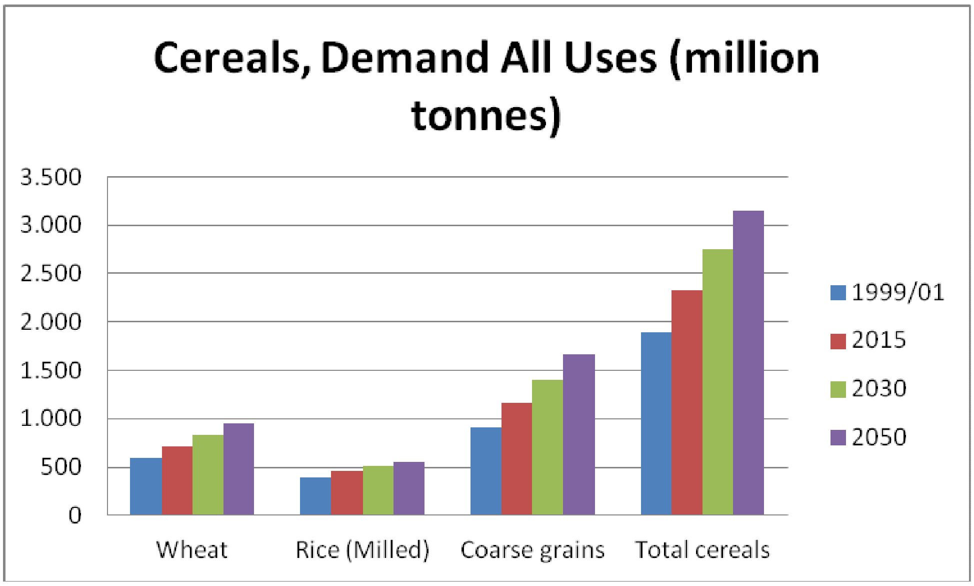


Figure 15: Cereals, Demand All Uses (million tonnes)

Source: ÖVAF calculations, 2012, Vienna

In the table above it become clear that - following the growth rates of world population - demand is constantly growing throughout the time horizon, nearly with the same speed as possible increases in production. Changing non food uses could change demand quantities in both directions - they could go up, but also down if third generation of bio fuels will already have reached a suitability for economically acceptable use.

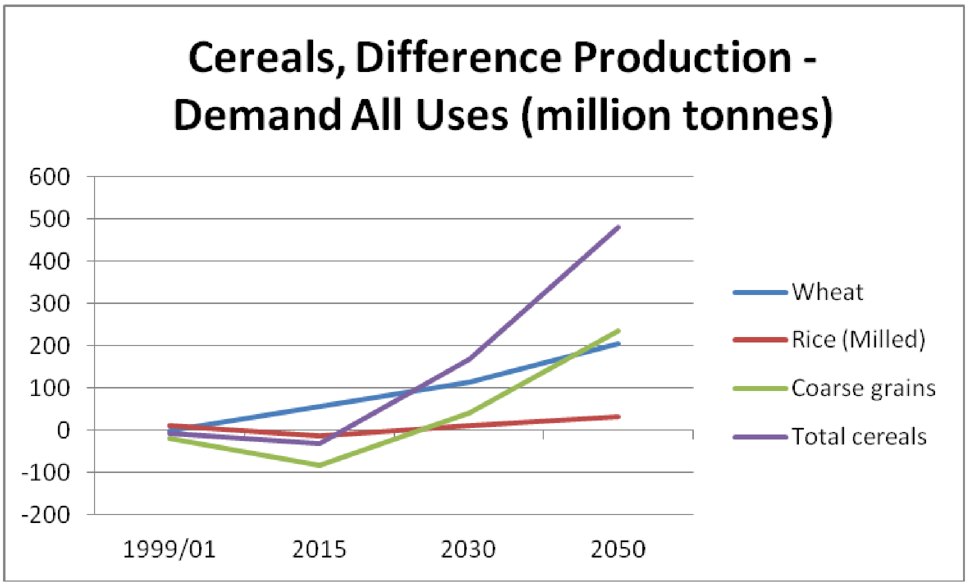


Figure 16: Cereals, Difference Production – Demand All Uses (million tonnes)
Source: ÖVAF calculations, 2012, Vienna

The lack between production and demand during the 1999/01 - 2020-ies period mirrors the boost of cereals' use in meat production due to higher purchasing power in the two most populated developing countries, China and India, but also because of bad harvests as a consequence of natural disasters in main producing countries. On the other hand, large stocks - especially in China - have been reduced, even accepting prices lower than costs of production had been.

The change concerning evolution of production and demand - especially with respect to coarse grains - is also based on the change of feed mix from pulses, roots and tubers to cereals, mostly coarse grains.

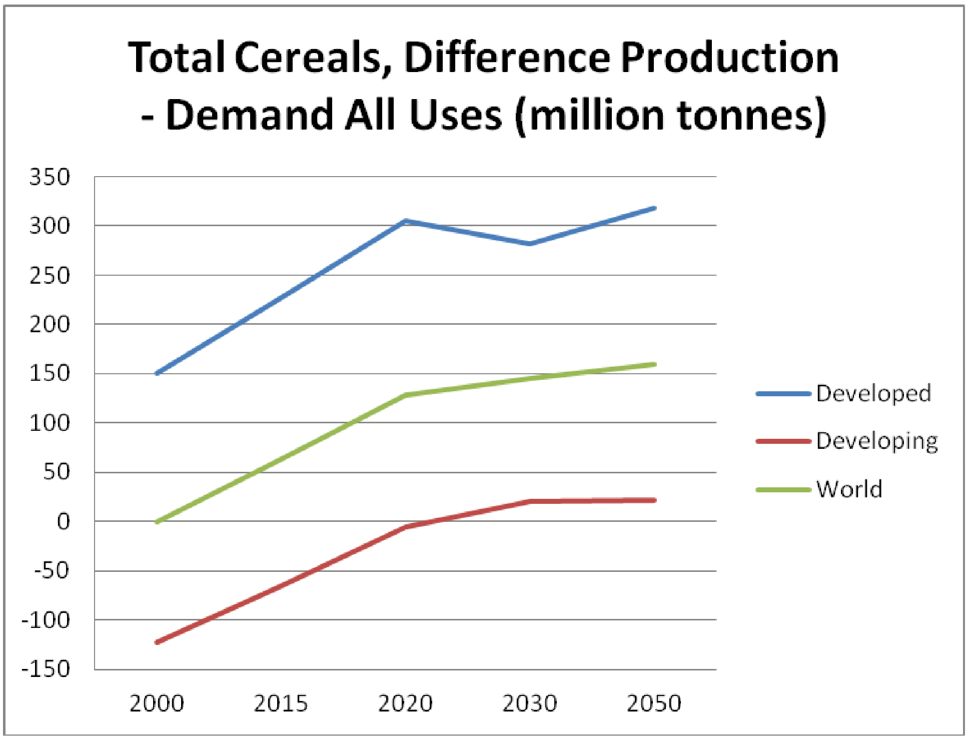


Figure 17: Total Cereals, Difference Production – Demand All Uses (million tonnes)
Source: ÖVAF calculations, 2012, Vienna

Figure 17 demonstrates - as has already been the case in the non intensive scenario - that until the mid twenties developing countries may not be able to produce sufficient cereals for their fast growing population. Mainly in Asia and sub-Saharan Africa, consumption of pulses saw drastic declines and stagnated in nearly all other developing countries. Roots and tubers experienced a fall, especially in the Democratic Republic of Congo, Madagascar, the United Republic of Tanzania and Uganda, meanwhile other developing countries such as Ghana, Malawi, Sierra Leone and Peru grew their production. In the latter country group, nearly all of their improvements in national average kcal/person/day since the 90ies are based on boosting their production of roots and tubers. It must be kept in mind that the use of roots, tubers and plantains is mostly a question of acceptance and traditional diets.

Oil crops

The following Figure No. 18 shows the same picture as already had been the case under the non intensive scenario. The difference lies in higher quantity levels, but the previously discussed facts are the same.

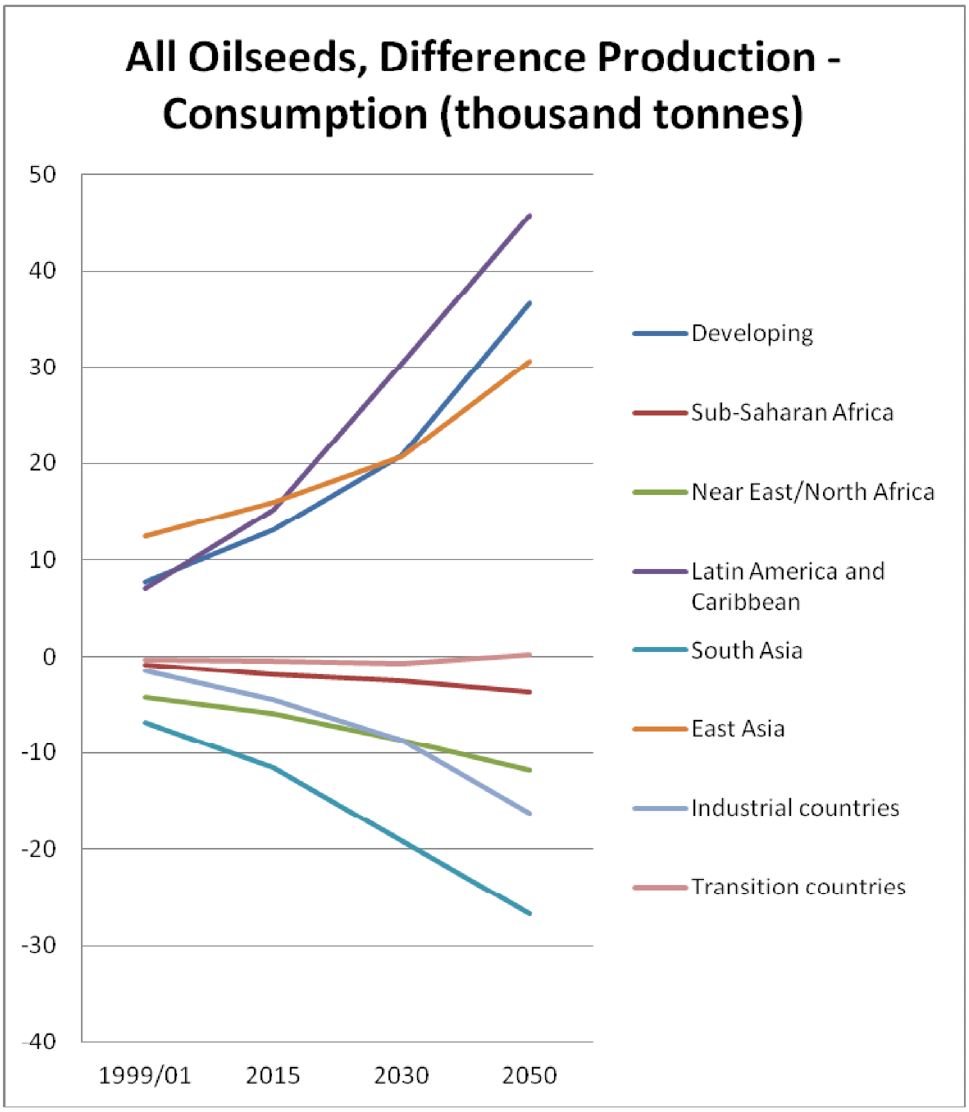


Figure 18: All Oilseeds, Difference Production – Consumption (thousand tonnes)

Source: ÖVAF calculations, 2012, Vienna

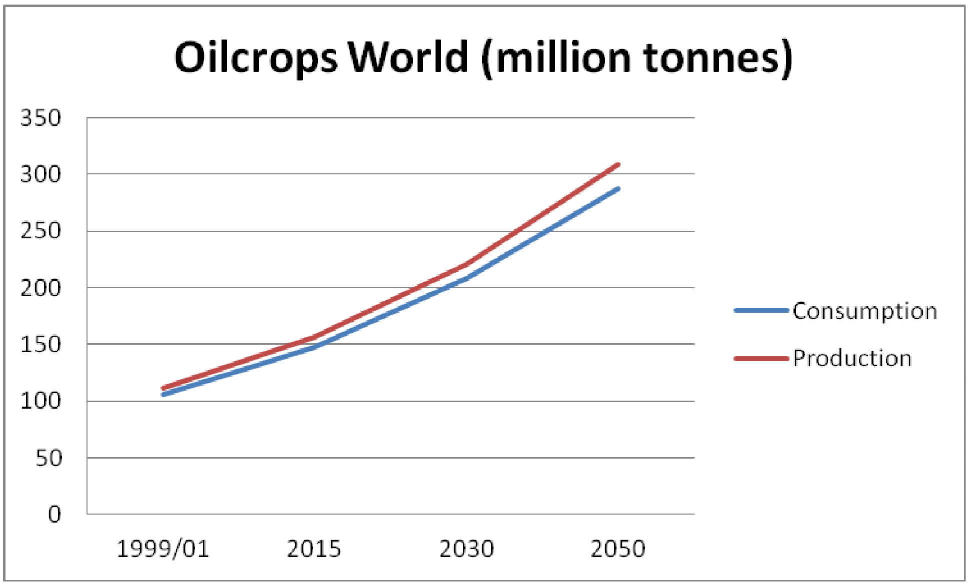


Figure 19: Oilcrops World (million tonnes)

Source: ÖVAF calculations, 2012, Vienna

The gap between production and consumption will be slightly more pronounced than under the none intensive scenario, which is explicable not only by intensifying and raising production, but also because of less demand in developing countries, whose population at the time being use oil as a prominent source of daily calorie intake.

Meat

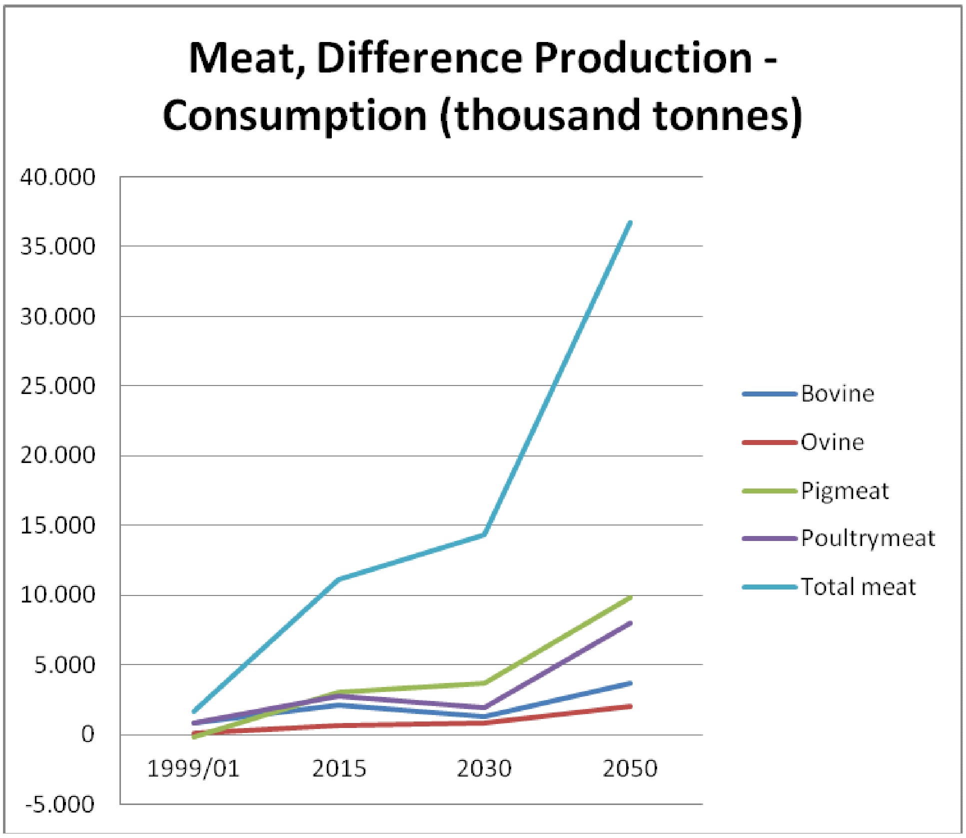


Figure 20: Meat, Difference Production – Consumption (thousand tonnes)
Source: ÖVAF calculations, 2012, Vienna

Assuming that the ongoing economic and financial crisis will not last for too long, Figure 20 shows how meat production and consumption will evolve worldwide. Meat production and consumption depend heavily on the purchasing power of consumers, but also on dietary habits and traditions and heavily on use restrictions set by religious dietary laws. Production will also grow as soon as prices for meat producers are satisfactory - as soon as this is not the case anymore, production will be on the decline, no matter which kind of meat we are talking about.

Milk and Dairy products

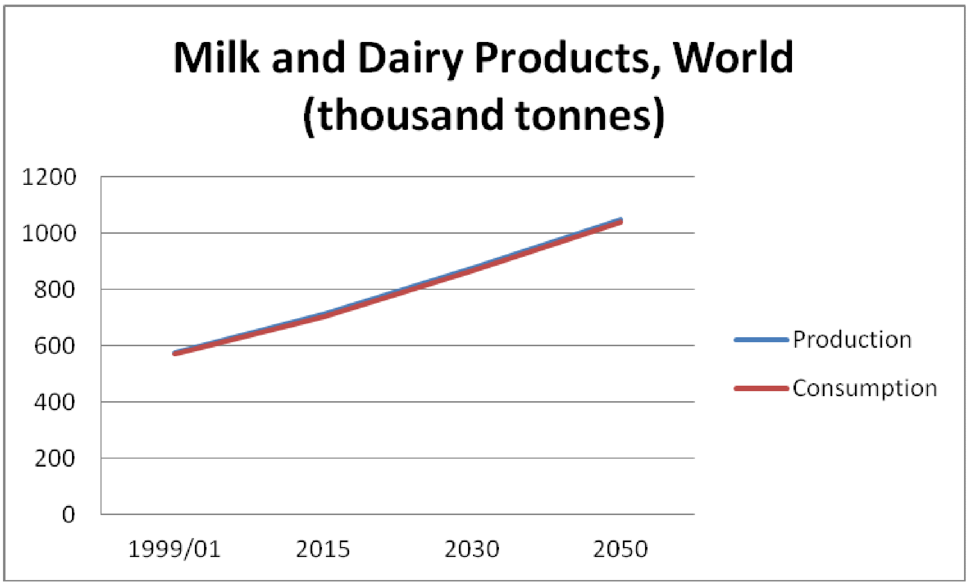


Figure 21: Milk and Dairy Products, World (thousand tonnes)
Source: ÖVAF calculations, 2012, Vienna

Rising purchasing power also raises the use of milk and dairy products, which is perfectly reflected in Figure 21, which is not including Lactose Intolerance. The more purchasing power the higher will the %age of dairy products with a high degree of processing relative to raw milk production. A totally different picture of consumption is presented in the following Figure 22, when lactose intolerance is taken into account.

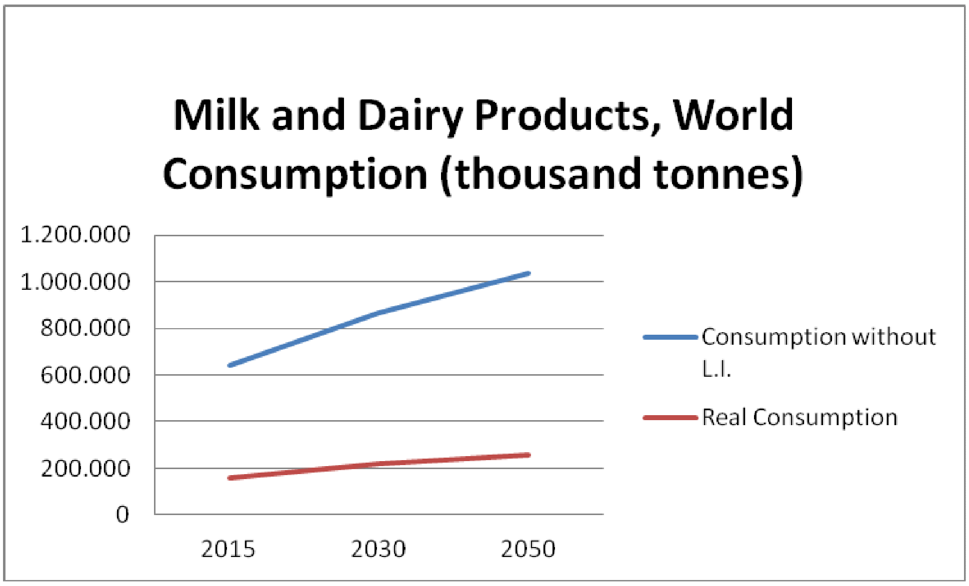


Figure 22: Milk and Dairy Products, World Consumption (thousand tonnes)
Source: ÖVAF calculations, 2012, Vienna

Even taking into account that most people suffering of lactose intolerance are not aware of it, there still are discrepancies, comparing today's production and demand situation with up to 75% of world population hit by this handicap. Therefore we have to assume that much more milk is used in animal feed than shown in official statistics. We also have to take into account that failure to maintain the necessary diet means loss in life expectancy for these people. Most of these people live in Africa, Asia and Latin America, where average expectation of life is lower than in countries where fewer people are affected by lactose intolerance.

Sugar

For this production we have to say that the same situation is occurring under intensive scenario conditions as under none intensive assumptions. The following Figure 23 clearly demonstrates that growth in sugar production and consumption shifts from developed countries to developing countries, especially for the dominant role of Brazil in this field of production.

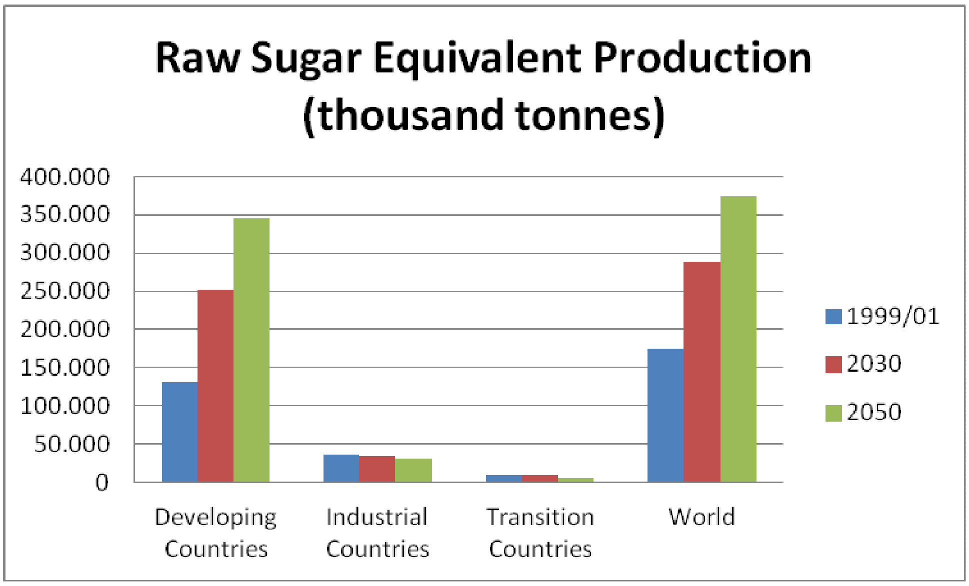


Figure 23: Raw Sugar Equivalent Production (thousand tonnes)
Source: ÖVAF calculations, 2012, Vienna

On one hand, that the Agreement on Agriculture within GATT/WTO does not take any environmental nor social aspects of production into account favors countries with no standards in production. On the other hand, use of sugar in food production is now much less common than before, especially in countries who had formerly been the main players in production and consumption like the USA, Europe and other industrial and developed countries with respect to their population. Even though it is foreseen that rates of growth in Brazil will not be as high as in the past, Brazil will be the biggest and most important producer of sugar in the future too.

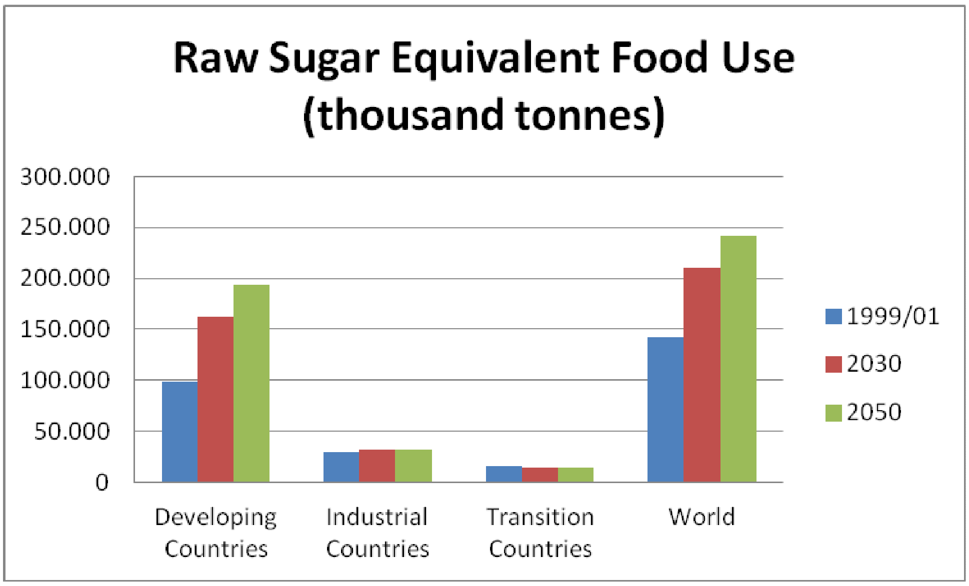


Figure 24: Raw Sugar Equivalent Food Use (thousand tonnes)

Source: ÖVAF calculations, 2012, Vienna

Apart from Brazil's use of sugar for industrial use, most developing countries will produce more sugar for food use in the next decades, starting with very low levels of sugar consumption.

Figure 25 shows that sugar production since the nineties has always been higher than demand, which explains its industrial use as already mentioned above.

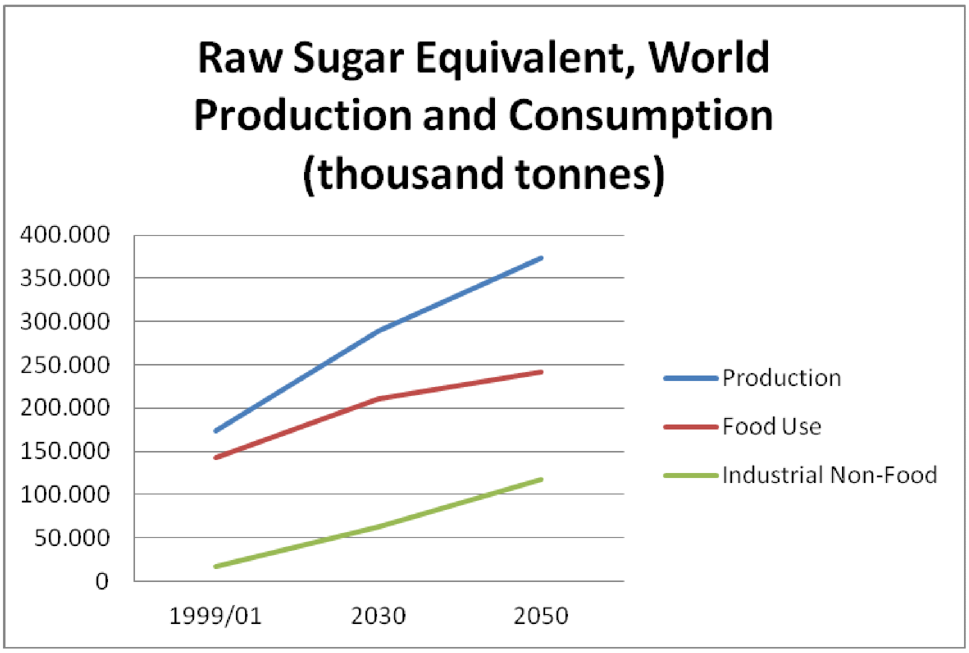


Figure 25: Raw Sugar Equivalent, World Production and Consumption (thousand tonnes)

Source: ÖVAF calculations, 2012, Vienna

To replace petrol based energy in the future, sugar will still be of relatively high importance, although growth rates of industrial non food use will slow down.

3.4.1.3. Intensive scenario taking climate change effects into account

This chapter is dedicated to the fact that we are undergoing a period of climate change that will have its biggest influence on agricultural production. Climate scenarios, however, are characterised by assumptions (i.e. emission scenarios) and many other uncertainties which lead to uncertain ranges of global warming in the future. Further, many climatic and atmospheric (i.e. CO_2 fertilization) effects on crops are uncertain and can cover a wide range. Many indirect climatic driven effects also influence crops productivity (i.e. through soil fertility). These uncertainties are, among others, the reason for some disagreements between scientist on causes of climate change, its impacts and effect of adaptation options. However, a majority of scientists confirm that ongoing climate change is at least partly caused by humans and will change natural and human systems.

In this chapter we shall not enter this discussion, but limit ourselves to the outcome of our meteorologist's project partners - Schlatzer, M. (2012): Yield change rates for selected major agricultural commodity groups. Working paper of the Institute of Meteorology, University of Natural Resources and Life Sciences. Vienna, BOKU.

As the first step, the climate change based %age growth rates were calculated using a weight average for the countries and country groups used in this chapter, their production area as well as their actual yields per hectare. The results of these steps were yearly %ages of growth of selected products as already used and explained above. It must also be kept in mind that the basis of inclusion of what we here call %age rates are those of the intensive scenario adding or subtracting – depending on if climate change effect provisions for each of the plants, countries and country groups were negative or positive - the results of the weighted average. These weighted %age rates were used to calculate the growth rates for the time periods under question 1999/01 - 2015, 2015 - 2030 and 2030 - 2050.

Once again we are not calculating production of bio fuel, taking for granted that only surplus production will be used for energy production. Surplus production in this context means that everyone in this world has permanent access to sufficient and healthy food. All production that exceeds this world demand or is not usable for human consumption, may be used for energy production or for non food use. We are aware that this may sound very unrealistic, but we decided to do it this way because of the international agreements in force as well as the knowledge that the relative number of undernourished worldwide will not change until 2050 - absolute numbers will even rise because of world population growth. Having this in mind, we also assume that only on field production will change because of climate change, not meat nor milk and dairy production. Therefore we shall limit ourselves to discuss here only cereals, oilseeds and sugar production and demand/consumption. Above all it is a question of input and output prices, who will produce what and which quantities as well as of the purchasing power of consumers that is ultimately decisive when talking about which food and which quantities people will be able to have access to.

Cereals

Cereal production, especially in relation to rice, will be influenced most by climate change. Concerning rice there has already been made progress by Japanese scientists, who specialize in plant breeding by applying biotechnological methods[6]. They succeeded to breed a rice variety, which is nearly resistant with respect to longer lasting droughts. Even in droughts lasting more than two months, losses in yields are only about one third of yields under optimal growing conditions. This variety could be used especially in dry mountainous regions all over Asia.

What also must be taken into consideration is the future situation of fertilizers and their availability as well as the environmental impact of phytosanitary measures.

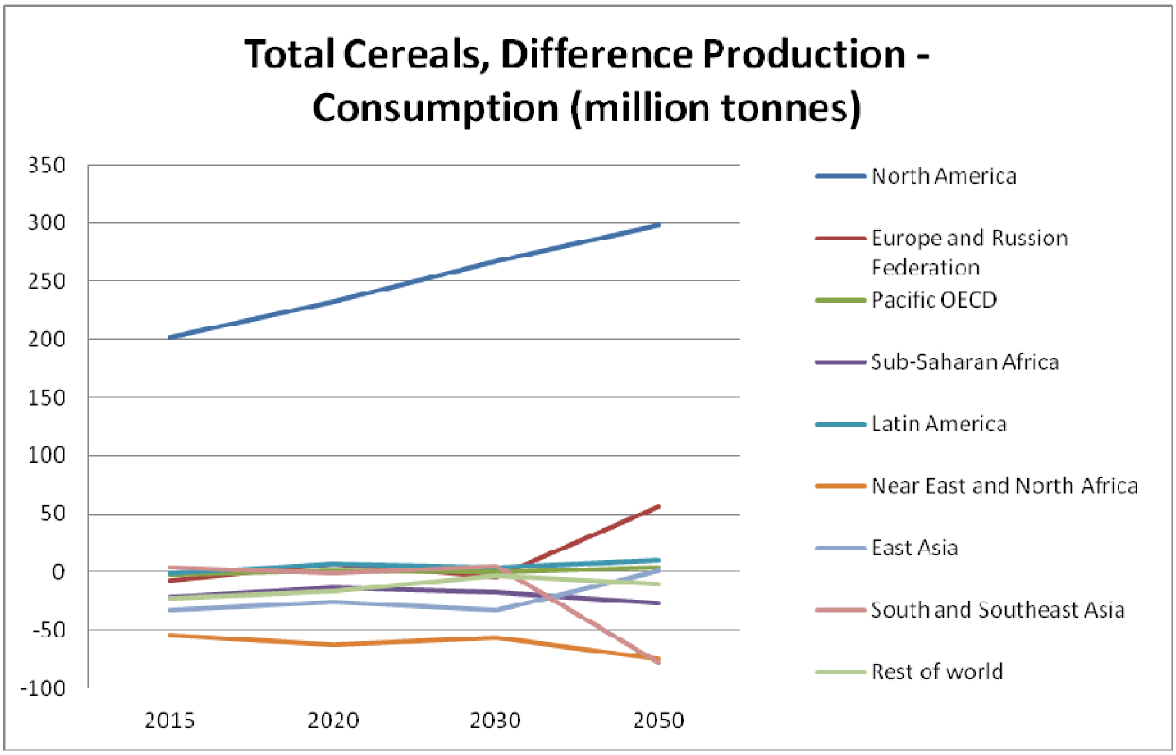


Figure 26: Total Cereals, Difference Production – Consumption (million tonnes)
Source: ÖVAF calculations, 2012, Vienna

What we can deduct from Chart 26 is that only North America will be producing a surplus up to the 30ies of this century, while Europe and the Russian Federation will not reach surpluses until that time horizon, nor will Latin America. Some other country groups will need until the 50ies to get there. In Europe and the Russian Federation one important factor is that population is on the decline, while Latin America will profit from intensified

[6] Die Welt 06.08.13, 19:21 UHR, Berlin

investments in agriculture, which should at least lead to better yields and fewer losses from the field to the consumer. The rest of the country groups like Pacific OECD, sub Saharan Africa, South and Southeast Asia as well as the Near East and North Africa will be on a permanent decline up to the 2050 horizon.

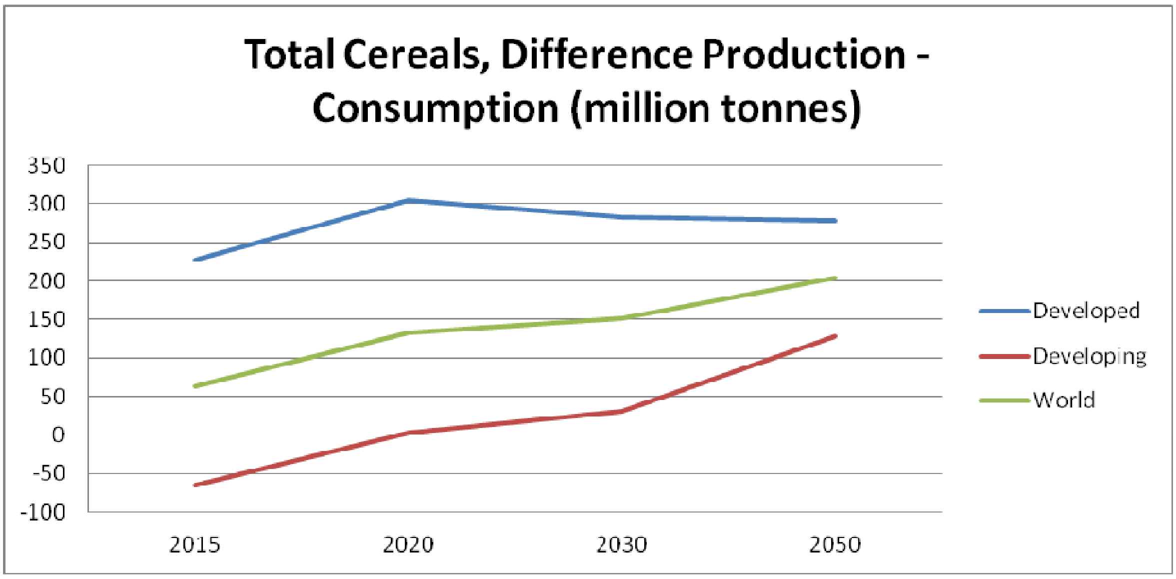


Figure 27: Total Cereals, Difference Production – Consumption (million tonnes)

Source: ÖVAF calculations, 2012, Vienna

Total cereal production for the World taken as a whole - even taking into account the positive effects of climate change on several crops - should have a quite limited surplus throughout the period 2015 - 2050, developed countries will be on the decline between 2020 and 2050. During the same period developing countries will significantly raise their production relative to consumption.

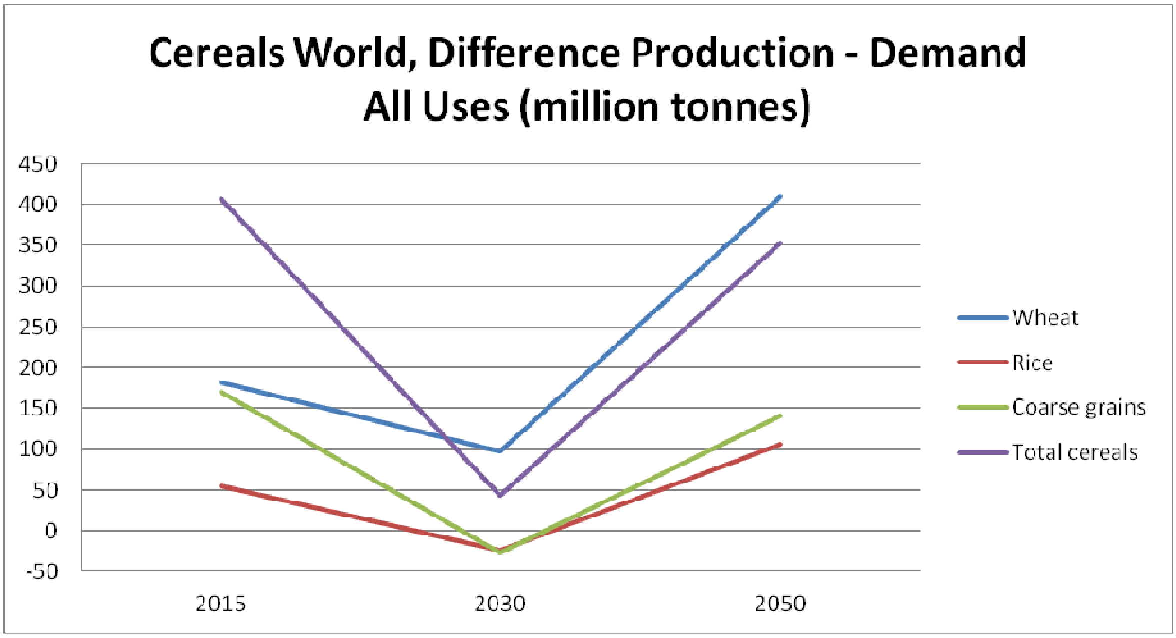


Figure 28: Cereals World, Difference Production – Demand All Uses (million tonnes)

Source: ÖVAF calculations, 2012, Vienna

What we can deduct from Figure 28 above is the fact that wheat will keep its dominant position in the cereal's group. Rice will undergo a slower decline than coarse grains. This is mostly due to the different uses of the both of them. While rice nearly is only used for direct consumption, coarse grains are mostly used as feed and less for food. This table also gives us some information about the rise of animal production, where coarse grains are mostly used.

Oil crops

Oil crops will continue gaining importance in production and consumption. Even under climate change conditions - at least during the projected period - production will exceed demand as can be concluded from Figure 29. Following the meteorological previsions for oil plants, oil crops are less vulnerable with respect to climate change than cereals and most of their production is situated in regions which will not be heavily affected before the 2050 time horizon.

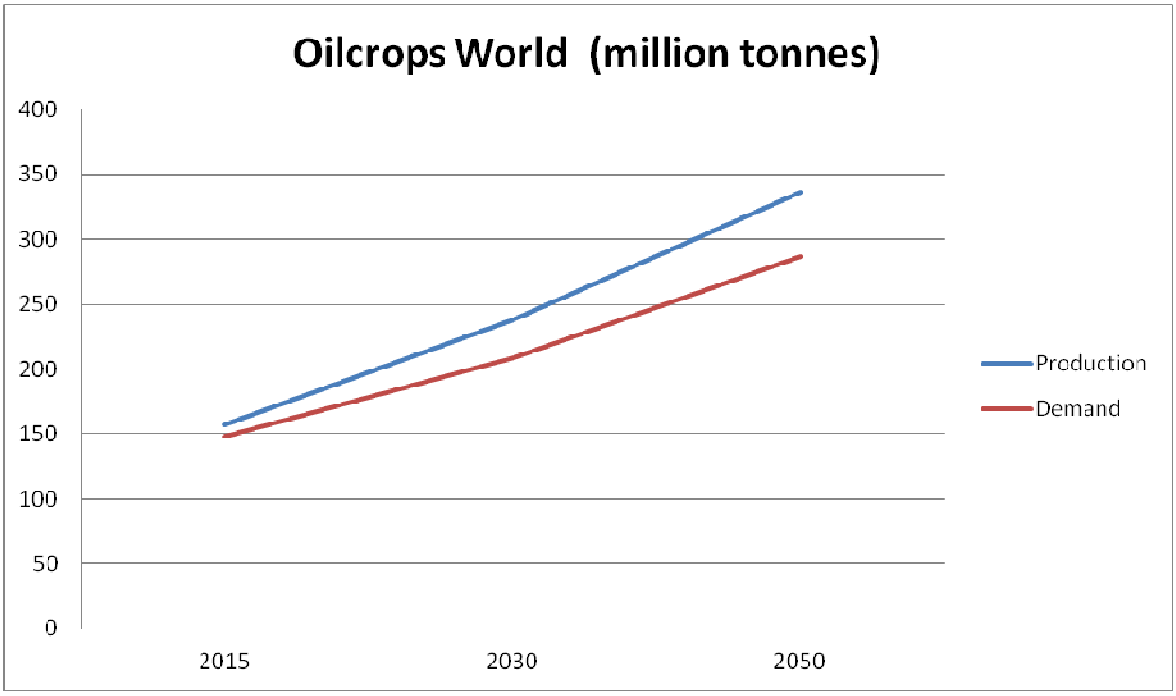


Figure 29: Oilcrops World (million tonnes), Source: ÖVAF calculations, 2012, Vienna

The following figure, Figure 30, shows nearly the same distribution of differences between developed countries and developing countries as well as within developing countries as demonstrated in Figure 29 above. This is not only due to what has already been said with respect to Figure 29 above, but also because countries with high production standards are losing their competitiveness with respect to producers who are only bound to fewer standards or no standards at all. Exploring the long term environmental consequences of low or even no existing production standards are not the objective of this project, but should be handled somewhere else. The most problematic regions with respect to oil crops are the same as for cereals - sub Saharan Africa, the Near East and North Africa and South Asia.

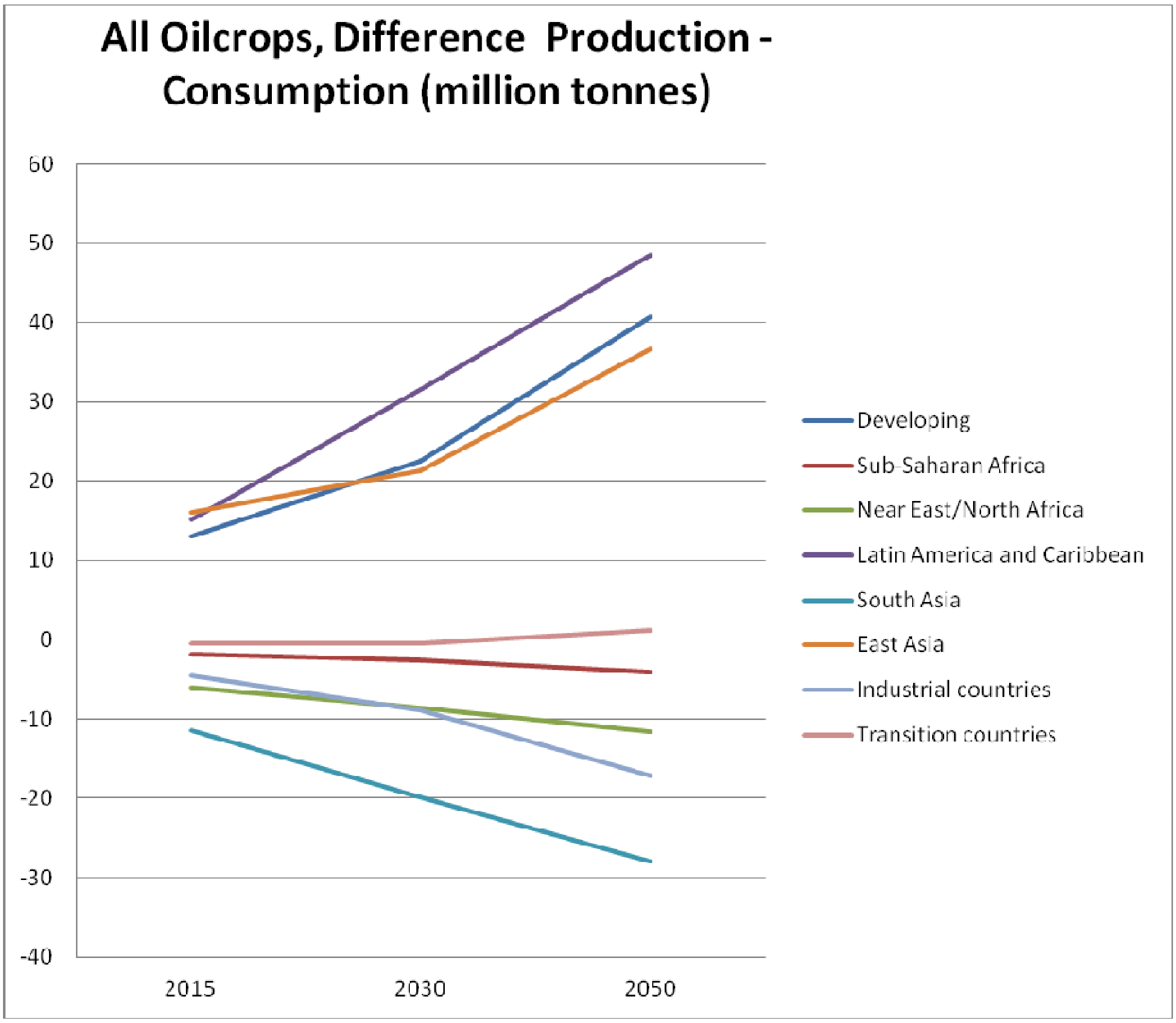


Figure 30: All oilcrops, Difference Production – Consumption (million tonnes)
Source: ÖVAF calculations, 2012, Vienna

Sugar

Sugar production and demand shows the same picture as is the case when climate change is not taken into account.

Figure 31 demonstrates a very significant upwards trend in sugar production since the 1999/01 period, which will last up to 2050, meanwhile production in industrial countries has been following the opposite trend since 1999/01. Transition countries will keep their 1999/01 production levels without significant variations, but will experience a relatively strong decrease during the 2030 - 2050 period.

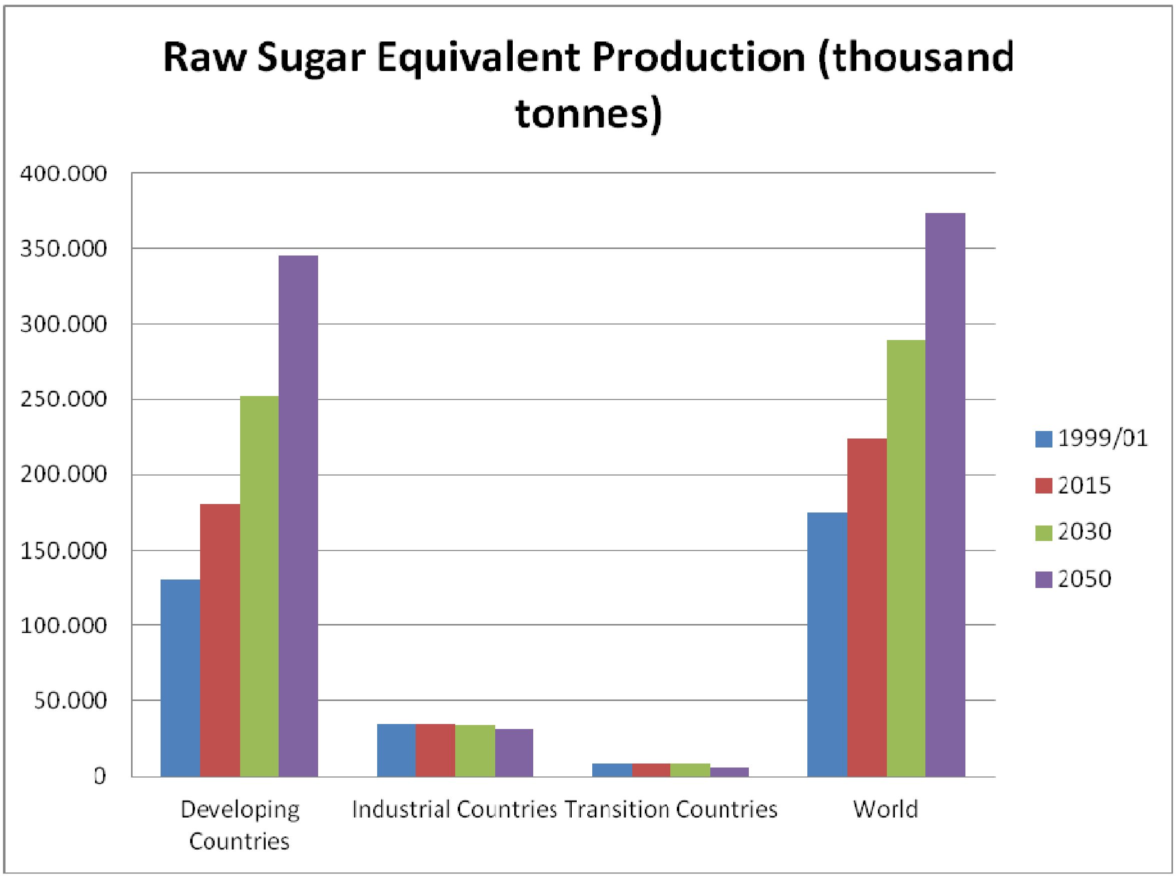


Figure 31: Raw Sugar Equivalent Production (thousand tonnes)

Source: ÖVAF calculations, 2012, Vienna

The following Figure 32, which demonstrates the food use of raw sugar equivalent in general, shows the same evolution as production does. The sharp increase in sugar consumption all over the developing countries has also to be seen from the historically low levels of the decades before the 1999/01 period. Industrial countries will only see very little increases in food use of sugar, mostly because they have already reached very high levels of consumption, while transition countries are more or less carrying forward their 1999/01 levels of consumption with some decline between 2030 and 2050, due to loss of population, which they will experience during these two decades.

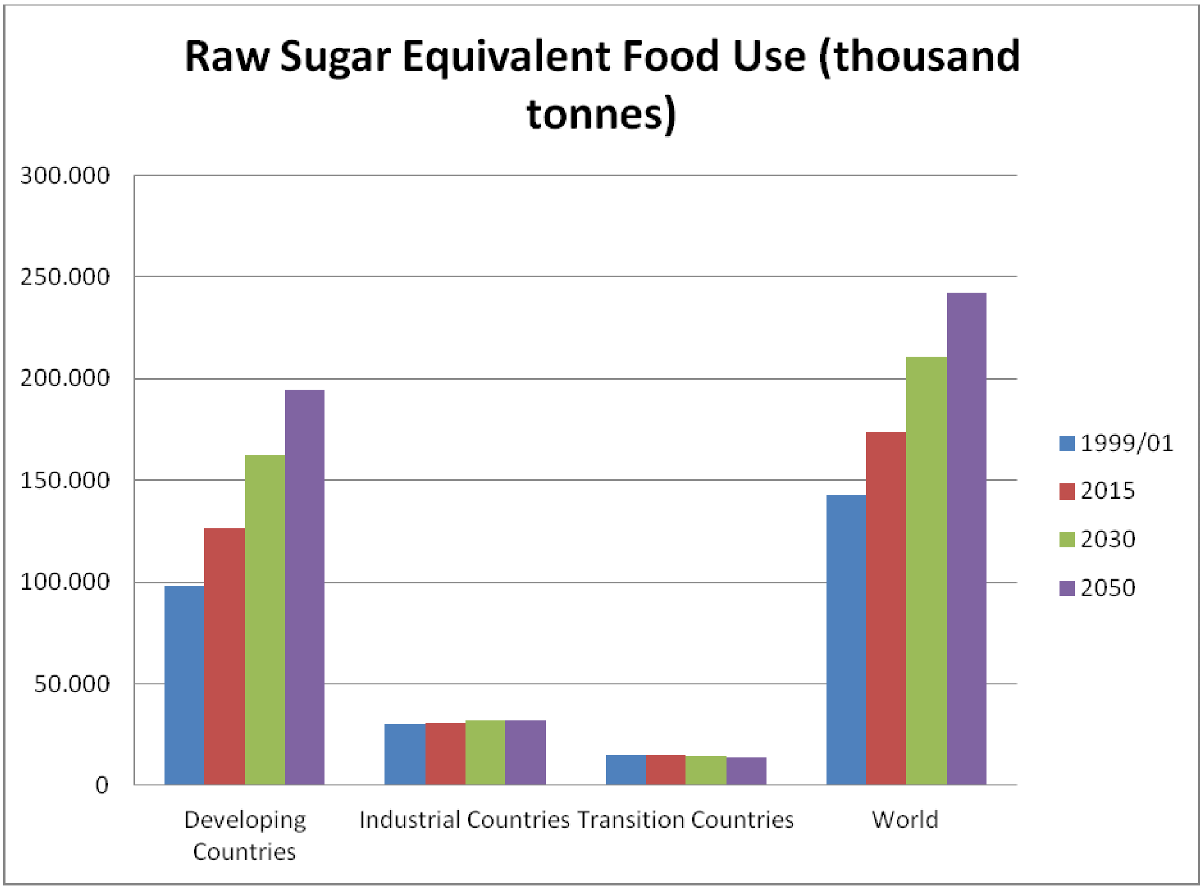


Figure 32: Raw Sugar Equivalent Food Use (thousand tonnes)

Source: ÖVAF calculations, 2012, Vienna

The following Chart 33 shows total production as well as worldwide food use and industrial non-food use. It's evident that there will be sufficient sugar to satisfy demand for both uses in 2050 too. Anyhow, this will only be the case if there were not a steep increase in the dedication of sugar to industrial non-food use. It has to be kept in mind that the last few years have seen growing interaction between the sugar and the energy market, especially because of distilling sugar and use of ethyl alcohol for fuel. In Brazil more than one half of sugar production is dedicated to this kind of use. How this market will evolve in the future is very uncertain and will have great influence on the world sugar balance.

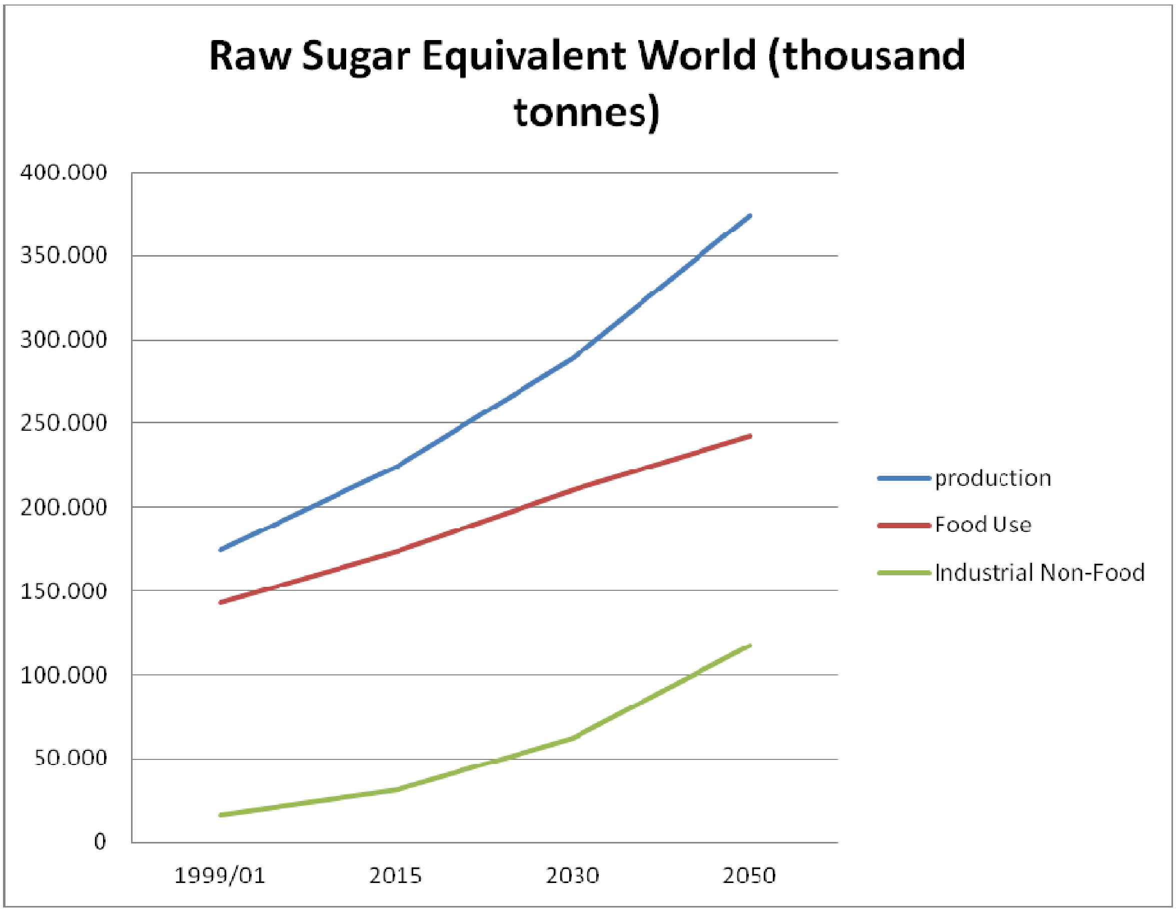


Figure 33: Raw Sugar Equivalent World (thousand tonnes)

Source: ÖVAF calculations, 2012, Vienna

3.4.2 EU Agricultural Production and consumption 2015

The 2015-forecasts show a 10%-increment for wheat production based both on a moderate enlargement of the area and higher expected yield progress, going along with increased consumption and thus resulting in almost equal self-sufficiency rates. For coarse grains, a light reduction in self-sufficiency is expected for 2015 at smaller change rates in production and consumption. Oil seeds show a continuing and remarkable rise in production and consumption since 2000, mainly due to larger cultivation areas, especially of winterrape. This rise could even increase the self-sufficiency rates for oil seeds and oil seed meals but not for vegetable oils. The steeply rising demand for bio oils lowered the self-sufficiency for this commodity in spite of the gain in oil seed production in the EU-27.

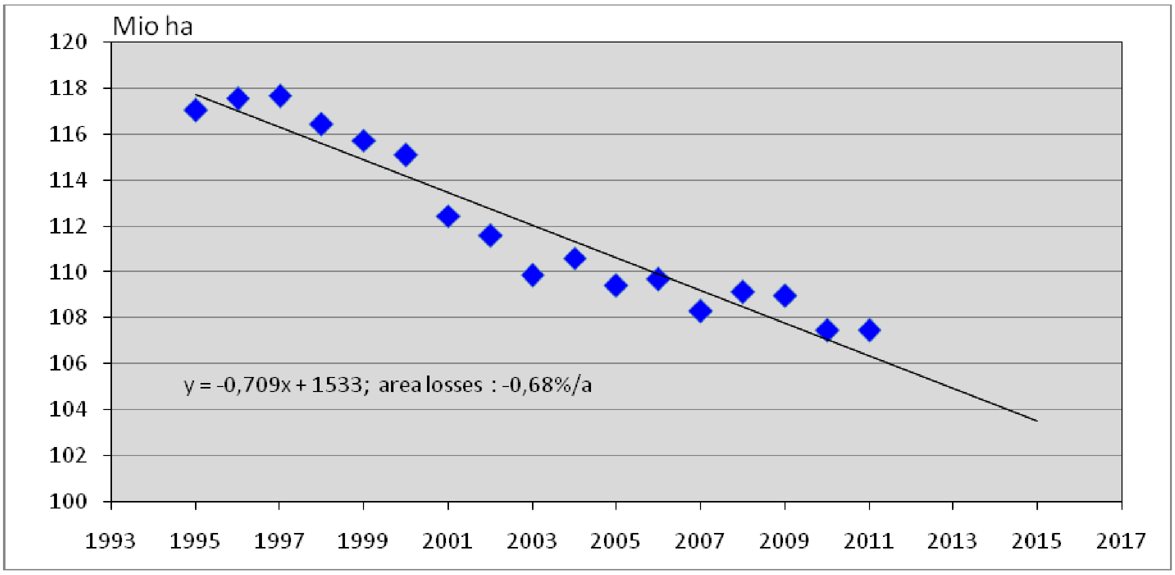


Figure 34: Development arable land in EU-27 since 1995 (FAOSTAT, 2012)

OECD forecasts are not available for soybeans. In EU-27, soybean area was fluctuating around 0.40 millions ha, with larger acreages in the period from 2010 to 2012 (FAOSTAT, 2013) after lower cropping data the years before. The forecast based on soybean shares of the oilseed sector would come to rather low areas for 2015, which does not seem very probable with respect to the intended enlargement of soybean cropping in the Danube region as agreed in the Danube soya declaration (Pernkopf et al., 2012). So the mean of 2000-2010 data for production and consumption was assumed to be adequate for the respective soybean figures in 2015. The self-sufficiency rate for soybeans is thus expected to rise a bit from 6% to 9%. EU-27 imports of soybean itself slid down during last years as other sources for vegetable oil became available for the food sector.

Table 7: Production of agricultural products in EU-27 (OECD, 2011a)

Product groups	Mean 2000-2010 (1000 t)	2015 (1000 t)	Delta 2015 %rel
Plant products			
Wheat	132,440	145,755	10.1
Rice	2,674	2,670	-0.2
Coarse grains	150,072	153,837	2.5
Soybean	1,040	1,040	0
Other oil crops	22,428	30,346	35.3
Oilseed meals	23,583	27,347	16.0
Protein crops	4,264	n.a.	-
Vegetable oils	11,554	15,332	32.7
Sugar	17,870	17,958*	0.5
Starch crops	66,356	n.a.	-
Fruits	58,953	n.a.	-
Vegetables	63,580	n.a.	-

Table 8: Production of agricultural products in EU-27 (OECD, 2011a), continued

Product groups	Mean 2000-2010 (1000 t)	2015 (1000 t)	Delta 2015 %rel
Animal products			
Beef and veal	8,219	7,622	-7.3
Sheep meat	1,054	810	-23.1
Pork	21,994	22,863	4.0
Poultry meat	11,311	12,303	8.8
Eggs	6,116	n.a.	-
Fish	7,150*	6,435*	-10.1
Milk	149,104	151,413	1.5
Butter	2,163	2,044	-5.5
Cheese	8,356	9,283	11.1

* Sugar, fish: OECD, 2013

Table 9: Consumption of agricultural products in EU-27 (OECD, 2011a)

Product groups	Mean 2000-2010 (1000 t)	2015 (1000 t)	Delta 2015 %rel
Plant products			
Wheat	123,775	133,544	7.9
Rice	3,904	4,521	15.8
Coarse grains	148,189	155,780	5.1
Soybean	14,866	11,223	-25.5
Other oilcrops	25,278	36,121	42.9
Oilseed meals	50,338	55,404	10.1
Protein crops	5,210	n.a.	-
Vegetableoils	18,367	27,367	49.0
Sugar	16,781	18,844*	9.1
Starchcrops	64,489	n.a.	-
Fruits	80,961	n.a.	-
Vegetables	68,459	n.a.	-
Animal products			
Beef and veal	8,287	7,986	-3.6
Sheep meat	1,295	1,023	-21.0
Pork	20,563	21,310	3.6
Poultry meat	11,083	12,192	10.0
Eggs	6,098	n.a.	-
Fish	11,856*	12,173*	+2.6
Milk	149,104	151,413	1.5
Butter	2,024	1,993	-1.5
Cheese	7,811	8,722	11.7

* Sugar, fish: OECD, 2013

At the same time, the increasing offer of oilseed meals from rape and sunflower are lowering growth rates of soybean meal demand from EU-abroad (USDA, 2012; OECD, 2011a).

EU sugar production declined by about 20% with reform of the EU sugar regime in 2006. However, in the OECD-FAO Outlook 2011, the forecast of EU- sugar production and self-sufficiency by 2015 seems too low. In the latest edition of the OECD-FAO Agricultural Outlook (OECD, 2013b) a sugar production of 15,555 kt and a self-sufficiency rate of 95% is expected for EU-27 in 2015.

Data for potatoes, fruits and vegetables are not explicitly covered by the OECD-FAO-Outlook. As for EU-27, more than 99% of acreages and production of starch crops go back to potato, a crop steadily shrinking in area, production and even more in consumption. Therefore one could observe slight increase of self-sufficiency rate during 2000-2010 from below 90% to 100%. In some member states (e.g. Ireland, Latvia, Lithuania, Estonia, Poland, United Kingdom) potatoes are a very substantial component of the human diet with per capita consumption higher than 100 kg a year.

Table 10: Self–sufficiency rates (%) of EU-27 for agricultural products (OECD, 2011a)

Productgroups	Mean 2000-2010	2015 (%)	Delta 2015 %abs
Plant products			
Wheat	107%	109%	2%
Rice	69%	59%	-10%
Coarse grains	101%	99%	-3%
Soybean	6%	9%.	3%
Other oil crops	91%	84%	-7%
Oilseed meals	47%	49%	3%
Protein crops	82%	n.a.	-
Vegetable oils	64%	56%	-8%
Sugar	106%	95%*	-13%
Starch crops	94%	n.a.	-
Fruits	79%	n.a.	-
Vegetables	100%	n.a.	-
Animal products			
Beef and veal	99%	95%	-4%
Sheep meat	81%	79%	-2%
Pork	107%	107%	0%
Poultry meat	102%	101%	-1%
Eggs	100%	n.a.	-
Fish	60%	53%*	-7%
Milk	100%	100%	0%
Butter	107%	103%	-4%
Cheese	106%	106%	1%

EUROSTAT data show a decrease in self-sufficiency from 85 to 77% among fruits and a very slight fall from 101% to 99% for vegetables during the first 2000-decade, in both cases this is due to a stronger reduction in production than in consumption.

The EU-self-sufficiency rates for important meats are near 100% or higher. For beef and veal, production is shrinking whereas consumption is raising. Thus self-sufficiency lowered by 4% in 2015, whereas pig and poultry meats are both growing in production and demand with almost unchanged self-sufficiency rates. High supply capacities are also given for milk and milk products. As for fish there exists a 50% dependency on supply from outside of EU-27.

3.4.3 Discussion of results, conclusions and recommendations

Taking the three scenarios - Non Intensive, Intensive and Intensive Under Climate Change Conditions - into consideration, we have to say that under Non Intensive Scenario conditions it will not be possible to feed the growing world population. This means that the target set by the International Community to half the number of undernourished and starving people in the World cannot be reached neither in 2015 nor in 2050.

There is only the possibility of using all available measures and instruments to intensify production all over the world to - at least - stop the increase of undernourished and starving world population!

It also has to be said that the turnaround to ecological production in industrial countries, with their high purchasing power if dietary habits stay unchanged, will even exacerbate the world's undernourished population. Losses of yields caused by agricultural production methods with reduced plant protection and fertilization may reach up to 40% of possible production. That trend will result in more demand from developed. It also must be added that the above mentioned waste of food - especially in the oversaturated developed countries - is exacerbating the situation in the rest of the World. Taking the IPCC study under consideration, climate change will in a first step hit mostly in developing countries, although most of its causes were produced in developed countries throughout the last 70 years.

The above shown and interpreted results of the scenarios also lead to another conclusion. Poverty and lack of adequate knowledge and technology of local producers may lead to unsustainable use of natural resources as well as production practices - especially when we talk about smallholders, who are in most of the cases subsistence farmers only selling at nearby local markets and trapped by the Dilema of the Ejidatario[7], which are harming environment and finally impoverish the natural resource base.

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[7] The "Dilema of the Ejidatario" describes the typical problem faced by subsistence farmers and those holding little area and only limited quantities of marketed production. Normally they have no or only little capital at hand. When they harvest more than necessary for their own alimentation, they can sell the surplus, but then prices normally are too low to be able to invest in the purchase of machinery and inputs like fertilizers or phytosanitary products to improve production. In the case of average or bad harvests, they need production for their alimentation and the seeds (Krachler, M. (1991), Founding and Statutes of a Raiffeisen Cooperative in a Developing Country, Taking Social, Educational and Economic Situation into Account, Using the Example of Mexico, Vienna).

The International Community should therefore commit itself to help developing agriculture in the most endangered Developing Countries by

- improving agricultural innovation systems
- building capabilities and
- setting priorities to strengthen the capacity of small farmers to produce more efficiently and sustainably.

Small and medium sized agricultural holdings are important investors in the rural areas of developing countries and nearly the only ones in the least developed countries. Therefore, to increase and stabilize supply for local people it seems essential to provide favourable conditions for them, enabling them to invest more and at reduced risk and financing costs.

One basis seems to be putting in place institutional and policy developments, which include:

- improved infrastructure and services especially for transportation, processing and storage, as well as investments designed for greater resilience to changing environmental conditions and climate change consequences,
- irrigation facilities, which normally are outside of the financing possibilities of small farmers,
- improved governance of rural areas as prerequisite, including long term development plans for rural areas and the necessary financial means,
- support to small and medium sized agricultural holdings by innovations in the financing of their activities, which in most cases requires public-private partnerships and last but not least
- legislation and policy environment, which fosters producer organisations, who can provide an array of services like enhancing market access, information flows, financial services and the implementation of new technologies in on field production as well as in animal breeding and animal production.

A success story of the latter said are the EU - producer organisations, who have helped to foster and stabilise small and medium sized agricultural holdings all over the European Union Member States.

To sum up it must be said that there is the urgent need for initiatives to be taken by national governments, international organisations, development and humanitarian organisations, the private sector as well as public - private partnerships including full involvement of farmers' organisations and the entirety of the civil society to be able to realise needed transformation and stabilisation of rural areas and agriculture but also all other rural economic sectors in developing and emerging countries.

Adequate policy environment and improvements in market functioning are sine qua non to attract private and public sector investment as well as specific initiatives to brush up research and development including adaptation to climate change conditions. Of no minor importance are the enhancement of education and extension services and the increase of productivity and resilience. If countries cannot afford to do this on their own budgetary expenditures, support from foreign governmental and non-governmental sources should be provided as an investment in the prevention of mass migration in the near to medium future.

Countries must also invest in sectoral efforts with respect to food production, research and development, education and extension services, efficient use of inputs but also in risk management, adaptation and mitigation of climate change and measures - including the necessary infrastructure - to minimise losses throughout the production chain. On the other hand, agricultural sectors in developing and emerging countries need to have full access to latest scientific state of knowledge, including affordable access to new seeds and biotechnological animal breeding.

This should serve to enhance the livelihood of rural and farming households as well as to lower food insecurity and undernourishment, being part of and in line with overall national development strategies addressing shortages in the overall enabling circumstances. There also should be improved efforts concerning good public governance and the flourishing of all kind of institutions necessary for high-performing markets and enterprises. In short this would enable the functioning of the whole economy of a country. A legal situation, which produces trust for investments, fights against corruption and an independent and objective administration of justice are sine qua non for any kind of betterment of the presently precarious situation.

In developedcCountries there should be more awareness about food insecurity existing in the rest of the world, about healthy dietary habits, avoidance of waste and losses as well as the value of food and agricultural self-sufficiency in general.

Raising activities and programs, including medical dietary promotion campaigns, could help to raise public awareness and initiate a slow but efficient change from animal proteins to more use of proteins stemming from plants and fruits.

Finally every international endeavour has to be made to overcome the international financial and economic crisis, which is having its strongest impact on developing and emerging countries, of which the least developed countries are suffering most.

4. Agricultural Production and Consumption in Austria in 2015

4.1. Specific Methodology and Data

Authors: AGES: Klemens Mechtler

AWI: Karl Ortner

Austrian figures (Statistics Austria, 2012a,b)[8)9] for crop specific production and consumption have been aggregated according to data structure of the OECD-FAO-database (see Figure 1). Austrian data for 2015 are extracted from forecast series from 2011 to 2020 for the variables production, consumption and cultivation area. These forecasts are conducted by calculating shares of the Austrian data from 2000 to 2010 according to the EU-figures given in the OECD-FAO Agricultural Outlook 2011 (OECD, 2011)[10] for this period. The Austrian data from 2000 to 2010 were transformed into shares of the EU-data (OECD, 2011) for this period. The shares were subjected to a logit transformation which yields values ranging from -∞ to +∞; these values are assumed to follow a linear time trend according to equation (1):

$$logit(s_{it}) = ln(s_{it}/(1-s_{it})) = a_i + b_i t+u_{it}$$

with s_{it} as share of the product$_i$ in year$_t$, and with a_i, and b_i as axis intercept and gradient of the linear trend and u_{it} as error term, respectively. If the shares (s_{it}) are distributed logistically, the error term u_{it} follows a normal distribution. The parameters of the function (a_i and b_i) can be estimated by ordinary least squares. The equation for the estimated and forecasted shares reads:

$$\hat{s}_{it} = 1/(1+e\hat{}-(a_i + b_i t))$$

The observed shares in (1) are the ratio between observed values of a region (Austria) to an aggregate region or, where the OECD-forecasts (2010 to 2020) have been lacking,

[8] Statistics Austria, (2012a): Agriculture and Forestry, Prices Supply balances. http://www.statistik-austria.at/web_en/statistics/agriculture_and_forestry/prices_balances/index.html

[9] Statistics Austria, (2012b): Agriculture and Forestry, Cultivated area and yields. http://www.statistik-austria.at/web_en/statistics/agriculture_and_forestry/farm_structure_cultivated_area_yields/index.html

[10] Statistics Austria (2013) Population forecasts. http://www.statistik.at/web_de/statistiken/bevoelkerung/demographische_prognosen/bevoelkerungsprognosen/

maximum values are used with these maxima assumed to be nearly twice the respective highest value that has been given in the observation. Adjustments have been made in case of unrealistically high or low forecasts. Thus data series from 2000 to 2020 were available for Austria, forming the basis for the simulation models for 2030 and 2050. Crop yields were calculated from the predicted values for production and area. Austrian population data are retrieved from respective forecasts data of Statistics Austria (2013).

EU-27 figures for production, area and consumption for the period 2000 to 2010 time as well as 2015 are based on the OECD-FAO agricultural outlook 2011 or FAO-database. Austrian figures for crop specific production and consumption have been aggregated according to data structure of the OECD-FAO-database. Figures for development of the Austrian population are retrieved from respective forecast data of Statistics Austria (2013).

4.2. Population Development and nutrition habits

Author: AGES: Klemens Mechtler

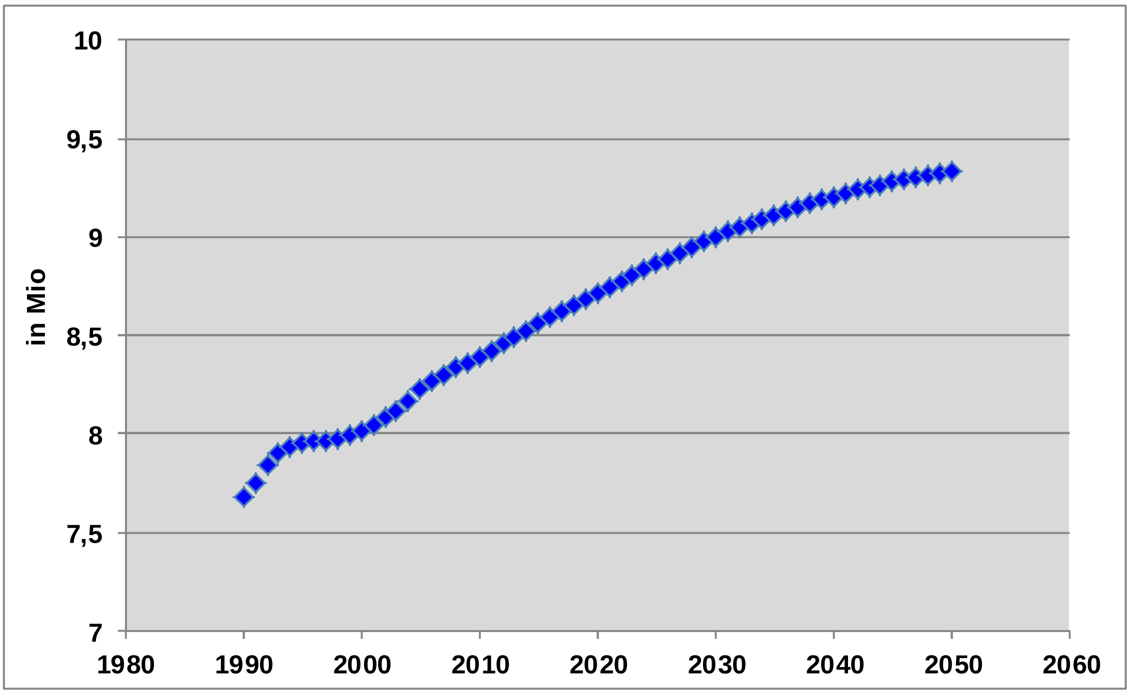

Figure 35: Population development in Austria since 1990 (Statistics Austria, 2013)

The growth of the Austrian population follows a rather linear course during the next two decades with an annual growth rate of some 30.000 inhabitants. However, from the first half of the 2030-ies on, a slight but steady decline of the annual increase rate is expected. The Austrian share in the EU-Population has been very slightly increasing from 1.63% in 1990 to 1.68% in 2015.

To characterise nutrition habits, a comparison is given between Austria and EU-27 based on per capita consumption for various agricultural products.

Austrian people largely show similar nutrition habits to EU people in general. The Austrian per capita consumption is lower for wheat - both netto consumption (Fig 37) and brutto consumption (2000-2010 628 kt, 2015 736 kt, including equivalents for not edible by-products such as e.g. bran) - and for potatoes but higher for coarse grains and pork. Austrian consumption increased for wheat, coarse grains and a bit also for poultry meat and decreased slightly for sugar and red meats since 2000. The total per capita demand of meat for purely human consumption is about 66.6 kg per year in Austria. For EU-27 the respective figures are with 64.9 kg (2000-2010) and 63.0 kg (2015) rather similar.The global per capita consumption of meat is much lower and lies at some points at 33.8 kg (OECD, 2011a). Furthermore, for Austria the whole domestic use of meat per capita, including the proportion for bones, losses on transport and meat used for pet feed, is even up to 100 kg per capita since the midth of the 1990-thies (Elmadfa, 2012).

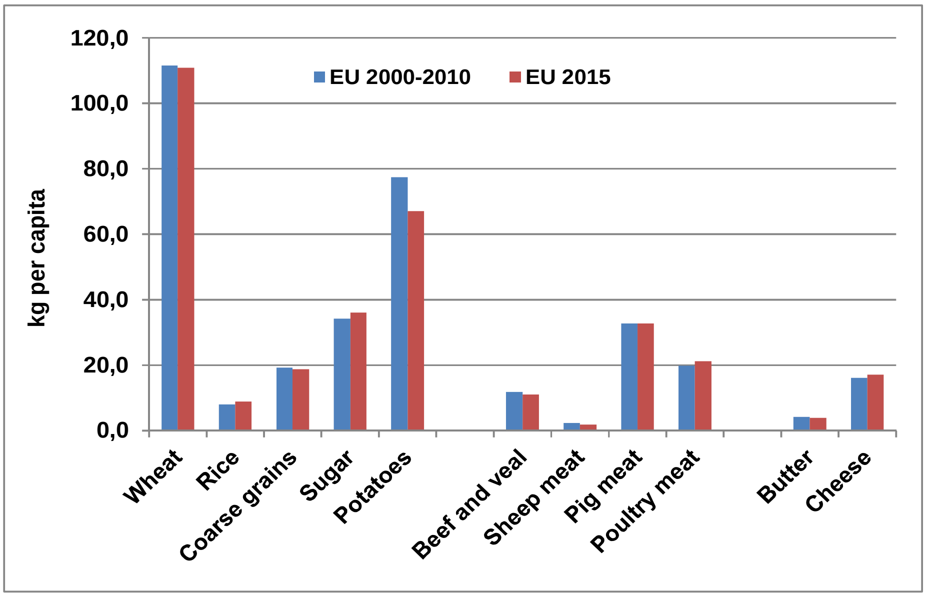

Figure 36: Per capita consumption of some selected commodities in the EU-27 (OECD, 2011a)

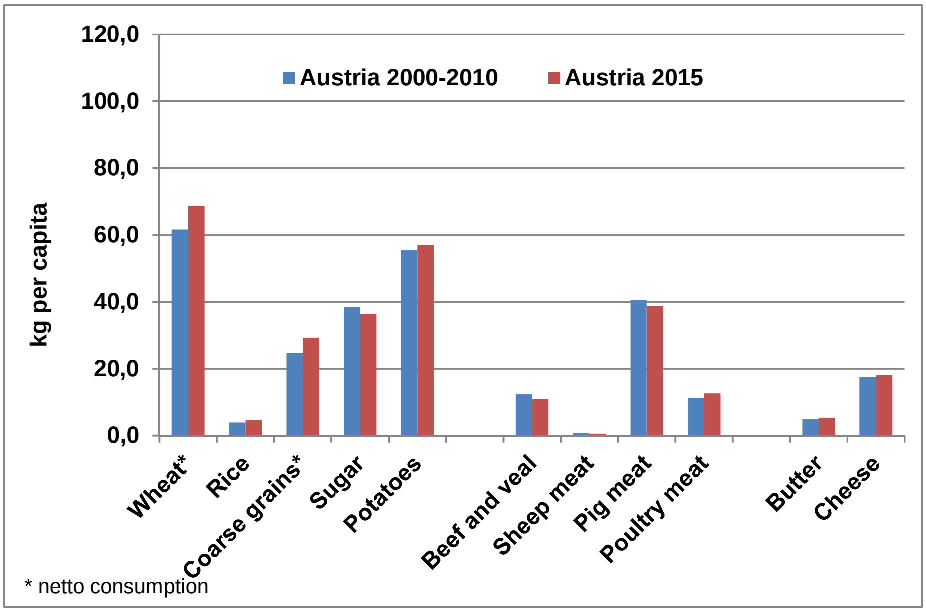

Figure 37: Per capita consumption of some selected commodities in Austria (Statistics Austria (2012b) and 2015-forecasts)

4.3. Agricultural production and consumption in 2015

Author: AGES: Klemens Mechtler

Currently 1,371,000 hectares (BMLFUW, 2013a) or 47.6% of the Austrian agricultural acreage account for arable land. However, as already seen in EU-27, arable land is subjected to an annual decline in Austria, too, and is shrinking with about 2,500 hectares or -1.8% per year since the 1990-ties. Agricultural acreage is sealed due to enlargement of settlements, cities, road and highway constructions and used for other land consuming projects and plans such as sand and gravel extractions or golf courses. One should be aware that mostly flat, arable and fertile areas are affected by these extensions, especially in case of valley plains along large rivers.

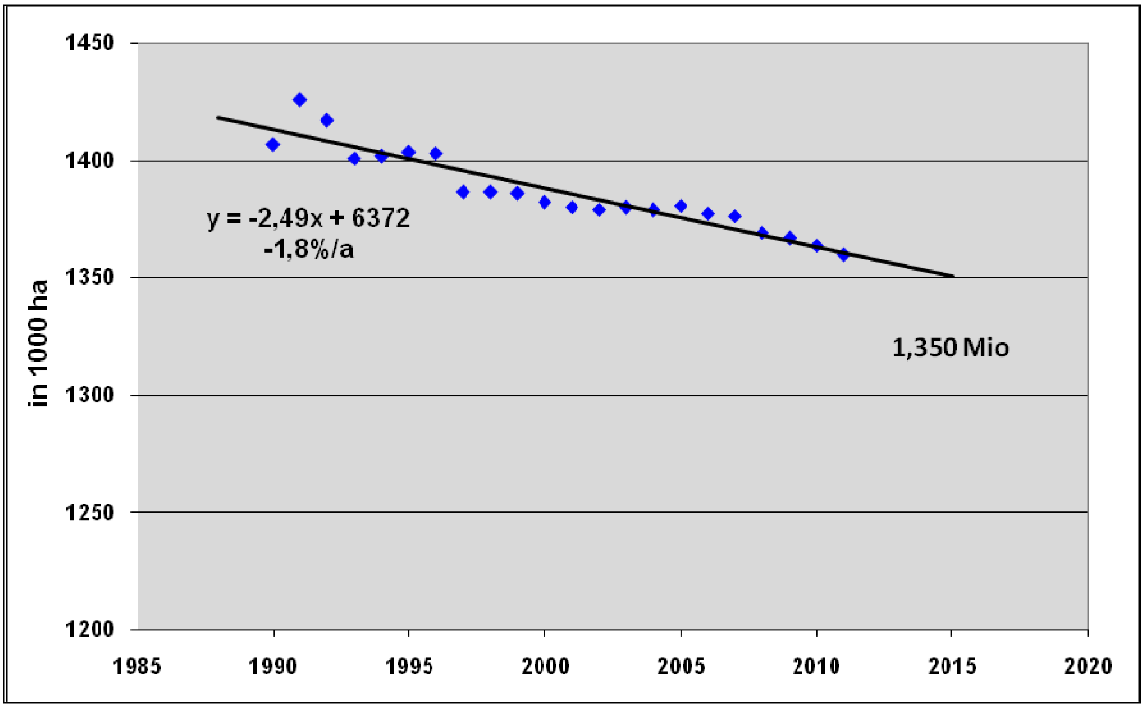

Figure 38: Development of arable land in Austria since 1990 (Statistics Austria, 2012)

Following the trendline of the last two decades the total amount of arable land is expected at 1.35 Mio ha in 2015. Figure 38 shows the respective areas for the different crop species, as given by the Austrian forecasts for 2015 based on the shares of the EU-crop areas. In order to show an area distribution referring to the whole arable acreage fallow land, forage and other crops have been considered in this figure, too. The crops included in the further considerations cover 1,040,000 ha or 77% of arable land.

Thus, in winter of 2015, wheat and oil crops, especially soybeans, show rising growing areas whereas protein crops and fallow land will be reduced in comparison to the mean value of 2000-2010 (Figure 39).

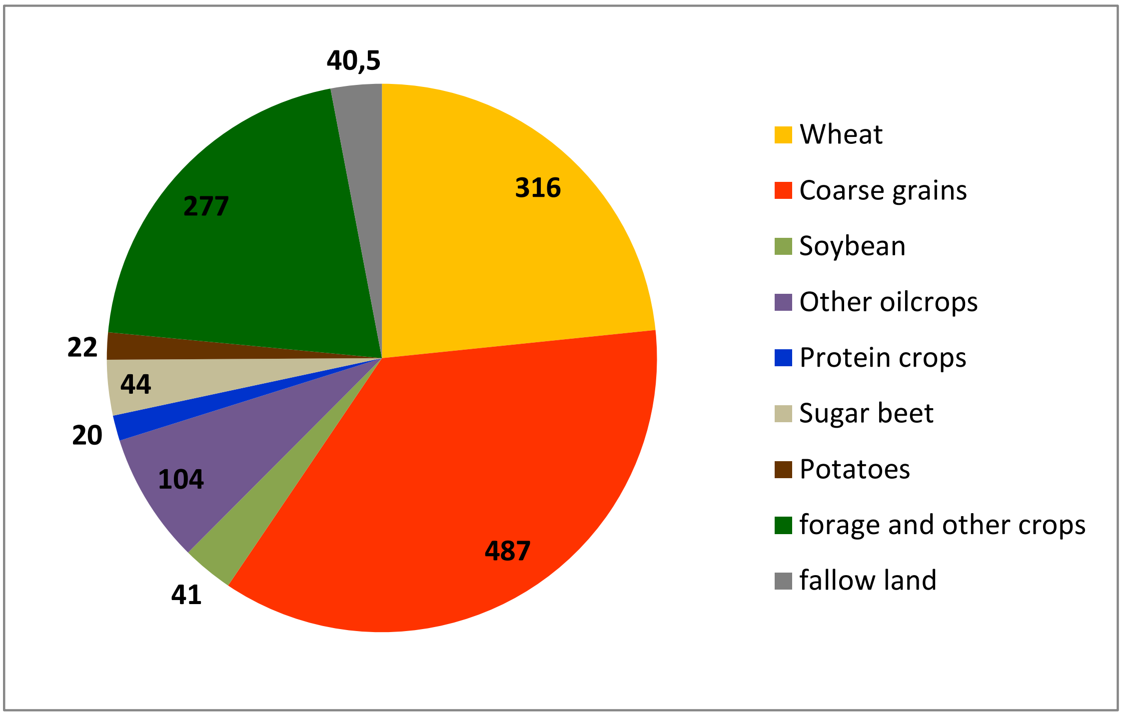

Figure 39: Cultivation areas of crop species on arable land in 2015 (1,000 ha)

Note: For 2015 fallow land was assumed to be 3% as it was approximately given in 2009 to 2011 (BMLFUW, 2013a13), the acreage for forage and other crops is the remaining difference to 1,350 Mio ha.

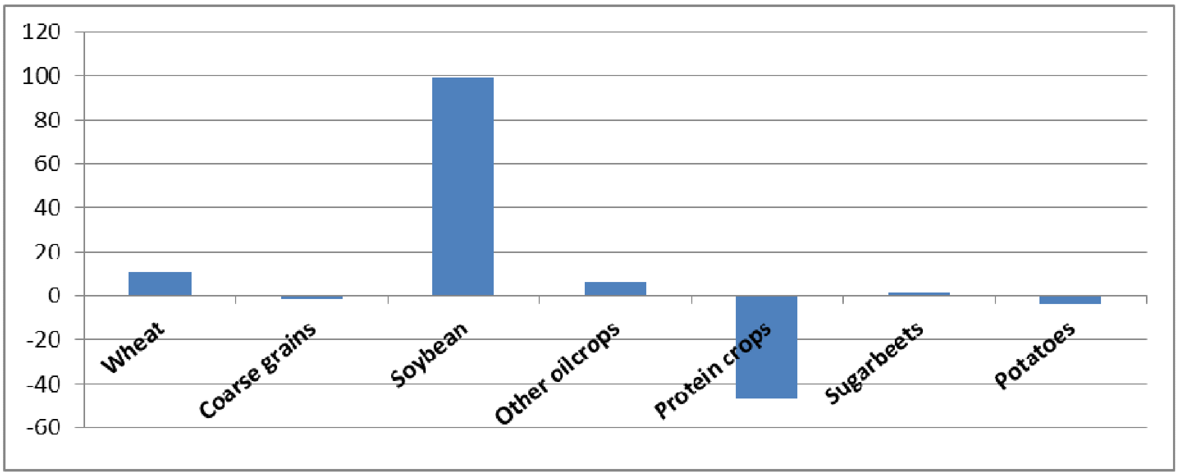

Figure 40: Relative changes of crop areas expected for 2015 compared to mean 2000-2010

Volume is expected to increase for wheat area and production in comparison to the mean of 2000-2010 by some 10%. The group of coarse grains is dominated by maize (around 45%) and the gains in yield performance of this crop result in a relevant higher production volume in 2015 at an almost unchanged acreage (Table 11). Since 2000 spring barley area has been reduced in half mainly in support of corn production. For wheat the higher domestic demand is caused by continuously increasing food use and abruptly and substantially higher amounts of industrial use since starting the production of bioethanol at site Pischelsdorf in 2008. The actual processing capacity is up to 620.000 t of different cereals (mainly maize and wheat but also triticale) with 190,000 t bioethanol and 190,000 t DDGS (= Distiller`s Dried Grains with Solubles) (Agrana, 2009). In 2011 and 2012

171,000 tons bioethanol have been produced in Austria (BMLFUW, 2013b). Furthermore industrial processing of wheat on this site has been expanded to a wheat starch production line in June 2013 with a capacity of 250,000 t wheat per year (Simak, 2013).

Among coarse grains domestic use has also been accelerated by the extended capacities for production of maize starch and derived products (Aschach, Pernhofen) as well as of bioethanol (see above). In the meantime the industrial use of maize is accounting for more than 1.1 million tons per year (AMA, 2013).

Among oil crops canola has established a growing level of 50,000-60,000 ha since 2005. Most marked changes are given for soybean cultivation. Since 2007, soybeans show an annually increasing cultivation due to higher outlets in food production.

Table 11: Production and consumption of plant products in Austria

Source: Statistics Austria (2012b) and 2015-forecasts)

Plant products	Mean 2000-2010 (1000 t)	2015 (1000 t)	Delta 2015 %rel
Production			
Wheat	1,468	1,682	14.6
Coarse grains	3,377	3,830	13.4
Soybean	53	115	116.4
Other oil crops	221	245	10.8
Oilseed meals	192[11]	269	39.7
Protein crops	94	41	-56.8
Vegetable oils	17	176	19.7
Sugar	432	449	3.9
Starch crops	688	711	3.4
Fruits	783[12]	828[13]	5.7
Vegetables	625[12]	631[14]	1.0
Consumption			
Wheat	1,191	1,606	34.8%
Rice	38	43	13.4%

[11] FEDIOL (2012)

[12] Mean 2000-2009, data extraction from fruit supply balances Austria before revision of fruits data of nonprofit orchards and fruit trees scattered in the landscape in 2012

[13] Mean 2007-2009 assumed as 2015 value, data extraction from fruit supply balances Austria before revision of fruits data of nonprofit orchards and fruit trees scattered in the landscape in 2012

[14] Mean 2007-2009 assumed as 2015 value

Coarse grains	3,764	4,065	8.0%
Soybean	74	135	81.6%
Other oil crops	416	639	53.8%
Oilseed meals	673[15]	674	4.7%
Protein crops	94	64	-32.5%
Vegetable oils	307	435	41.9%
Sugar	319	325	1.7%
Starch crops	762	760	-0.2%
Fruits	1,213[12]	1,251[13]	3.1%
Vegetables	1,032[12]	1,071[14]	3.7%

Soya production in Austria is supported by the need for GMO-free soya-lots for domestic processors and farmers, the increased awareness of dependency on oversea protein meal markets and last but not least by the high demand for soybean and soybean products in the world market. Thus in Austria soybean is more likely to be seen as a protein delivering plant than an oil crop.

Despite doubled area, soybean cropping accounts for only 3.0% of the arable land. Further protein crops in Austria such as peas and faba beans are cultivated to an even lower extent. Especially field peas have been cropped on a shrinking area during the last decade due to yield risks and lack of market position.

Consumption including food, feed, seed, industrial use and losses have increased sharply during the last decade for wheat, soybean, other oil crops and vegetable oils.

The national demand for oilseeds and vegetable oils was rising significantly during the 2000 to 2010, mainly due to increasing food use, especially industrial use of bio fuels. Production of biodiesel was 122,000 t in 2006 and is already above 250,000 t since 2008. Furthermore the whole production capacity of 14 Austrian production sites is nearly up to 650,000 tons (ARGE Biokraft, 2012). On the contrary, Austrian consumption of sugar and potatoes remained comparatively unchanged during this period. For fruits and vegetables a little higher consumption can be expected, respectively for vegetables driven by a 70% increase in the per capita consumption of tomatoes and carrots.

[15] Consumption of oilseed meals set equivalent to respective feed

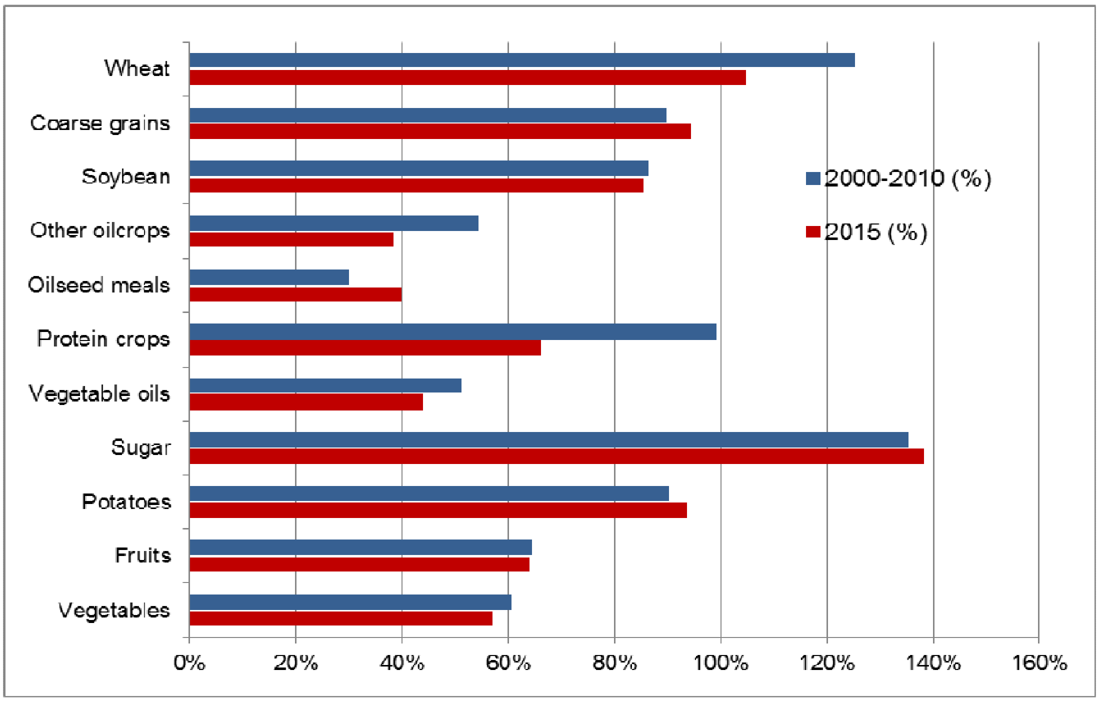

Figure 41: Self-sufficiency rates for plant products mean 2000-2010 and 2015 (%)

Source: Statistics Austria (2012b) and 2015-forecasts)

Self-sufficiency rates will decrease in 2015 for wheat, other oil crops and vegetable oils in the context of the higher needs of these commodities for industrial use. Supply rate of sugar will remain on a very high level. Similarly, no remarkable changes are expected for the supply rates with Austrian potatoes, fruits and vegetables.

Production data for animal products in Table 10 refer to brutto production of slaughter weight. Imports and exports of living animals intended for slaughter are therefore not yet included. Consumption data is comprised of food use, pet feed, losses and waste. As can be seen on supply balances shares for direct human food vary between 60% to 70% depending on the kind of meat.

Small decreases in beef and veal production and a more marked decline in consumption are expected for 2015, thus rising the self-sufficiency rate further up to 153%. Exports of beef and veal have already doubled from 2000 to 2010, though cattle numbers are slightly shrinking for bulls as well as for cows. For the other meat species and animal products, figures mostly show a similar increase in production and consumption up to 2015, especially for poultry meat, eggs and cheese, thus the supply rates remain almost unchanged. As for butter, the increase in consumption is covered by higher imports resulting in a lowered self-sufficiency rate.

Table 12: Production and consumption of animal products in Austria

Source: Statistics Austria (2012b) and 2015-forecasts)

Animal Products	**Mean 2000-2010 (1000 t)**	**2015 (1000 t)**	**Delta 2015 %rel**
Production			
Beef and veal	218	216	-1.2%
Sheep meet	8	6	-16.6%
Pork	483	505	4.5%
Poultry meat	114	132	15.3%
Eggs	96	101	6.2%
Fish	3.1	2.9	-3.8%
Raw milk	3,232	3,265	1.0%
Butter	34	32	-4.0%
Cheese	147	167	14.1%
Consumption			
Beef and veal	151	141	-6.8%
Sheep meat	10	9	-10.4%
Pork	471	479	1.7%
Poultry meat	156	183	17.1%
Eggs	120	133	11.0%
Fish	58	93	61.4%
Raw milk	3,232	3,265	1.0%
Butter	43	51	20.1%
Cheese	158	176	11.5%

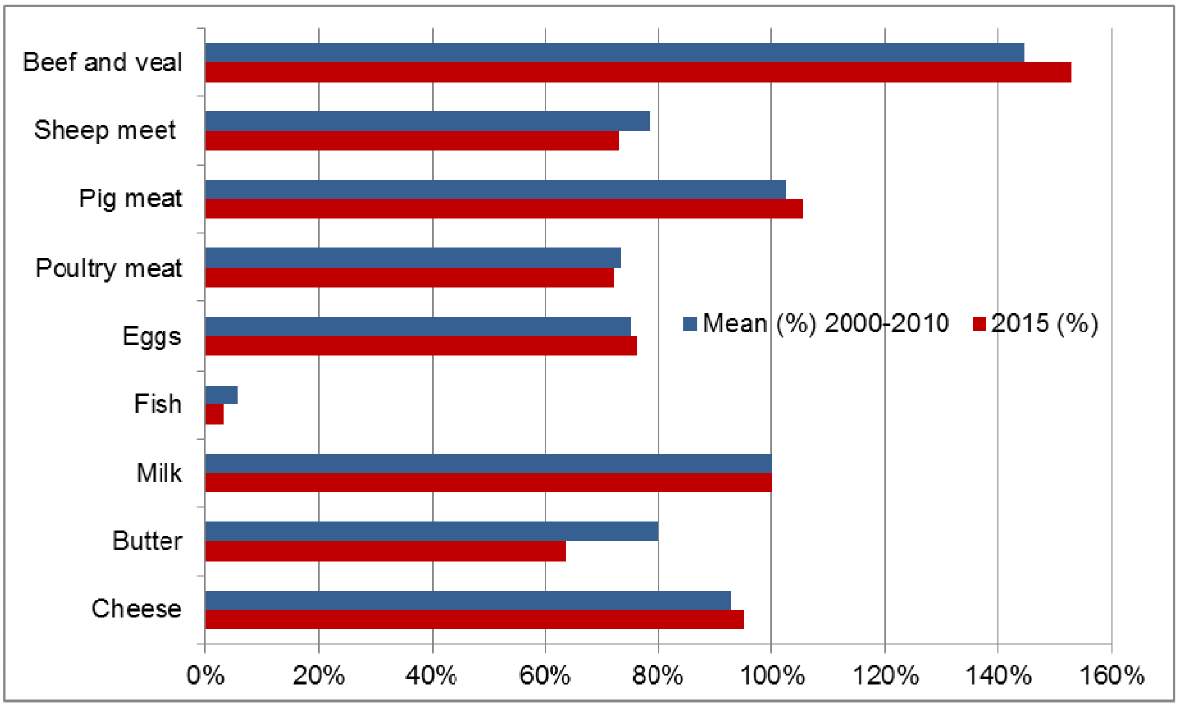

Figure 42: Self-sufficiency rates for animal products, mean 2000-2010 and 2015 (%)

Source: Statistics Austria (2012b) and 2015-forecasts)

The protein component in oil seed meals is essential for Austrian pig and poultry feeding. In spite of the succesful raising of the supply rate for oil seed meals by reinforced domestic oil plant production, the protein supply situation remains neuralgic. Consequently, the good or at least relevant self-sufficiency levels for pork and poultry meat are more or less superficial and very sensible to shortages of the protein supply from abroad.

5. Global and Austrian Specific Supply Risks

Authors: PLUS: Friedrich Steinhäusler, Lukas Pichelstorfer

Within this chapter (WP 2) the objective is the identification, description and assessment of political and socio-economic threats of exporting regions relevant for feed, food and energy supply of Austria. In view of its membership in the European Union, all EU Member States exporting feed, food or energy to Austria are considered stable trading partners and therefore excluded from this analysis. Furthermore, WP 2 takes into consideration the resilience of the food and feed supply from global markets on a political and socio- economic basis.

5.1. Discription of the current situation

The price of food started rising significantly in late 2006. This price increase continued in 2007 and reached its maximum value in 2008. As a result, millions of people living at or near the poverty line in urban areas could no longer afford to purchase their daily food. As one of the consequences riots over affordable food occurred in several countries, e.g., Haiti and Mozambique. On the other hand 70% of poor people are living in rural areas, mainly working in agriculture or are dependent on agriculture[16]. Rising agricultural prices could help to overcome poverty in rural areas. High farm gate prices would enable investments into agriculture and enhance productivity. So far higher agricultural prices did not arrive at farm gates in many regions due to inappropriate agricultural and distribution policies. In any way, the increase in food prices worldwide has attracted the attention of political decision makers with regard to its relationship with national food security, since it raises several questions bordering on national security.

At the World Food Summit in 1996, the international community agreed that food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for a healthy and active life. In this report the term food security adheres to this definition, i.e. it is the capability of a country to produce food sufficient for the needs and demands of its population. If this food supply meets both energy and nutritional requirements of the population, the country is termed as food sovereign.

This report analyses the extent to which the Republic of Austria would be threatened in its national food sovereignty due to climatic changes, irrespective of the source of the food,

[16] Prowse M. and Chimhowu A. (2007): Making agriculture work for the poor. Natural Resource Perspectives, Overseas Development Institute.

i.e., domestically produced or imported from other countries. In this context the issue of animal feed, as well as fertilizer and energy required for maintaining a certain level of food production, will also be analysed. In view of the complexity of effects induced by climate change it is essential to analyse its impact on food security as an interrelationship between energy supply and affordability, access to water and its adequate distribution, and access to fertilizer.

5.1.1. Objectives of the Work Package

WP 2 has the objectives of identification, description and assessment of political and socio- economic threats of exporting regions relevant for feed, food and energy supply of Austria. In view of its membership in the European Union, all EU Member States exporting feed, food or energy to Austria are considered stable trading partners and therefore excluded from this analysis. Furthermore, WP 2 takes into consideration the resilience of the food and feed supply from global markets on a political and socio- economic basis.

5.1.2. WP Content

WP 2 has two main components:

- Identification, description and assessment of political threats relevant for feed, food and energy supply to Austria caused by climate change and potential military conflicts
- Identification, description and assessment of socio-economic threats relevant for feed, food and energy supply to Austria.

Results of assessmenst (expressed as National Resilience) are presented in the following pages. National Resilience Levels are assessed by using a combination of various indices, based on a wide spectrum of parameters. These parameters describe the current situation in quantitative manner, using arbitrary units.

Methodology used is described in detail in Chapter 14.2 (Appendix).

5.1.3. Austrian Dependency on Imports

Table 13 shows the importance of the different product groups for nourishing the Austrian population (8.56 Mio people in 2015, Statistics Austria, 2011). The quantities of demand in the different product groups have also been randomized into protein and energy units for an appropriate comparability of the different items.

Table 13: %ages for the different product groups in the nourishment of the Austrian people, calculated for 2015 on basis of trends in populations growth and nutrition during 2000 to 2009

Item	Demand (%)	Protein (%)	Energy (%)
Wheat	10.8	21.1	21.6
Coarse grains	4.4	6.8	8.6
Oil seeds	0.6	2.4	1.6
Soybean	0.3	1.5	0.6
Sugar	5.8	0.0	12.6
Potatoe	9.0	3.2	4.3
Vegetable oils	2.3	0.0	11.6
Vegetables	17.9	3.4	2.0
Fruits	16.5	2.2	5.4
Bovine and veal	1.9	6.1	1.9
Sheep meat	0.1	0.3	0.1
Pork	6.2	15.4	11.4
Poultry meat	2.0	6.5	2.0
Milk	14.6	7.8	5.1
Butter	0.8	0.1	3.3
Cheese	3.1	14.1	5.3
Eggs	2.3	4.8	1.9
Fish	1.5	4.5	0.7
	100	100	100

Within the selected plant products wheat and coarse grains (maize, rye, triticale, barley, oat, millet) and within the animal products group pork, milk and cheese, are the main sources for protein and energy in general Austrian diet. Table 13 demonstrates that self-sufficiency rates are rather high for these product groups - also taking into account further findings from literature analysis in WP 1 and aims to serve as a basic background for the following Work Packages.

The following Tables 14 and 15 take major findings of literature search from WP 1 into account and aims to serve as a basic background for the next Work Packages.

Table 14: EU 27 self-sufficiency rate for different products

Item	EU27 Self sufficiency rate (in%)	Source
Wheat	117.91	OECD-FAO (2011)
Rice	62.82	OECD-FAO (2011)
Course grains	92.95	OECD-FAO (2011)
Oil Seeds	64.25	OECD-FAO (2011)
Soybean		n.a. (2011)
Soybean meal	2.5	Fefac (2011)
Protein meals	48.92	OECD-FAO (2011)
Vegetable Oils	59.04	OECD-FAO (2011)
Sugar	79.47	OECD-FAO (2011)
Beef and veal	98	OECD-FAO (2011)
Sheepmeat	77.61	OECD-FAO (2011)
Pork	109.41	OECD-FAO (2011)
Poultrymeat	101.60	OECD-FAO (2011)
Milk		n.a. (2011)
Butter	100.89	OECD-FAO (2011)
Cheese	106.49	OECD-FAO (2011)
Eggs	125.12	EUROSTAT (2011)
Fish		n.a. (2011)
Vegetables		n.a. (2011)
Potatoes	183.16	FAOSTAT (2011)
Fruits		n.a. (2011)
Biofuels	82.96	EUROSTAT (2011)
Crude oil	15.60	EUROSTAT (2011)
Gas	36.72	EUROSTAT (2011)
Energy	47.70	EUROSTAT (2011)
Essential amino acids		n.a. (2011)
Vitamins		n.a. 2011)

Table 15: Austria self-sufficiency rate for different products

Item	AUSTRIAN SELF-SUFFICIENCY RATE (in%)	Source
Wheat	101	Statistics Austria, 2011
Course grains	89	Statistics Austria, 2011
Oil Seeds	49	Statistics Austria, 2011
Soybean	59	Statistics Austria, 2011
Vegetable Oils	27	Statistics Austria, 2011
Sugar	123	Statistics Austria, 2011
Beef and veal	145	Statistics Austria, 2011
Sheepmeat	73	Statistics Austria, 2011
Pork	108	Statistics Austria, 2011
Poultrymeat	73	Statistics Austria, 2011
Milk	100	Statistics Austria, 2011
Butter	71	Statistics Austria, 2011
Cheese	94	Statistics Austria, 2011
Eggs	75	Statistics Austria, 2011
Fish	5	Statistics Austria, 2011
Vegetables	60	Statistics Austria, 2011
Potatoes	83	Statistics Austria, 2011
Fruits	69	Statistics Austria, 2011
Biofuels	55	EUROSTAT, 2011
Crude oil	8	Statistics Austria, 2011
Gas	20	Statistics Austria, 2011
Energy	36	Statistics Austria, 2011
Soybean meal	<10	AGES, 2011
Essential amino acids	0	AGES, 2011
Vitamins	0	AGES, 2011

Calculation of Austrian self sufficiency rates for plants and animals in 2015, including changes in population (+0.4%/a) and in agricultural production, (actual capacities for industrial use, decrease in arable land) based on trend analysis and expert assessment gave quite similar figures, but with higher rates for sugar (140%) and soybean (in kernels, 78%) due to expected enlargement of crop area, when compared with those in 2010.

Currently Austria compensates for deficits in self-sufficiency by importing feed, food and energy from several EU member states and non-EU countries. Table 16 lists the items Austria is dependent as non-EU imports, together with the main countries serving as exporters to Austria at present.

Table 16: Main non-EU exporters of feed, food and energy to Austria

Item	Main exporter
Crude oil	Libya, Kasachstan, Nigeria
Diesel	Russia, Venezuela
Natural gas	Norway, Russia
Soya	Argentina, Brazil, USA
Phosphate	Algeria, Jordan, Morocco, Syria
Bananas	Columbia, Costa Rica, Ecuador
Vitamins, pesticides, essential amino acids	China (P.R.), India, Japan, Switzerland, USA

The starting point for WP 2 is the analysis of Austria's dependencies on imports of feed-, food- and energy- related items derived from WP 1. Most imports in the food and feed sector originate in EU-member states. However, there are severe dependencies especially in the energy and fertilizer sector.

Energy: crude oil, diesel, natural gas
Inputs: phosphate, potassium, pesticides, vitamins, essential amino acids
Food: bananas
Feed: soy

5.1.4. Social Resilience of Exporters to Austria

For the main exporters of feed, food and energy to Austria an analysis was carried out to determine their resilience against social unrest caused by economic difficulties (*Social Resilience; SR*).[17] The working hypothesis assumes that a country with a high Social Resilience is less likely to experience social unrest and therefore more likely to represent a reliable partner, enabling it to continue its exports of feed, food and energy to Austria even in times of crisis. The methodological details for the assessment of the national Social Resilience are described in the *Appendix*.

The *SR* value is determined for each country that serves as a key supplier of products essential for Austrian feed, food or energy supply. The numerical value assigned ranges from 1 to 5, i.e. Social Resilience equal 1 represents the highest and 5 represents the lowest resilience.

[17] It is assumed that a Member State of the European Union will fulfill its obligations in all cases, i.e. *Social Resilience* = 1. Therefore, none of the EU member states exporting feed, food or energy to Austria were subject of this analysis.

The results of the assessment of the Social Resilience for these main exporters are shown in Table 17. The lower the SR Index, the higher the probability for this country to remain a reliable exporter to Austria.

Table 17: Social Resilience for the main countries exporting feed, food and energy to Austria

Country	LS	ED	HE	LW	SR[18]
Argentina	3	3	3	4	3.3
Belorussia	5	2	3	4	3.5
Brazil	3	4	4	4	3.8
China (P. R.)	3	4	4	4	3.8
Columbia	4	4	4	4	4.0
Costa Rica	-	4	3	4	3.7
Ecuador	-	5	4	4	4.3
India	4	4	5	5	4.5
Japan	2	2	1	1	1.5
Jordan	4	4	4	5	4.3
Libya	-	3	5	4	4.0
Kazakhstan	-	4	5	4	4.3
Morocco	4	4	5	5	4.5
Nigeria	3	5	5	5	4.5
Norway	1	1	1	1	1.0
Russia	4	2	4	4	3.5
Switzerland	1	2	1	1	1.3
Syria	-	5	4	5	4.7
United States (USA)	1	1	2	2	1.5
Venezuela	2	4	4	4	3.5

Where:

LS … Life Style Index
ED …Education Index
HE …Health Index
LW …Labour & Wealth Index
SR …Social Resilience Index (SR = 1 denotes the most stable exporter; SR = 5 denotes the least stable exporter).

[18] Rounded off value

The main exporting countries of feed, food or energy to Austria fall into three categories in terms of *Social Resilience* (SR):

SR < 2: Japan, Switzerland and the USA can be considered as highly resistant to social unrest, potentially interrupting export of feed, food or energy to Austria. Any such interruption is highly unlikely.

SR < 4: Argentina, Belorussia, Brazil, China (P. R.), Costa Rica, Russia and Venezuela are countries of medium Social Resilience and may experience limited social unrest with some negative consequences. However, these are probably only of limited duration before exports of feed, food or energy to Austria would resume again.

SR >= 4: Columbia, Ecuador, India, Jordan, Libya, Kazakhstan, Morocco, Nigeria and Syria should be viewed as highly vulnerable to social unrest. In view of the rather large possible negative consequences the disruption of exports of feed, food or energy to Austria for an undefined time period is more probable than not.

5.1.5. Political Resilience of and Military Threats to Exporters of Food-, Feed- and Energy to Austria

For the main exporters of feed, food and energy to Austria, an analysis was carried out to determine their resilience against political instability (*Political Resilience; PR*) and potential military threats.[19] The working hypothesis assumes that a country with a high Political Resilience is less likely to change its export policy towards Austria and therefore is more likely to represent a reliable partner, enabling it to continue its exports to Austria of feed, food and energy also in times of political crisis. A significant additional factor influencing the immediate political stability of the exporting countries is the issue of potential military threats exporters may be facing in the near term.

The methodological details for the assessment of the national Political Resilience are described in the *Appendix.*The country-specific *Political Resilience* (PR) is defined as the aggregate of the following indices:

- Governance Index
- Corruption Perception Index
- Failed State Index
- Economic Freedom Index.

The *PR* is determined for each country which is a key supplier of products essential for Austrian feed, food or energy supply. The numerical value assigned ranges from 1 to 5,

[19] It is assumed that a Member State of the European Union is not threatened by military actions and will comply with its export obligations to Austria in any case, i.e. *Political Resilience* = 1. Therefore, none of the EU member states exporting feed, food or energy to Austria were subject of this analysis.

i.e. Political Resilience equal 1 represents the highest and 5 represents the lowest resilience.

The results of the assessment of the Political Resilience for these main exporters are shown in Table 18. The lower the PR Index, the higher the probability for this country to remain a reliable exporter to Austria.

Table 18: Political Resilience for the main countries exporting feed, food and energy to Austria

Country	GI	CPI	FSI	EFI	PR
Argentina	42+/-11	105/178	145	138/51.7	3
Belorussia	18+/-13	127/178	83	155/47.9	4
Brazil	57+/-5	69/178	123	113/56.3	3
China (P. R.)	35+/-19	78/178	72	135/52.0	2
Columbia	43+/-19	78/178	44	45/68	3
Costa Rica	70+/-6	41/178	137	49/67.3	2
Ecuador	23+/-11	127/178	62	148/47.1	4
India	43+/-18	87/178	76	124/54,6	3
Japan	85+/-6	17/178	164	20/72.8	1
Jordan	49+/-15	50/178	96	38/68.9	3
Libya	15+/-14	146/178	111	173/38.6	5
Kazakhstan	35+/-18	105/178	107	78/62.1	2
Morocco	43+/-12	85/178	87	93/59.6	3
Nigeria	15+/-9	134/178	14	111/56.7	4
Norway	93+/-3	10/178	176	30/70.3	1
Russia	25+/-12	164	82	143/50.5	3
Switzerland	94+/-3	8/178	174	5/81.9	1
Syria	22+/-12	127/178	48	140/51.3	4
United States (USA)	85+/-14	22/178	148	9/77.8	2
Venezuela	10+/-8	164/178	80	175/37.6	4

GI Governance Indicator
CPI Corruption Perception Index
FSI Failed State Index
EFI Economic Freedom Index
PR National Political Resilience

5.1.6. National Resilience of Exporters of Food-, Feed- and Energy to Austria

NR is defined as the arithmetic average of the national Political Resilience (PR) and the national Social Resilience (SR), taking into account the Self Sufficiency Index (SSI). The lower the NR value, the higher the resistance of that country against disturbances in the supply of a given item.

NR<2: Countries featuring a National Resilience Level lower than 2 can be considered highly reliable trading partners. Unforeseen interruptions in supply of food, feed or energy are very unlikely.

NR<4: Describes countries of medium National Resilience. Imports from these countries may be interrupted for limited duration before they resume again normally.

NR≥4: These countries should be viewed as highly vulnerable. In view of the rather large possible negative consequences due to additional stress, the disruption of exports for an undefined time period is more probable than not.

Note that the NR is rather a tool for relating various trading partners to each other than an absolute risk assessment.

More information on the evaluation of the NR and numerical values for PR and SR can be found in the Appendix.

The *National Resilience* (NR) is derived from the application of equation Table A 14.2.2/A (Appendix). The tables below contain the NR score for key suppliers of feed, food and energy to Austria.

Table 19: National Resilience Score with regard to crude oil for Austria's key suppliers

Country	Political Resilience (PR)	Social Resilience (SR)	Self Sufficiency Index (SSI)	Resilience Score (NR)
Libya	5	3	0	**4**
Kazakhstan	2	3.3	0	**3**
Nigeria	4	4.5	0	**4**

Table 20: National Resilience Score with regard to natural gas for Austria's key suppliers

Country	Political Resilience (PR)	Social Resilience (SR)	Self Sufficiency Index (SSI)	Resilience Score (NR)
Norway	1	1	0	**1**
Russia	3	3.5	0	**3**

Table 21: National Resilience Score with regard to diesel fuel for Austria's key suppliers

Country	Political Resilience (PR)	Social Resilience (SR)	Self Sufficiency Index (SSI)	Resilience Score (NR)
Russia	3	3.5	0	**3**
Venezuela	4	3.5	0	**4**

Table 22: National Resilience Score with regard to potassium for Austria's key suppliers

Country	Political Resilience (PR)	Social Resilience (SR)	Self Sufficiency Index (SSI)	Resilience Score (NR)
Belorussia	4	3.5	0	**4**
Russia	3	3.5	0	**3**

Table 23: National Resilience Score with regard to phospate for Austria's key suppliers

Country	Political Resilience (PR)	Social Resilience (SR)	Self Sufficiency Index (SSI)	Resilience Score (NR)
Jordan	3	4.3	0	**4**
Morocco	3	4.5	0	**4**
Syria	4	4.7	0	**4**

Table 24: National Resilience Score with regard to soy for Austria's key suppliers

Country	Political Resilience (PR)	Social Resilience (SR)	Self Sufficiency Index (SSI)	Resilience Score (NR)
Argentina	3	3.3	1	**4**
Brazil	3	3.8	0	**3**
USA	2	1.5	0	**2**

Table 25: National Resilience Score with regard to vitamins and essential amino acids for Austria's key suppliers

Country	Political Resilience (PR)	Social Resilience (SR)	Self Sufficiency Index (SSI)	Resilience Score (NR)
China	2	3.8	0	**3**
Japan	1	1.5	0	**1**
USA	2	1.5	0	**2**

Table 26: National Resilience Score with regard to bananas for Austria's key suppliers

Country	Political Resilience (PR)	Social Resilience (SR)	Self Sufficiency Index (SSI)	Resilience Score (NR)
Columbia	3	4.0	0	**4**
Costa Rica	2	3.7	0	**3**
Ecuador	4	4.3	0	**4**

Table 27: National Resilience Score with regard to pesticides for Austria's key suppliers

Country	Political Resilience (PR)	Social Resilience (SR)	Self Sufficiency Index (SSI)	Resilience Score (NR)
China (PR)	2	3.8	1	**4**
India	3	4.5	0	**4**

5.1.7. Threats to Energy Exporters to Austria

Author: ÖVAF: Martin Weigl

The amount of crude oil and natural gas available worldwide is limited.

Global *crude oil* production is estimated to 'peak' within the next decade. The term *Peak Oil* refers to the maximum rate of the production of oil in any area under consideration, recognizing that it is a finite natural resource. Once the peak value has been reached, subsequently production is likely to go into sustained decline. The International Energy Agency (IAE) views the situation as follows, "*The age of cheap energy is over. The only question now is, will the extra rent from dearer energy go to an ever smaller circle of producers, or will it be directed back into the domestic economies of the consumers, with the added benefits of increased environmental sustainability?*"[20] If by 2015 Iraqi production does not increase exponentially, global oil supply will face a major problem, even if Saudi Arabia fulfils its promises to compensate for any such lack of oil, since the gap between supply and demand will widen significantly.[21] This will cause significant increases in energy prices, including diesel and natural gas, with subsequent price increases for the food production industry.

[20] Tanaky, Mr. (2011): Speech by Mr Tanaka at the Bridge Forum Dialogue in Luxembourg (ref.: IEA: The age of cheap energy is over, http://www.peakoil.net/ , last visited: 24 January 2012).

[21] Fatih, B. (2007): Chief Economist,International Energy Agency, in: Oil Depletion Analysis Centre (ODAC), Preparing for Peak Oil: Local Authorities and the Energy Crisis, http://www.peak-oil-forum.de/ (last visited: 24 January 2012).

5.1.7.1. Nexus Energy – Food Production

Food production requires energy in the production phase (e.g., fuel for farming machinery, fuel and gas for nitrogen fertilizer) and for delivery (e.g., lorry transport of either raw materials or finished food to shops).

Energy exports to Austria can be impeded by a wide variety of political problems threatening exporting countries and therefore indirectly posing a threat to Austria's access to crude oil, its derivates and natural gas, such as:

- Crude oil, diesel and gas shortages due to political reasons
- Exhausted resources
- Export restrictions
- Excessive population growth
- Economic instability
- Social riots
- Military conflict

The largest oil- and gas reserves are located in some of the least politically stable countries, predominantly in the Middle East and North Africa. A recent example of the impact of political instability on crude oil and gas supply was the war in Libya with NATO-protected insurgency leading to a regime change. The fighting in Libya, Africa's third-largest oil producing country, lead to the halting of output by several oil-industry companies for security reasons:

> Spain and Italy: Repsol and Eni shut down production.
>
> Austria: OMV expected "a temporary reduction" of its Libyan production and "cannot exclude a complete stop".
>
> Germany: BASF unit Wintershall halted output of as much as 100,000 bpd.
>
> UK, Netherlands: BP and Royal Dutch Shell removed staff
>
> France, USA: Schlumberger, the world's largest oilfield services company, shut down operations.

The price for crude oil reached a maximum value in 2008, when a barrel of oil cost US$ 147. As an example of the nexus between energy and food, subsequently the price of rice tripled in six months, in line with significant price increases of other food (Table 28).[22]

[22] Index Mundi, Rice Monthly Price - US Dollars per Metric Ton, http://www.indexmundi.com/commodities/?commodity=rice&months=60 (last visited: 24 January 2012).

Table 28: Price development of rice in 2008 (5% broken milled white rice, Thailand nominal price quote, US Dollars per Metric Ton; adapted from Index Mundi, Rice Monthly Price - US Dollars per Metric Ton)

Time	Jan 2008	Feb 2008	Mar 2008	Apr 2008	May 2008	Jun 2008	Jul 2008	Aug 2008	Sept 2008	Oct 2008	Nov 2008
Price	393.48	481.14	672.64	1,015.21	1,009.32	834.60	799.00	737.00	722.00	624.00	563.25
Change (in%)	4.10	22.28	39.80	50.93	-0.58	-17.31	-4.27	-7.76	-2.04	-13.57	-9.74

Multiple warning signals exist since the energy crises of 1973 and 1979 for exporting countries to use crude oil, its derivates and natural gas as a “weapon”. For example, the dispute between Russia and Ukraine caused shortages in the gas supply of Eastern and Central Europe for two weeks in 2009.[23] Austria’s dependence on foreign gas deliveries is significant: it currently imports gas from Russia, Germany and Norway, with Russia being its largest supplier.[24] The threat by Iran in January 2012 to close the Street of Hormuz in case of EU sanctions – and thereby impeding oil export from the Middle East - is a recent example for the threat of using oil as a weapon.[25] OPEC-and non-OPEC countries have done so in the past and can apply the same method – blackmailing customers with the intentional disruption of exports of crude oil and/or natural gas - again in the future.

Austrian energy security with regard to hydrocarbons in the immediate future is dependent on the exporting country’s domestic hydrocarbon production capacity and Austria’s ability to acquire second source energy imports in the event of an interruption from one or more suppliers. The following section analyses the Political Resilience and potential military threats of the main energy exporters to Austria.

5.1.7.2. Kazakhstan

The country has the second largest oil reserves and the second largest oil production among the former Soviet republics after Russia (1.54 million barrels per day (bbl/d),[26]. Kazakhstan has large reserves of natural gas, and production of both oil and gas is

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[23] Q&A: Russia-Ukraine gas row, BBC News, 20 January 2009; http://news.bbc.co.uk/2/hi/europe/7240462.stm (last visited: 24 January 2012).

[24] Russian Petroleum Investor (2009), Report: CIS Natural Gas- Outlook for International Impact

[25] Caitlin Talmadge, Closing Time: Assessing the Iranian Threat to the Strait of Hormuz, International Security, volume 33, issue 1, pages 82-117.

[26] US Energy Information Administration (November 2010): Kazakhstan http://205.254.135.7/countries/cab.cfm?fips=KZ (last visited: 14 January 2012).

steadily increasing.[27] It is the declared political target to become one the world's top oil exporters in the next decade, based on the development of three major oilfields. The national oil industry exported about 1.3 Mbbl/d light, sweet crude oil in 2009.[28] This delivery occurs mainly by (a) pipelines to the Black Sea via Russia; (b) barge and pipeline to the Mediterranean via Azerbaijan and Turkey; (c) barge and rail to Batumi, Georgia on the Black Sea; and (d) pipeline to China. This dependency on pipelines, and rail transport and barges through third countries (Azerbaijan, Georgia, Russia, Turkey) makes Kazakhstan vulnerable to external political pressure in order to maintain the transit rights. However, in the near future the probability of major upheaval is low, since (a) the president and his political party have secured another overwhelming victory in the last election in April 2011; (b) the country has continuously strengthened its political and economic ties with Russia (e.g., founding member of the Customs Union with Belarus and Russia since 2010; founding member - together with Russia - of the intergovernmental mutual-security organisation *Shanghai Cooperation Organisation* in 2001); (c) Kazakhstan has no open conflict with any of these countries.

National Resilience: 3

Conclusion: The probability of an unforeseen interruption of petroleum-based exports from Kazakhstan to Austria due to security threats is not significantly elevated at present.

5.1.7.3. Libya

Libya has the 10th-largest proven oil reserves of any country in the world and the 17th-highest petroleum production.[29] The country is an OPEC member and also holds the largest proven oil reserves in Africa, 6.60×109 m3 as of January 2007, up from 6.22×109 m3 in 2006. It is a net exporter of 240×10^3 m3/d (data from 2004) and depends primarily upon revenues from the petroleum sector. This income represents practically all export earnings and over half of GDP. Due to the small population this resulted in Libya having had the highest nominal per capita GDP in Africa [30] prior to the civil war fought between forces loyal to Colonel Muammar Gaddafi and those seeking regime change, initiated by protests in Benghazi on 15 February 2011. As of March 2011 Libya started being governed by the National Transitional Council (NTC).[31] Whether the claim by the NTC,

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[27] US Energy Information Administration, Kazakhstan, http://205.254.135.7/countries/country-data.cfm?fips=KZ (last visited: 24 January 2012).

[28] Mbbl = Megabarrel; 1 Barrel = 158.9873 Litre.

[29] OPEC Annual Statistical Bulletin, (2004), "World proven crude oil reserves by country, 1980–2004" (last visited: 10 January 2012).

[30] USD 12,062 as of 2010 (IMF estimate); rank 48 worldwide, followed by Equatorial Guinea with USD 11,081 on rank 51. World Economic Outlook Database, April 2011(last visited: 8 January 2012).

[31] http://en.wikipedia.org/wiki/Economy_of_Libya, http://en.wikipedia.org/wiki/Libya

issued as the de facto government in August 2011, that it will aim for dissolution and introduction of a representative legislature instead, will be fulfilled awaits to be seen. The NTC indicated further that countries, willing to offer recognition early, may receive more favorable oil contracts and trade deals.

Since the killing of Muamar Ghaddafi in August 2011 and the subsequent dissolution of the regular National Armed Forces, Libya faces the following security threats:

Civil War

Unlike Tunisia and Egypt, which had strong political parties and a strong civil society before the uprising, Libya has never had a single political party since Muamar Ghadafi took over power in 1969. After the killing of Muamar Gaddhafi political parties have started to appear on the political scene and civil society organizations have been formed. However, these parties are very weak. Libyan Islamists are constantly increasing the pressure in their demands for Muslim sharia law to shape the future national legislation. The Islamist group encompasses: (a) Members of the conservative *Muslim Brotherhood* and harder-line *Salafis*. Both parties support strict versions of Islam; (b) Moderates who prefer a civil state inspired by sharia. It is probable that the Muslim Brotherhood, the most organized political force, will emerge as the leading political party in Libya. On the other hand, there is a pronounced emergence of secular political parties after the fall of Gaddafi's dictatorship in 2011. The chairman of Libya's ruling NTC, Mustafa Abdul Jalil, had indicated already in October 2012 to uphold Islamic law. If reconciliation between these extremes cannot be found, this could lead to internal struggles, potentially escalating to an armed conflict of Islamist political and religious groups versus secularists.

Invasion by Neighbors

Significant differences in economic wealth and natural resources between Egypt and Tunisia on one side, and Libya on the other, entail a security risk for the latter.[32] The motive for such forceful actions by neighboring states lies in the attraction to make use of the current military weakness of Libya. Having only recently re-established itself under the leadership of the NTC, Libya's national security organizations are still largely in disarray. Parallelly, large numbers of armed groups left over from the uprising against the Ghaddafi regime are frequently operating outside of Governmental control. These groups tend to form increasingly armed gangs, aiming to take control over limited areas rather than being available to defend the national territory.

National Resilience: 4

[32] Lt.General Khalifa Haftar , Chief of staff of Libyan armed forces, *The New Enemies of Libya* , 10 January 2012; http://egyptianchronicles.blogspot.com/2012/01/new-enemies-of-libya.html (last visited: 13 February 2012).

Conclusion: The probability of an unforeseen interruption of petroleum-based exports from Libya to Austria due to security threats is high at present.

5.1.7.4. Nigeria

Nigeria, the most populous country in Africa, is also Africa's biggest oil producer and highly dependent on the oil and gas sector in its national economy. It is a member of OPEC and the world's eighth largest exporter of oil. Income from Liquefied Natural Gas (LNG) is likely to exceed oil revenues in the next decade. Nigeria has inadequate refining capacity and needs to re-import refined products to cover domestic consumption. Due to wide spread corruption a large segment of the population remains in poverty. National security is dominated by the role of the national Armed Forces, who have exercised their power repeatedly in the past. The last military rule ended in 1999.

Currently Nigeria faces the following security threats:

Lawlessness in the Niger-Delta

The Niger-Delta region is the centre of Nigeria’s oil production. The region suffers from a steady increase in lawlessness. Lack of security results in kidnappings, mainly of foreigners among the oil workers. Together with frequent armed attacks on oil facilities, this leads to unforeseeable interruptions in the national oil production.

Religious Violence

*People Committed to the Propagation of the Prophet’s Teachings and Jihad (*Jama’atu Ahlis Sunna Lidda’awati Wal-Jihad*),* also known by its Hausa name *Boko Haram,* has repeatedly carried out coordinated attacks*.* The radical Muslim sect is bombing almost everywhere in Nigeria, with a predominance in the North of the country. So far its targets covered a wide range, such as churches, a United Nations Building, military checkpoints, and police headquarters.

Border disputes

Nigeria had several border disputes in the past, ranging from issues with Cameroon, Niger and Chad over Lake Chad, to disputed maritime boundaries with Cameroon and Equatorial Guinea. In view of the continually disputed jurisdiction over oil-rich areas in the Gulf of Guinea, further diplomatic disagreements are likely.

National Resilience 4

Conclusion: The probability of an unforeseen interruption of petroleum-based exports from Nigeria to Austria due to security threats is high at present.

5.1.7.5. Russia

Russia as the largest country in the world, covers more than one eighth of the Earth's inhabited land area. It is a country with significant natural resources, i.e.:

World's largest reserves of mineral and energy resources[33]

Number one natural gas producer[34]

Number one oil producer globally.[35]

This abundance of natural resources, particularly in oil and natural gas, contributes significantly to the fact that Russia has the world's 11th largest economy, reaching by nominal GDP.[36] Due to oil export earnings the country increased its foreign reserves almost fifty times between 1999 and 2008, reaching $597.3 billion. Thereby, Russia owns the third largest foreign exchange reserves globally.[37] The creation of the national *Stabilization Fund* contributed significantly for Russia to weather the global financial crisis.[38]

The national Armed Forces possess the largest stockpile of weapons of mass destruction, making Russia one of the five recognized nuclear weapons states. http://en.wikipedia.org/wiki/Russia - cite_note-fas-22[39] Russia has the second largest fleet of ballistic missile submarines and is the only country - apart from the U.S. - with a modern strategic bomber force.[40] Between 2006 and 2015 the Russian Armed Forces will receive a major equipment upgrade, estimated to cost about. $200 billion.[41] Russias foreign policy fosters strong relations with Brazil, India and China (P.R.). In particular, ties

[33] UNESCO, Commission of the Russian Federation for UNESCO: Panorama of Russia. http://www.unesco.ru/en/?module=pages&action=view&id=1; (last visited: 14 February 2012).

[34] CIA World Factbook; (last visited: 14 February 2012).

[35] CIA World Factbook; (last visited: 14 February 2012).

[36] International Monetary Fund, World Economic Outlook Database, September 2011: Nominal GDP list of countries. (last visited: 14 February 2012).

[37] CIA World Factbook; (last visited: 14 February 2012).

[38] Kudrin and Fischer honoured by Euromoney and IMF/World Bank meetings in Washington, Euromoney, 10 September 2010 http://www.euromoney.com/Article/2683869/Kudrin-and-Fischer-honoured-by-Euromoney-at-IMFWorld.html; (last visited: 14 February 2012).

[39] Federation of American Scientists, "Status of Nuclear Powers and Their Nuclear Capabilities". http://www.fas.org/nuke/guide/summary.htm; (last visited: 14 February 2012.

[40] Russia pilots proud of flights to foreign shores, by David Nowak, 15 September 2008, The Associated Press. http://www.komonews.com/news/national/28390779.html (last visited: 14 February 2012).

[41] Big rise in Russian military spending raises fears of new challenge to west, by L. Harding, 9 February 2007, *Guardian* (London). http://www.guardian.co.uk/world/2007/feb/09/russia.usa. Retrieved 6 Jan. 2008 (last visited: 14 February 2012).

with China (P.R.) have been strengthened (Treaty of Friendship, Tran-Siberian oil pipeline). Russia has also multiple political, economic, cultural and scientific agreements with the European Union, starting in 1999.[42] Russia is facing the following security threats at present:

Southern Kuril Islands

The islands Etorofu, Kunashiri, Shikotan, and the Habomai group were occupied by the Soviet Union in 1945. These islands are currently administered by Russia and claimed by Japan as the "Northern Territories". Due to this dispute a peace treaty - formally ending World War II hostilities - has not been signed.

Abkhazia and South Ossetia

Following an attack by Georgia on South Ossetia in 2008, Russia intervened militarily and subsequently recognized South Ossetia as an independent state.

Abkhazia as an independent state (*Republic of Abkhazia*) and is recognised by Russia, Nicaragua, Venezuela, Nauru, Tuvalu and Vanuatu and also by South Ossetia, Transnistria and Nagorno-Karabakh. Since the Georgian government considers both areas as a part of Georgia's territory, the potential for an outbreak of renewed hostilities is high.

Caspian Seabed

The already ratified Caspian Seabed Treaties between Azerbaijan, Kazakhstan, and Russia are based on equidistance. However, since Iran does not recognize these treaties and requests ownership of 20% of the total area, a latent security threat remains between Russia and Iran.

Baltic States and Ukraine

Serious diplomatic differences between Estonia, Latvia and Russia are caused by the discriminatory treatment of Russian citizens in these Baltic States and over border agreements. Estonia and Latvia announced issuance of unilateral declarations referencing Soviet occupation and ensuing territorial losses in 2005, e.g., referring to the reintegration of the Narva region with Estonia. Russia has an ongoing dispute concerning the boundary with the Ukraine through the Kerch Strait and Sea of Azov.

Continental Shelf

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[42] Agreement on Cooperation in Science and Technology between the European Community and the Government of the Russian Federation (1999); (last visited: 20 February 2012).

The question of limits of the Continental shelf, an area considered to be rich of natural resources, remains unresolved between Russia, USA, Denmark (Greenland) and Norway. Solutions are currently discussed at the *Commission on the Limits of the Continental Shelf* (CLCS).

Missile Defence System in Europe

The US initiated Missile Defense system, with operational components in several NATO countries (Czech Republic, Poland, Romania and Spain), is reportedly designed to shoot down missiles from rogue states such as Iran. It raises serious security concerns in Russia, which perceives the system as threatening its strategic deterrent.

National Resilience: 3

Conclusion: Security threats no. 1, 2 and 6 have the potential to result –differing in largely probability - in a military conflict between the parties involved. Such events can in turn inflict unintended interruptions in the oil- and gas export by Russia in the near term. However, the medium level National Resilience represents a dampening factor on this supply risk.

5.1.7.6. Venezuela

Venezuela, founding member of OPEC, is among the top ten world crude oil producers; for example, the Orinoco Belt itself is estimated to contain 2.2×10^{11} m^3 of heavy crude in proven and unproven deposits.[43] The reported proven reserves reach 4.72×10^{10} m^3, surpassing that of Saudi Arabia with 4.21×10^{10} m^3 (2009 data). Also, the Venezuelan Government reported that the country had the eighth largest proven gas reserves in the world, and that it would soon reach fifth place.[44] Venezuela's economy is largely dependent on oil- and gas export, representing about 80% of all exports and over 50% of the revenues.[45]

For the past one hundred years Venezuela had no major political disputes with most Latin American and Western nations and none with countries in the Middle East. The current

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[43] Schenk C.J., Cook, T.A., Charpentier, R.R., Pollastro, R.M., Klett, T.R., Tennyson, M.E., Kirschbaum, M.A., Brownfield, M.E., and Pitman, J.K. (2009). An estimate of recoverable heavy oil resources of the Orinoco Oil Belt, Venezuela: U.S. Geological Survey Fact Sheet 2009–3028, 4 p. http://pubs.usgs.gov/fs/2009/3028/ (last visited: 15 February 2012).

[44] Venezuela: Oil reserves surpasses Saudi Arabia's. REUTERS, 16 January 2011 ; http://english.ahram.org.eg/NewsContent/3/14/4060/Business/Markets--Companies/Venezuela-Oil-reserves-surpasses-Saudi-Arabias.aspx (last visited: 15 February 2012).

[45] CIA, The World Factbook,https://www.cia.gov/library/publications/the-world-factbook/geos/ve.html (last visited: 15 February 2012).

political leadership of Venezuela is focused on the personality of its president, Hugo Chávez, having undergone treatment for cancer.

While Venezuela is not facing any imminent security threats from South America or Europe, its pronounced criticism of US policies has created tension with the US Government.

National Resilience: 4

Conclusions: The probability for a significant deterioration of the national security situation is high, i.e., it cannot be discounted that export of oil to Austria could be interrupted in the near-term, e.g., triggered by a change in the political leadership.

5.1.8. Threats to Soy Exporters to Austria

Author: AGES: Veronika Kolar

Austria does not have any significant national supply of soy. Therefore, it has to import almost all of its soy from Argentina, Brazil, and USA.

5.1.8.1. Argentina

Argentina is involved in an unresolved dispute with the British Government over the fate of the Malvinas Islands off the mainland (referred to as the Falkland Islands by the British Government). Although the Argentine government refers to the British Government as belligerent and warlike, it has made it clear that a military solution to the standoff over the Malvinas islands - not yet decolonized being under the sovereignty of Britain - is not considered an option.[46]

National Resilience: 4

Conclusions: The probability of an unforeseen interruption of soy exports from Argentina to Austria due to security threats is high at present.

5.1.8.2. Brazil

Brazil has no unresolved border conflict with any of its neighbours. Also, the country had none of its military deployed abroad since World War II.

National Resilience: 3

[46] Argentina urges UK to stop waging wars. PressTV, 5 February 2012, http://www.presstv.ir/detail/225112.html; (last visited: 14 February 2012).

Conclusions: The probability of an unforeseen interruption of soy exports from Brazil to Austria due to security threats is not significantly elevated at present.

5.1.8.3. USA

The United States of America (USA) have been involved in more than forty military operations of various magnitude worldwide since 1902, excluding the *Cold War.* As the only remaining Superpower after the collapse of the Soviet Union, the country with the largest Armed Forces worldwide projects its power globally. Nevertheless, the country still faces indirect security threats related to its diminishing prosperity, reflected in an excessive national debt (including implicit fiscal insolvency) and concurrent shrinking global influence versus the rising importance of BRIC countries.[47] The increasingly frequently adopted policy option of inducing regime change in a third country can result in further military conflict in several geographical regions at relatively short notice (e.g., Iran).

National Resilience: 2

Conclusions: In the case of US exports of soy to Austria, the pronounced US National Resilience compensates for the increased likelihood of further military US engagements in the near term, i.e., also US soy export to Austria is viewed as of not being threatened by US military operations at present.

5.1.9. Threats to Phosphate Exporters to Austria

Authors: AGES: Andreas Baumgarten, Helene Berthold

Phosphate rock is a finite non-renewable resource. About 95% of the phosphate rock mined is used to produce fertilizers, animal feeds and pesticides.

The use of phosphate rock as fertilizers started around 1900 and boosted in the fifties.

[47] BRIC countries = Brazil, Russia, India, China (P.R.).

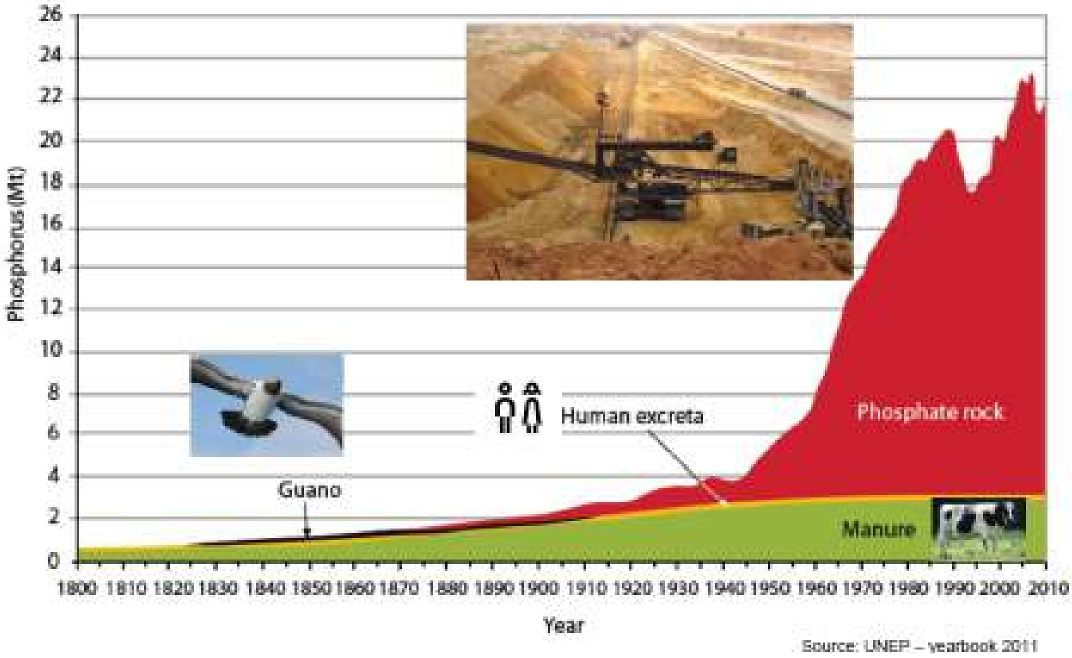

Figure 43: Use of Phosphate fertilizers, UNEO Yearbook 2011

Phosphates were excavated from minerals, such als apatite ($Ca_5(PO_4)$ (F, Cl, OH)), which exactly depends on its chemical partner (Fluor- , Chlorine- or Hydroxid). The natural resources of phospates are limited and most of them are contaminated with cadmium and/or radioactive heavy metals. The cadmium content of phosphate deposits is very variably because of the different mining areas.

The world phosphate rock reserves are largely consisting of the reserves in Morocco and Western Sahara (5,700,000,000 t), which represents about 45% of the global reserves.[48] With a weighted average global fertilizer consumption of 17.0 metric tons per 1,000 persons[49], a further growing global population will accelerate the agricultural use of phosphate rock and thereby increase global competition for this resource.[50] Morocco will have to increase its phosphate production to meet the worldwide demand for (15% in

[48] Cost less than US$40/tonne; FAO- Natural Resources Management and Environment Department, Use of phosphate rocks for sustainable agriculture..., World phosphate deposits, http://www.fao.org/docrep/007/y5053e/y5053e07.htm#TopOfPage (last visited: 24 January 2012).

[49] Fertilizer consumption measures the quantity of plant nutrients used per unit of arable land. Fertilizer products cover nitrogenous, potash, and phosphate fertilizers (including ground rock phosphate). Traditional nutrients - animal and plant manures - are not included. The time reference for fertilizer consumption is the crop year (July through June); Agriculture Statistics - Fertilizer consumption, Nationmaster, http://www.nationmaster.com/graph/agr_fer_con_met_ton_percap-consumption-metric-tons-per-capita (last visited: 24 January 2012).

[50] Cooper, J., Lombardi, R., Boardman, D., Carliell-Marquet, C.:The future distribution and production of global phosphate rock reserves; Resources, Conservation and Recycling, 2011 p. 78-86.

2010 to around 80% in 2100; Cooper et. al., 2011). In this case, the demand and the free market price is determined by a single country.

Austria imports rock phosphate mainly from *Morocco*. Morocco is the world's biggest exporter and third-largest producer of phosphorus, with China leading and USA second[51][52].

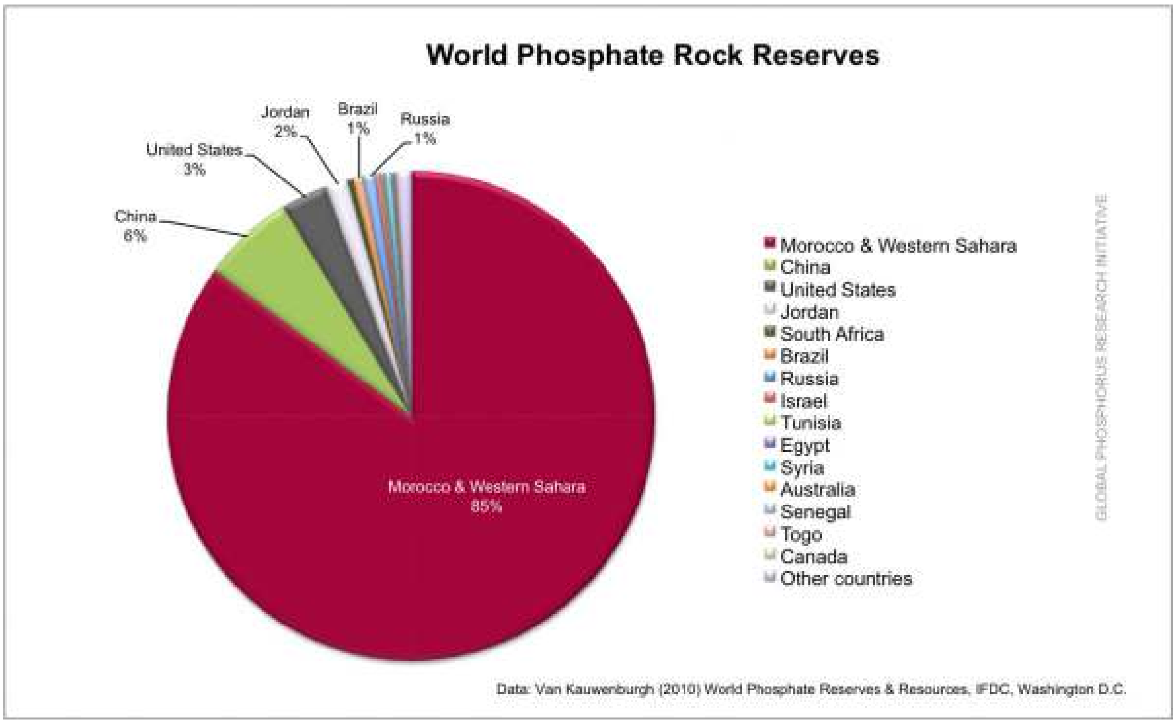

Figure 44: World Phosphate Rock Reserves, Van Kauwenburgh (2010) World Phosphate Reserves and Resources, IFDC, Washington D.C.

Due to the fact that the relationship between rising demand and production decline is drifting more and more apart, individual countries, especially Morocco, must increase their phosphate rock production and thereby exert even greater control and power (Cooper et al, 2011).

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[51] D. A. Vaccari (2009), Phosphorus: A Looming Crisis; Scientific American, 300, 54-59.

[52] Cooper, J.; Lombardi, R.; Boardman, D.; Carliell-Marquet, C. (2011): The future distribution and production of global phosphate rock reserves. Resources, Conservation and Recycling 57, 78-86.

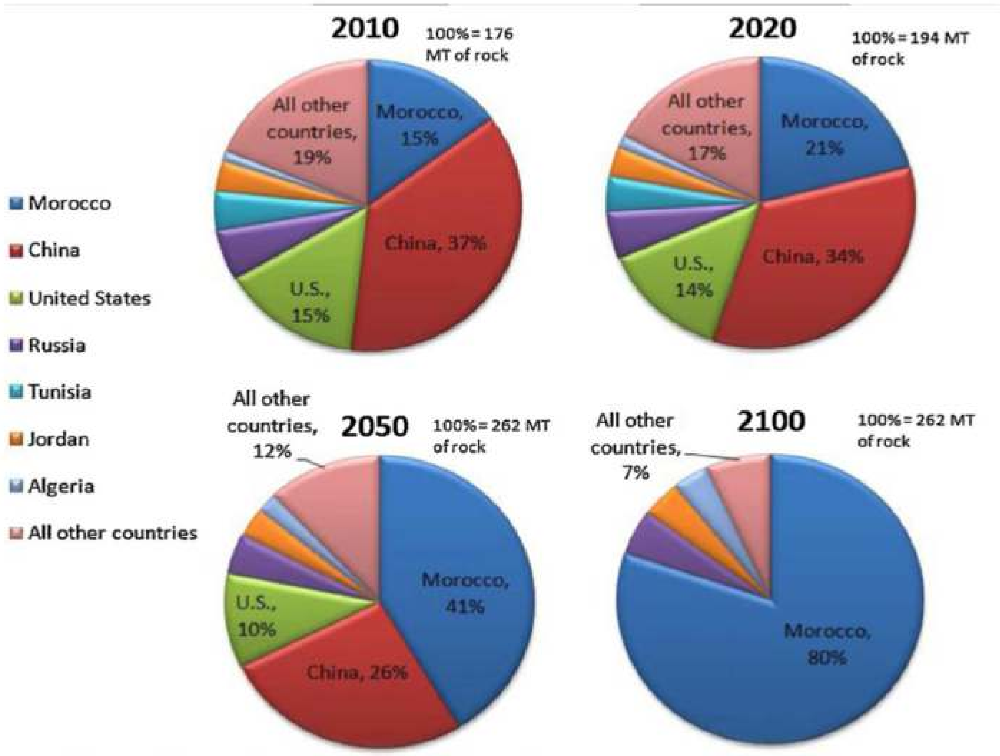

Figure 45: World Phosphate Rock Productions, Jasinski 2011, prepared by Baumgarten, AGES 2013

Morocco faces two security threats:

- *External* security threats are lingering due to an unresolved dispute over the Western Sahara, in particular over the status of two regions (Saguia el-Hamra and Rio de Oro), which have already escalated into war in the recent past. Currently a ceasefire is in effect. However, neither the administration of this territory by Morocco, nor the self-declared independent *Sahrawi Arab Democratic Republic* are internationally recognized.

- *Internal* security threats follow from the extensive public uprising in early 2011. Subsequently, a committee was established, aiming for drafting a new constitution in order to weaken the power of the current monarchy. In November 2011 the Islamist Justice and Development Party won the majority vote in an election, adding further to national instability.

National Resilience: 4[53]

[53] National Resilience is equally low for the other two main exporters of phosphate to Austria, i.e. Syria (NR = 4) and Jordan (NR = 4).

Conclusions: Austria's phosphate supply, originating in Morocco, has an increased probability of interference by security operations, i.e., uninterrupted delivery of phosphate is subject to significant military threats.

5.1.10. Threats to Exporters of Vitamins, Essential Amino Acids and Pesticides to Austria

Authors: AGES: Alois Leidwein

ÖVAF: Martin Weigl

Currently Austria has a significant dependency on exporting countries (China, India, Japan, Switzerland, USA) with regard to vitamins, essential amino acids and pesticides. Not all of these countries have a high degree of political- and/or social stability at present:

National Resilience - China: 3

National Resilience – India: 4

National Resilience - Japan: 1

National Resilience - Switzerland: 1

National Resilience - USA: 2

Conclusions: The supply of vitamins, essential amino acids and pesticides to Austria originates largely in countries with high National Resilience (1<=NR<= 2), i.e., neither Japan and Switzerland or USA are likely to interrupt such exports. By comparison, exports originating in India or China, however, are subject larger uncertainties.

5.1.11. Impact of Climate Change on Food Production

Authors: AGES: Gudrun Strauss

BOKU: Josef Eitzinger, Herbert Formayer, Martin Schlatzer

Multiple national and international organizations have come to the conclusion that the climate of the Earth is changing, e.g., United Kingdom[54] and the United Nations.[55] In summary, climate change is expected to have the following large scale effects:

- Rising global temperatures
- Changes in the global weather patterns

[54] Department for Environment, Food and Rural Affairs, United Kingdom , Adapting to climate change - UK Climate Projections, 2009; http://www.defra.gov.uk/publications/files/pb13274-uk-climate-projections-090617.pdf (last visited: 24 January 2012).

[55] Intergovernmental Panel on Climate Change (IPCC), IPCC Fourth Assessment Report: Climate Change 2007; http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml#1(last visited: 24 January 2012).

- Rising sea levels
- Increased frequency and intensity of extreme weather worldwide.

Forecasts on the impact of climatic change on food production in a certain area is associated with significant uncertainties, since plant type and the anticipated changes in weather patterns and precipitation will ultimately determine the extent of the impact. However, in generic terms, global food production will be impacted as follows according to the latest report by IPCC (2007):

Local average temperature increase between 1 to 3 °C above pre-industrial levels: *Increase* in global food production

- Local average temperature increase above this range: Decrease in yields of all major cereal crops in all the main areas of production, followed by widespread malnutrition in the poorest countries.
- Higher variability of rain fall: Less predictability of water availability (drinking water and water for irrigation alike).
- Negative effects on water supplies due to salt water contaminating fresh water supplies and soils in coastal areas: *Reduced availability of drinking water and reduced crop yields in the affected areas*.

5.1.11.1. Primary Effects

An aggravating factor is ***global population growth***. The world has reached seven billion people by the end of October 2011. In order to understand the development over the past approximately two hundred years it is illustrative to review the growth rate:[56]

- The global population reached one billion people by the early 19th century.
- It took over one hundred years to double the global population to two billion.
- It only required thirty three years to reach three billion people.
- Fourteen years were needed to reach four billion people.
- Thirteen years to reach five billion.
- Twelve years each to reach six, respectively seven billion.

In a given country population growth is accompanied by decreasing availability of water and land per capita, resulting in some countries in growing stress with regard to already scarce reserves. For example, Yemen has a fast growing population with a four-fold increase since 1970. The need to match the water supply with the growing demand of the enlarged population forced Yemen to deplete aquifers, which in turn contributed to reduce

[56] Lenntech BV, Use of water in food and agriculture, http://www.lenntech.com/water-food-agriculture.htm#ixzz1kUOIl7uX (last visited: 24 January 2012).

the national grain harvest by one third. Pakistan also suffers from a fast-growing population.[57]

It is anticipated that the global population will continue to grow also in the future, putting further pressure on food production and associated water supply. The severity of the nexus ***water supply, food production and climate change*** is reflected in two examples: Major grain-producing areas in China, India and the United States use unsustainable mining of groundwater; in North Africa and Australia climate-related changes of precipitation have already critically reduced the levels of freshwater supply.[58]

Another important nexus is the interrelatedness between adequate amounts and affordable prices for ***energy, water and food***, all three representing key elements for ensuring growth in the economy and ensuring stability in society:[59]

- Production of food necessitates supply of water and energy;
- extraction of water and its distribution necessitates energy;
- production of energy necessitates water;
- food production costs are inter alia dependent on energy costs (fertilizers, irrigation, transport, processing).

5.1.11.2. Secondary Effects

Besides these primary effects of climate change, there is also the possibility of secondary effects of climate change and food production, such as warming of the Earth could change the **balance between parasites and hosts**. This would have significant consequences, for example, on the fishing industry, since rising water temperature promotes the growth of fish parasites. Parasites multiply faster and increase in size, whilst the number of fish hatching in the warmer water decreases.[60]

Shortages in food have already occurred due to extreme weather conditions, for example droughts in Russia during summer months of 2010 have reduced grain harvest by about 30%;[61] in August 2011, extensive floods destroyed the agriculture infrastructure in

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[57] Lenntech BV, Use of water in food and agriculture, http://www.lenntech.com/water-food-agriculture.htm (last visited: 24 January 2012).

[58] Fitzgerald Reading, B. (2011): World Population Hitting 7 Billion. Earth Policy Release Eco-Economy Indicator. http://www.earth-policy.org/indicators/C40/population_2011 (last visited: 24 January 2012).

[59] World Economic (January 2011), GLOBAL RISKS 2011 Forum Sixth Edition, p. 29 http://blogs.ethz.ch/klimablog/files/2011/04/global-risks-2011.pdf (downloaded: 14 January 2012).

[60] Macnab, V. and Barber, I. (2011): Some (worms) like it hot: fish parasites grow faster in warmer water, and alter host thermal preferences. Glob. Change Biol. DOI: 10.1111/j.1365-2486.2011.02595.

[61] Kim, L. and Levitov, M. (2010): Russia Heat Wave May Kill 15,000, Shave $15 Billion of GDP, Bloomberg, http://www.bloomberg.com/news/2010-08-10/russia-may-lose-15-000-lives-15-billion-of-economic-output-in-heat-wave.html (last visited: 24 January 2012).

Pakistan, affecting more than nine million people and leaving three million people in need of emergency food assistance.[62] In Australia large scale flooding – the worst in over fifty years - inundated an area greater than the size of France and Germany combined. This – resulted in the highest prices for wheat, sugar, corn and oil seeds since the food crisis of 2007-2008.[63] Queensland Sugar, the country's biggest sugar exporter, had to buy more raw sugar from Brazil and Thailand to fulfill its own export orders.

5.1.11.3. Possible effects of Climate Change on agricultural pests

Several scientific studies have been undertaken to determine the impact of climate change on the evolution of specific pests or disease pressures. Today there is a large body of scientific evidence documenting the overall increase in the number of disease outbreaks and northward migration of a wide variety of weeds, insects, and pathogens (STDF, 2009).

In this section the relationship between climate change, trade, plant pests and diseases and the possible consequences for the food safety is described by reporting some of the most important current, scientific facts pertaining to this relationship.

A scientific literature search was conducted by defining specific search terms and combinations and the search was performed in different databases (CAB Abstracts, AGRIS) and on specific websites from international organizations and relevant institutions (IOBC; IPCC; DAISIE; The Standards and Trade Development Facility; FERA) to capture the up-to-date scientific evidence in regard to the impact of climate change on agriculture plant health risks.

The relationship between climate change and phytosanitary risks issues is highly complex and there is still considerable uncertainty surrounding the individual factors involved and the relationships between them. Therefore, the possible impact of climate change on agricultural pests and crop losses is described generally rather than specifically for Austria. Some specific examples of the interaction between climate and implications on pests are mentioned below. The aim is to provide a common understanding of the link between climate change-induced emerging plant health risks on agriculture productivity and food supply.

Impact on crop yield by pests and diseases

Crop yield and quality are affected by climate change directly and indirectly by the geographic distributions of pests and pathogens (Newton et al., 2010).

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[62] http://www.oxfam.org/en/emergencies/pakistan-floods (last visited: 24 January 2012).

[63] Melik, J. (2011): Australia's floods disrupt commodity supplies . BBC News, 5 January 2011, http://www.bbc.co.uk/news/business-12111175 (last visited: 24 January 2012).

Between 10 and 16% of crop production is lost to pests, with similar losses postharvest (Oerke, 2006; Flood 2010; Chakraborty and Newton 2011). Actual average losses for rice in the period 2001–2003 totalled 37.4%, comprised 15.1% of pests, 10.8% of pathogens and 1.4% of viruses, with the remaining 10.2% accounted for by weeds (Oerke, 2006). Indeed, losses of major crops to fungi and oomycetes alone amount to enough to feed 8.5% of today's population (Fisher et al., 2012). Low crop yields are common in many developing countries and improved productivity is vital to reducing rural poverty and increasing food security. While the causes of low productivity are complex, one major contributory factor is crop losses due to plant health problems (Flood, 2010).

Impact of world-wide trade and rising temperatures on pests

Insects are poikilothermic organisms and their body temperature fluctuates with the temperature of the environment. Therefore, temperature has a direct impact on insect physiology and is probably the most important environmental factor influencing insect development, reproduction, survival and distribution (Petzoldt and Seaman, 2006).

More than half of all emerging diseases of plants are spread by introduction (Anderson et al., 2004). Expanding world-wide trade and climate change contribute to an accelerated international movement and establishment of alien organisms (Roques, 2010). Although pests are spread by human activities and aerial dispersal (Anderson et al., 2004; Brown and Hovmøller, 2002) prevailing climatic conditions are likely to determine their subsequent establishment and growth (Bebber et al., 2013).

Spread is facilitated primarily by human transportation, which is facilitated by the increasing interconnectedness of the global food chain. For example, of the 90% of alien terrestrial insects that arrived in Europe unintentionally, 75% were associated with a commodity and 15% as stowaways (Roques et al., 2010). Additionally there is increasing concern that climate change allows establishment of said insects in hitherto unsuitable regions (Bebber et al., 2013).

Winter temperatures are widely predicted to increase (IPCC, 2007). Most researchers agree that warmer temperatures in temperate climates can potentially affect insect survival, development, geographic range and population size. Climate change may directly change the realized climatic niche of a species and cause habitat shifts and range shifts in latitude and altitude (Rabitsch, 2010). Bebber et al. (2013) recently published a comprehensive analysis of latitudinal range shifts of crop pests using published observations of 612 crop pests and pathogens. They detected significant positive latitudinal trends in many taxa that support the hypothesis of global warming-driven pest movement. The average poleward shift since 1960 is calculated as 2.7±0:8 km yr^{-1}, but with significant variation in trends among taxonomic groups.

However, interactions between climate change, crops and pests are complex, and other factors could bias the results. New crop varieties and agricultural technologies have extended the agricultural margin northward in the USA (Reilly et al., 2003), and deforestation has increased production in the tropics, thus providing new opportunities for pest invasions at high and low latitudes. Correlations between land use change and climate change can obscure analyses based on species temperature ranges (Parmesan and Yohe, 2003; Clavero et al., 2011).

There is evidence of the growing season being extended in many places: at more northerly latitudes, higher temperatures extend the summer season, increasing the available thermal budget (number of day-degrees) for growth and reproduction (Barnett et al., 2006). At middle latitudes of Europe, global warming will allow earlier planting of crops in the spring, earlier maturation and harvesting, as long as the provided moisture is adequate and the risk of heat stress is low. A pest species that is already present, but occurs only in small areas or at low densities may be able to spread more widely in terms of latitude and altitude widening and reach damaging population densities (Gregory et al., 2009; Kocmankova et al., 2010).

Higher temperatures may enhance the population growth rate and lead to faster development cycles of pest organisms. Multivoltine pest species, like many aphid species, would develop more rapidly and complete their development earlier in the year and probably produce more generations per year. For example, Samietz et al. 2013 evaluated the impact of climate change on phenology and prospective diapause induction in a global insect pest the codling moth, Cydia pomonella. Under future conditions of increased temperatures (2045-2074), the present risk of below 20% for a pronounced second generation in Switzerland will increase to 70-100%. The risk of an additional third generation will increase from presently 0-2% to 100%. They identified a significant two-week shift to earlier dates in phenological stages, such as overwintering adult flight.

There is a clear linkage between winter temperatures and the first emergence of key pests: Due to warmer winter temperatures, winter mortality will be reduced, pest populations will increase and the spread of plant pathogens spread by vector species may increase (Harrington et al., 2001; Gregory et al., 2009). Harrington et al., 2007 report higher survival rates of vector species through winter lead to higher severity of plant infection diseases in the following year. It seems very likely, that some important pest or vector species will become active earlier in the season (Harrington et al., 2007). This effect could lead to an increase in disease spread for plant pathogens spread by vector species (Newton et al., 2010). Warming generally stimulates insect herbivory at higher latitudes, primarily through increased winter survival (Bale et al., 2002), as seen in mountain pine beetle (Dendroctonus ponderosae) outbreaks in the US Pacific Northwest (Woods, 2011).

Impact of changes in precipitation

In general, there are fewer scientific studies on the effect of precipitation on insects than temperature. Some insects are sensitive to precipitation and are physically washed off the plant by heavy rainfall. The predicted more frequent and intense precipitation events forecasted with climate change would suppress populations of small pest insects. In this case fungal pathogens of insects (=entomopathogene fungi) that rely on high relative humidity for a successful reduction of a pest population could benefit from higher relative humidity.

Small insects are often more of a problem during dry seasons. Climate change resulting in drier conditions could intensify pest problems (Petzoldt and Seaman, 2006). For instance, in Sub-Saharan Africa, there is already increasing evidence that changes in rainfall patterns are driving migratory patterns of the desert locust (Schistocerca gregaria), which devastates crops in Africa, the Middle East, and Asia. Hulme et al. (2001) suggest that precipitation patterns in Southern Africa are likely to decrease in December–February, but increase in June–August when this will most benefit S. gregaria, leading to further problems. On the other hand, insects not tolerant of drought, such as the pea aphids, are expected to be negatively affected (Macvean and Dixon, 2001).

Impact on invasive alien species

There is increasing evidence that climate change will interfere with processes underlying biological invasions. There is a general consensus that climate change will potentially favour invasive alien species (IAS) leading to new invasions and spread of the already established IAS.

Invasions by pests and pathogens have a huge impact on agriculture (Termorshuizen, 2008). Alien species are the reason for the loss of more than 20% of the world's food production (Nentwig and Josefsson, 2010). Many alien insect and mite species cause serious socio-economic hazards as pests of agriculture, horticulture, stored products and forestry. They may also affect human and animal health. Alien invasive species have not coevolved with the host or ecosystem in which they emerge and, as such, are more likely than endemic diseases to pose a threat to biodiversity through biomass loss, changes in host species complements and via the extinction of host species (Anderson et al., 2004).

Invasive alien species, like the western corn rootworm *Diabrotica virgifera virgifera* or the Colorado beetle *Leptinotarsa decemlineata* have already been shown to impose enormous costs on agriculture (Pimentel et al., 2005). Results of a study of Kocmánkova et al. (2010) predict an increase of the potential geographic distribution of two major corn pests, the Colorado potato beetle and the European corn borer, *Ostrinia nubilalis*, in Austria and the Czech Republic under climate change until 2050. Furthermore, areas that originally support only one generation would support more generation per year. Consequently, a significant increase in the %age of arable land threatened by these species is possible and where protective measures are needed (Kocmánková et al., 2010). These results demonstrate that the expected increases in temperature will most likely alter the developmental limitations of pest species and permit widening of their areas of occurrence.

The multi-trophic interactions between crops, pests and pathogens are complex and poorly understood in the context of climate change, what make it extremely difficult to predict the impact of climate change on agriculture, pest management and food security in the future (Gregory et al., 2009). Nevertheless, it seems possible to make several generalizations with respect to the direct effects of climate change on insect herbivores.

Temperature is identified as the dominant abiotic factor directly affecting herbivorous insects and directly affects development, survival, range and abundance (Bale et al., 2002). Species with a large geographical range will tend to be less affected. Changes in temperatures may stress native species, decreasing the resistance to invasion of natural communities. Likewise, increasing disturbance elements such as fires, floods, storms, heat-waves, droughts, etc. as a direct consequence of climate change, could benefit alien species.

It is now well recognized that factors such as earlier springs, altered growing seasons, etc. may result in the shifting of pest and host distribution ranges, establishment potential of pests, phonological cycles of plants and synchronization between pest and plants.

It is very likely that an increase in the mean temperature will result in northward expansion of the geographic range of pest species. This means that farmers in the north will have more and new types of insects to manage. A general pattern of increasing latitudinal range with mean global temperature is anticipated, either through direct effects of climate change on the pests, or on the availability of host crops (Anderson et al., 2004). It is very likely that the pest life-cycle will be faster and that multivoline pest species will be able to produce more generations per season because of a prolonged growing season. Higher population size of pests would probably lead to more crop damage and more insecticide applications to maintain populations below economic damage thresholds. Through changes in temperature and precipitation, some pests will be able to invade new areas. Due to less severe frost periods thermophile new pest species, that are not very frost tolerant, may have greater changes to survive winter and to establish in hitherto uncoloniced areas, where they formerly were not able to establish (Bouma 2008; Termorshuizen, 2008).

In general it can be concluded that agriculture is extremely vulnerable to climate change and that higher temperatures eventually reduce yields of desirable crops while encouraging weed and pest proliferation. Changes in precipitation patterns increase the likelihood of short-run crop failures and long-run production declines. This may result in additional price increases for the most important agricultural crops that are rice, wheat, maize, and soybeans. Higher feed prices will result in higher meat prices. As a result, climate change will reduce the growth in meat consumption slightly and cause a more substantial fall in cereal consumption. Although there will be gains in some crops in some regions of the world, the overall impacts of climate change on agriculture are expected to be negative, threatening global food security (Nelson et al., 2009).

Despite the diversity of the expected effects, it is seems likely that climate change will affect food safety, animal and plant health in a way that makes the emergence of new or more serious threats inevitable (STDF, 2011). Therefore, improved identification and evaluation of changing or emerging diseases and pests would contribute greatly to a better prediction of agri-food phytosanitary risks worldwide.

Further research is needed to better understand the effects of climate change on pest and disease. If climate change will make it easier for crop-destroying organisms to spread, renewed efforts to monitor the occurrence of pests and diseases and control their transport will be critical in controlling this growing threat to global food security (Anderson et al., 2004; Flood, 2010; Fisher et al., 2012; Bebber et al., 2013).

5.1.12. Impact of Food Prices on Political and Social Stability of Exporters to Austria

Violent protests against rising food prices have broken out in a number of poor countries in 2007/2008. In altogether 39 countries – among them Cameroon, Haiti, Kenya, Somalia, Egypt, Burkina Faso, Gabon, Honduras and Mauritania - hunger riots have taken place. One of the worst such riots happened in Haiti, where looters gathered in the capital Port-au-Prince. Youth took over a number of streets, blocking them with barricades made of rubber tyres and rubble and thereby impeding traffic of goods and transport of people. Subsequently, several shops were raided by armed protesters. The trigger for large scale unrest in Haiti was a price hike the previous week: the price for a 50 kg sack of rice rose from 35 US dollars a few days earlier to 70 US dollars; the cost of petrol increased for the third time in two months. Such events should not be viewed as isolated cases of the past, instead they are likely to occur again, if prices reach a level making food unaffordable by the poor. On the other hand, rural poverty is neglected consequently in political discussions. 70% of poor people are living in rural areas. Most of them are farmers or farm laborers.[64]

70% of the poor and hungry of the world are farmers or farm workers and rising agricultural prices will help them escape poverty in the medium term. History shows that sustained increases in farm-gate prices together with certain political rights such as freedom of organisation, market organisations favouring farmers and land tenure rights

[64] Prowse M. and Chimhowu A. (2007): Making agriculture work for the poor. Natural Resource Perspectives, Overseas Development Institute.

support the redistribution of margins and wealth among market participants in the medium term.[65]

Increased financial resources for agricultural inputs, such as fertilizer, plant protection and infrastructure, would boost production relatively quickly, especially in countries with developed agricultural structures.[66] In many regions, however, even the higher farm-gate prices witnessed in 2008 and 2010 were insufficient to stimulate increased agricultural investment. Farm prices need to double in real terms to ensure sustainable growth in agricultural production for future food security.

Of course, in net food importing countries and in regions where land rights are unclear, and farmers are not well organized or where subsistence farming or pastoral societies prevail, a different solution would apply.

Farmers, irrespective of the scale of their operation will increase production if it pays. Programs that target land tenure, grassroots organization of farmers and sustainable production techniques are indispensible. An economically viable agricultural sector where farmers benefit from higher prices and start to invest in and consume agricultural services boosts the broader economy.

Steering an even course to minimize the volatility of agricultural markets, is a key challenge for agricultural policy-makers. High prices resulting from food shortages are a threat to social stability just as low market prices resulting from oversupply are a threat to agriculture. Smart and pragmatic solutions that are tailored to the particular circumstances of a given country are essential to this task.

Although this will more likely apply to countries with a low GDP, it should not be overlooked that also countries with a high GDP have an increasing number of poor with difficulties feeding themselves:

- *Long-term unemployed*, facing the loss of unemployment benefits and thereby the means to buy an adequate amount of food;
- *Working Poor*, frequently needing to work two jobs to enable them to avoid hunger.

[65] Bruckmueller et al. (2002): Agrargeschichte Oesterreichs 2002, Ruhland. Ruhland System der politischen Ökonomie 1903: http://www.vergessene-buecher.de/band1/wcharts166.html#anfang (last visited: 24 January 2012).

[66] Food Security, Climate Change and IP Rights (2011): Wipo Magazine, http://www.wipo.int/wipo_magazine/en/2011/03/article_0001.html (last visited: 20 January 2012).

In Austria, a country with a GDP among the top 10 worldwide, 12% of the population is characterised as *poor,* i.e., their monthly total income is less than € 994 (twelve times per year), respectively € 852 (14-times a year).[67]

Main price drivers for food prices are usually not agricultural prices but labor costs and administrative burdens in food procession sectors and trade in OECD countries. Political discussions are slightly different.

Price for grains and other farm products began rising in the autumn of 2010 again. Due to poor harvests Canada, Russia and Ukraine had reduced global supplies.[68] In the winter of 2010/2011 hot, dry weather in South America has cut soy bean production in Argentina. In January 2011 flooding in Australia wiped out much of that country's wheat crop. At the same time the FAO announced that its food price index rose by 32% in the second half of 2010, higher than the previous record level set in 2008.

The political consequences could be observed in Northern Africa and the Middle East in 2011. Violent riots in Tunisia and Algeria, to a significant extent motivated also by the scarcity of affordable food, changed the political landscape in these two nations considered otherwise to be stable and without any major political uncertainties.[69] However, protesters openly fought with police, throwing "Molotov Cocktails (fire bombs)" or shooting fireworks at the security forces. Police responded with significant violence. In Algeria, protesters have been killed by police; several others have set themselves on fire to protest the economic conditions. In Tunisia, more than 100 people have been killed and the president fled the country. In the Jordan, peaceful demonstrations, protesting rising food prices, were held across the country.

Security experts have identified three main issues relating **food supply and cost** with future threats to security:[70]

- Political and social unrest in many countries is the “most alarming and immediate consequence” of the food crisis. Sooner or later “several, if not hundreds of millions" will react, once they realize that prices have moved food out of reach for them;

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[67] Armut in Österreich. Arbeiterkammer Oberösterreich, http://www.arbeiterkammer.com/online/page.php?P=128&IP=59927 (last visited: 14 January 2012.

[68] John W. Schoen, MSNBC (2011): Global food chain stretched to the limit, http://www.msnbc.msn.com/id/41062817/ns/business-consumer_news/ (last visited: 24 January 2012).

[69] The Economic Collapse, Food Riots (2011): http://theeconomiccollapseblog.com/archives/food-riots-2011; (last visited: 24 January 2012).

[70] NATO (2008): "Ernährung und Sicherheit - Fragen und Antworten", Brief 5/2008.

- disappointed young men could turn to radical solutions, endangering the security of armed forces. Internationally such attacks have already occurred on guarded food transports, e.g., 30 attacks in Afghanistan in 2007;
- increased migration pressure on the member states of the European Union due to significant price increase in food in countries outside the EU.

An indication about the probability of such riots in case of further increasing food prices is provided by the IMF: each 10% increase in food prices doubles the likelihood of civil disorder by 100%.[71] The section below summarizes the extent to which food prices could threaten the socio-political stability of main feed and food exporters to Austria.

5.1.12.1. Argentina

It is estimated that Argentina has 27,200,000 hectares of arable and permanent cropland., making it one of the world's leading producer of cereal, oil grains and seeds, sugar, fruit, wine, tea, tobacco, and cotton.[72] It is the world's second biggest exporter of corn and the third biggest exporter of soybeans. This represents a significant capacity to feed its people. Nevertheless, Argentina has experienced a major agricultural crisis due to the worst drought in half a century, causing a state of emergency in 2008. In view of the national wheat consumption of about 6 million t/a on the domestic market, the government had concerns over a shortage of wheat for national consumption. Subsequently, Argentina stopped wheat exports in January 2009.[73] The administration tried to raise taxes on grain and soybean exports in line with rising world prices, thus creating a domestic surplus that would keep prices down and inflation in check. Since the sliding tariffs pushed the tax on soybeans, Argentina's most important export, to almost 50%, farmers, staged violent demonstrations.

Social Resilience (Table 5.1): 3.3 Threat level: medium

5.1.12.2. Brazil

Brazil has land currently under cultivation that is more than twice that of Argentina; it is the world's first or second largest exporter of beef, soybeans, orange juice, chicken, sugar

[71] A 10% increase in international food prices corresponds to an added 0.5 antigovernment protests over the following year in the low-income world — a twofold increase from the annual average In: R. Arezki and M. Brueckner (2011): Food Prices and Political Instability. International Monetary Fund, WP/11/62, (http://www.imf.org/external/pubs/ft/wp/2011/wp1162.pdf; (downloaded: 24 January 2012).

[72] Encyclopedia of the Nations, Argentina – Agriculture; http://www.nationsencyclopedia.com/Americas/Argentina-AGRICULTURE.html#ixzz1klLLSZ1H (last visited: 24 January 2012).

[73] Argentinean wheat exports stopped, by E. deCarbonnel, Market Skeptics, February 4, 2009 http://www.marketskeptics.com/2009/02/texas-and-florida-hit-hard-by-winter.html (last visited: 14 February 2012).

and coffee.[74] However, in 2008 the Brazilian government had to announce the temporary suspension of rice exports, as the commodity's price hit a record high on the futures markets.[75] The export ban was aimed at preventing internal shortages. Since Argentina had suspended the sale of its wheat to its principal importer, Brazil, bread prices rose by more than 20% in the past year because Brazil imports more than 70% of its supplies.

Social Resilience (Table 5.1): 3.8 Threat level: medium

5.1.12.3. Columbia

Since the 1980's, the banana industry in Columbia has been subjected to operate in an environment of guerilla warfare. The Government of Columbia and the national army lack significant control over certain areas, such as those controlled by the Revolutionary Armed Forces of Colombia (FARC) and the National Liberation Army.

(ELN), the Socialist Renewal Current (CRS), the Popular Liberation Army (EPL), and the nascent Esperanza party, the EPL's right-leaning political counterpart.[76]

The country was spared the enormous negative impact of the food crisis in 2008. However, it suffered from food inflation at a level of 13% in 2008.[77] This was caused by the combination of negative effects due to "El Niño", high transportation costs due to high oil prices, and high biofuel prices causing producers to shift production away from food crops towards biofuel crop. These factors caused prices of corn flour to increase by as much as 40% in 2008 as compared to 2007. Despite several political counteractions taken by the government, the public had to face the burden of high food prices (FAO/GIEWS 2008).

Social Resilience (Table 5.1): 4.0 Threat level: high

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[74] Downie, A. (2008): As Food Prices Soar, Brazil and Argentina React in Opposite Ways, , New York Times, 27 August 2008.

[75] Costa, M. (2008): Global food crisis grips Latin America, http://www.wsws.org/articles/2008/apr2008/food-a25.shtml (last visited: 24 January 2012).

[76] Moore, W. (2011): Para-Business Gone Bananas: Chiquita Brands in Columbia, http://www.truth-out.org/para-business-gone-bananas-chiquita-brands-columbia/1314035320 (last visited: 24 January 2012).

[77] Food Security Portal, Colombia, http://www.foodsecurityportal.org/colombia/resources (last visited: 24 January 2012).

5.1.12.4. Costa Rica (bananas)

The national banana industry, the country's number two foreign currency earning industry, has expanded to meet the demand of a growing international market: From 32 000 hectares of banana plantations in 1992 to over at least 50 000 hectares today.[78]

Facing a growing food crisis in 2008, Costa Rica announced during a summit on Seguridad y Soberanía Alimentaria (Nutritional Safety and Sovereignty, also called "Food for Life", in Managua that it will allocate $70 million dollars to help confront the nutrition problems of its people. This is in addition to a previous $15 million investment to boost production of local grains.[79]

Social Resilience (Table 5.1): 3.7 Threat level: medium

5.1.12.5. Ecuador (bananas)

In Ecuador, four out of ten people live in the countryside. They produce most of Ecuador's food but are almost twice as poor as the national average, according to the Ecuadorian Institute of Statistics and Census. Smallholder producers and family farmers produce most of the country's maize, rice and potatoes.[80] A household survey in Ecuador showed that the people experienced an 8% average reduction in calorie intake after the food price crisis, affecting both urban and rural households.[81] Ecuador was one of the most negatively affected countries in South America, with the general population experiencing a decrease in calorie consumption regardless of economic status. Post 1990 an increasing number of Ecuadorians had to leave their homeland for Europe due to political insecurity and social hardship, forming, e.g., the largest immigrant group in Madrid and one of the largest in Spain.[82] This emigration has significant implications for Ecuadorian families, the economy, and the nation-state, adding another layer of uncertainty to the already precarious situation.

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[78] Infocostarica, The Banana Industry, http://www.infocostarica.com/business/eco_banana.html (last visited: 24 January 2012).

[79] Costa Rica Pages, Costa Rica Allocates $70 Million to Prevent National Food Crisis, http://www.costaricapages.com/blog/costa-rica-news/million-to-prevent-national-food-crisis/916 (last visited: 24 January 2012).

[80] OXFAM (2009): The World Food Crisis - far from over, http://blogs.oxfam.org/en/blog/09-11-12-world-food-summit-far-over (last visited: 24 January 2012).

[81] International Food Policy Research Institute, The impact of the food price crisis on calorie consumption in Latin America, http://www.ifpri.org/blog/impact-food-price-crisis-calorie-consumption-latin-america?print (last visited: 24 January 2012).

[82] Jokisch, B. and Pribilsky, J. (2002): The Panic to Leave: Economic Crisis and the "New Emigration" from Ecuador, International Migration, Volume 40, Issue 4, pages 75–102.

5.1.13. Threats due to export restrictions and liberalization effects in trade policy

Authors: AWI: Christoph Tribl, Josef Hambrusch

Domestic food security can be improved either by increasing domestic production or by increasing imports.[83] Thus, the issue of food security has been addressed by countries through the following two options:[84] food self-sufficiency (i.e., the provision of sufficient domestic production) and food self-reliance (i.e., the employment of a set of policies by which international trade patterns and corresponding risks and benefits determine the sources of food). In this sense, self-sufficiency emphasizes domestic production as the major source of supply while self-reliance does not. Food self-reliance in the following sense is more commonly accepted as an appropriate means to ensure food security: *"[…] what countries need […] is sufficient capacity to generate the foreign exchange necessary to import whatever quantities they consume over and above what is sufficient to consume, based on the comparative advantage*."[85] Accordingly, food self-reliance is based on a country's ability to export goods in order to earn the funds which are necessary to pay for imports. Food self-sufficiency, in contrast, may require support for or protection of the domestic agricultural sector.[86]

In late 2007 and early 2008, the dramatic increase in commodity prices prompted various countries to impose export restrictions in order to ensure (domestic) food security.[87] Export restrictions are considered the key drivers of the "food crisis" and related price increases in the world market during 2007-2011.[88] Other contributing factors were aggressive food imports even in the case of rising prices caused by some sort of panic behaviour. Examples of export restrictions include export embargos or bans, export licenses or quotas, and export taxes, minimum export prices, voluntary export restraints or

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[83] Trueblood M. and Shapouri, S. (2001): Implications of Trade Liberalization on Food Security of Low-income Countries. Agricultural Information Bulletin No. 765-5; United States Department of Agriculture (USDA), Economic Research Service, Washington.

[84] FAO (2003): Trade Reforms and Food Security – Conceptualizing the linkages. Commodity Policy and Projections Service, Commodities and Trade Division. FAO, Rome. ftp://ftp.fao.org/docrep/fao/005/y4671e/y4671e00.pdf (downloaded: 1 March 2012); see p. 20 and 35.

[85] FAO (2003), p. 35.

[86] FAO (2003), p. 49.

[87] Mitra, S. and Josling, T. (2009): Agricultural Export Restrictions: Welfare Implications and Trade Disciplines. IPC Position Paper, Agricultural and Rural Development Policy Series; International Food and Agricultural Trade Policy Council (IPC); January 2009.

[88] Sharma, R. (2011): Food Export Restrictions: Review of the 2007-2010 Experiences and Considerations for Disciplining Restrictive Measures. FAO Commodity and Trade Policy Research Working Paper No. 32; FAO, Rome.

orderly marketing arrangements, export cartels and state trading.[89] In most cases, export restrictions to agricultural products and raw materials are applied by low-middle and low income economies.[90] In general, a mix of various instruments (both sequentially and concurrently) is implemented.[91]

Justifications for export restrictions include food security, price stabilisation, protection of consumers with low purchasing power from rising commodity prices, a large time gap between successive crop harvests, collection of government revenues (by export taxes), political reasons (e.g., pleasing before elections), etc.[92] Other rationales include the promotion of downstream industries, control of price fluctuations, and “non-economic” objectives like strategic arms control or environmental protection.[93]

Export restrictions create a price differential between the price prevailing in the domestic market (for processors and consumers) and the price charged to buyers abroad.[94] This differential favours domestic processors and induces an increase of production in the domestic processing industry which reduces efficiency. Generally, the effect of export restrictions is an increase of supply and a lower price in the domestic market in the short run.[95] However, export restrictions have undesirable long term effects for processors and consumers abroad. In most cases export restrictions aim to ensure domestic food security.[96] If they are effective, they exacerbate shortages in supply elsewhere, resulting in further price increases there. Thus if export restrictions are implemented ad hoc and in an uncoordinated way, they may increase price instability on world markets and, in turn, impair food security in other countries.[97] Export restrictions are particularly popular in times of low buffer stocks.[98] The policies of large producers like the U.S., the EU and

[89] Mitra and Josling (2009); see also Bonarriva, J.; Koscielski, M.; and Wilson, E. (2009): Export Controls: An Overview of their Use, Economic Effects, and Treatment in the Global Trading System. Office of Industries Working Paper No. ID-23, U.S. International Trade Commission; Washington, USA.

[90] Bonarriva et al. (2009); see also Bouet, A. and Laborde, D. (2010): The Economics of Export Taxation: A Theoretical and CGE-approach Contribution. http://www.oecd.org/dataoecd/56/3/43965958.pdf (downloaded: 27 February 2012).

[91] Sharma (2011).

[92] See, Mitra and Josling (2009).

[93] Bonarriva et al. (2009).

[94] Kim, K. (2010): Recent Trends in Export Restrictions. OECD Trade Policy Working Papers, No. 101, OECD Publishing.

[95] Bonarriva et al. (2009)

[96] Mitra and Josling (2009).

[97] FAO (2008): Soaring Food Prices: Facts, Perspectives, Impacts and Actions Required. High-Level Conference on World Food Security: The Challenges of Climate Change and Bioenergy; Rome, 3-5 June, 2008.

[98] Mitra and Josling (2009).

China have contributed to a rather low level of global grain stocks and to an increased global price volatility. The number of countries applying export duties over the period 2003-2009 was higher compared to previous years.[99] Export duties have been applied in particular by developing and least developing countries.

Population growth combined with economic growth (and thus a higher purchasing power of consumers) increases domestic demand, which may be a threat to food security if there are fluctuations or deficiencies in agricultural production and/or if buffer stocks are decreasing.[100] Examples for corresponding export restrictions are bans on rice exports in India in 2002 and 2008. Sharp increases in the demand of importing countries (e.g., due to appreciation/devaluation of the importer's/exporter's currency, supply volatility due to weather conditions or climate change, price reductions following tariff reductions, etc.) may cause shortages in the domestic market of exporters. A corresponding example is the increase in poultry exports due to the devaluation of the Brazilian Real in 2001 and 2002.

According to the FAO, one quarter of 77 countries surveyed (in particular East Asian and South Asian countries) used some type of export restriction as a response to the recent rise in food prices.[101] Examples of export restrictions in recent years are rice (in particular India, Vietnam, China), wheat (e.g., Pakistan, Bolivia, Russia, Kazakhstan), soybeans (Argentina, Kazakhstan), sunflower seeds (Kazakhstan).[102] Other examples include palm oil (Indonesia, Malaysia, Papua New Guinea), cotton (Pakistan), and coffee, cocoa and copra oil (Papua New Guinea).[103]

Export taxes on soy products in the case of Argentina are a prominent example of export restrictions.[104] Argentina taxed exports at 23.5% (soybeans), 19.3% (soybean meal) and 20% (soybean oil), respectively. In fact, Argentina is the leading country that has been using export taxes in terms of the exports' value. Following the devaluation of the Peso in 2002, Argentina applied export taxes to abate the impact of exchange-rate fluctuations on

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[99] Kim (2010).

[100] Mitra and Josling (2009).

[101] FAO (2008).

[102] Mitra and Josling (2009).

[103] See Bouet and Laborde (2010) who provide a list of export restrictions during the food crisis 2006-2008. An even more extensive list of export restrictions during 2007-2011 and a review of various analyses of the recent food crisis is provided by Sharma (2011).

[104] Deese, W. and Reeder, K. (2007): Export Taxes on Agricultural Products: Recent History and Economic Modeling of Soybean Export Taxes in Argentina. Journal of International Commerce and Economics; United States International Trade Commission, Sept. 2007. http://www.usitc.gov/publications/332/journals/export_taxes_model_soybeans.pdf (downloaded: 29 February 2012).

domestic products and the fall in tax revenues.[105] Export restrictions imposed by one country may induce the application of similar measures in other countries. As importing countries may look for other exporting countries, the latter may also employ export restrictions in order to meet domestic demand. An example of this is the export tax imposed in 2004 on soybeans by Paraguay (due to a lack of raw products for the domestic processing industry) as an answer to export taxes imposed by Argentina. In addition to Argentina, export taxes on soybean products have been applied by China in 2008.[106] Temporary export restrictions on soybeans were also applied by Bolivia in 2010/11.[107]

Quantitative export restrictions are – in principle – prohibited under the current WTO rules, but there is no consensus regarding a ban on export duties so far.[108] Currently, this topic is under revision at multilateral and bilateral levels. However, certain export restrictions aiming at mitigating food shortages are currently allowed in the WTO.[109]

Trade liberalization is a policy goal which requires reforms in regard of domestic support measures, export subsidies and tariffs.[110] Trade policies directly affect global and national food availability and indirectly affect food security via changes in prices and income distribution.[111] The removal of market distortions reduces the gaps between prices in different markets, and prices become more uniform across countries. Due to trade liberalization, the relative prices of traded and non-traded goods and factors change, along with the allocation of resources. Whether a certain sector benefits from trade liberalization depends on the flexibility of production and trade structures, the degree of market access, the development of institutions, etc.

Changes in (global) trade policies particularly affect food security of low-income countries.[112] For these countries that are generally dependent on food imports, global trade liberalization (e.g. the abolishment of certain subsidies and other trade-distorting measures) imposes costs as world food prices increase. The ability (i.e., budgets) to import food may be limited for some countries; however, other countries may be able to increase their exports as prices rise and production takes off. Because trade liberalization

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[105] Kim (2010).

[106] See also Sharma (2011).

[107] WTO – OECD – UNCTAD (2011): Reports on G20 Trade and Investment Measures (Mid-October 2010 to April 2011). http://www.oecd.org/dataoecd/20/46/47955250.pdf (downloaded: 29 February 2012).

[108] Kim (2010).

[109] WTO – OECD – UNCTAD (2011).

[110] FAO (2003), p. 38.

[111] FAO (2003), p. 19.

[112] Trueblood and Shapouri (2001).

removes restrictions on access to markets, domestic food security may improve. As price gaps between countries narrow, producers in developing countries may increase their exports.

5.1.14. Threats due to Excessive Population Growth

Authors: ÖVAF: Martin Maria Krachler, Martin Weigl

Most of population growth will be realized in Developing Countries and Transition Economies. Although population growth in Asia will slow down, Asia, particularly China, India and Southest Asia, will account for about 60% and more of the world's population by 2050 (UN Population Division, 2010).

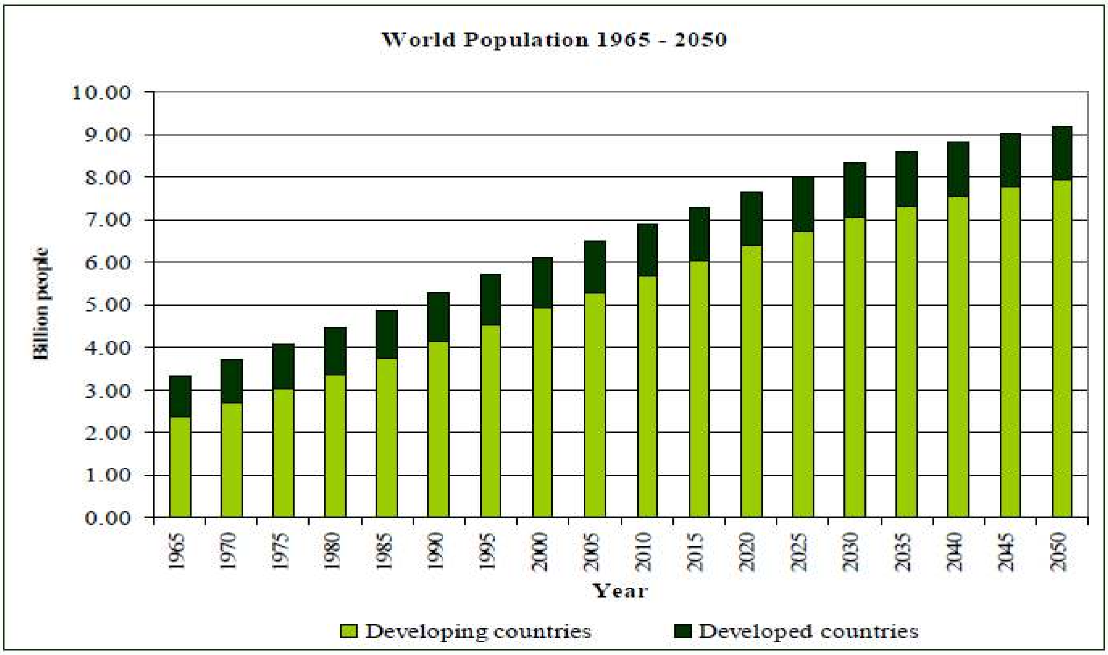

Figure 46: UN population prospects (medium variant)

Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2007)

The rate of population growth, however, is still relatively high in Central America, and highest in Central and part of Western Africa. In relative numbers, Africa will experience the most rapid growth, over 70% faster than in Asia (annual growth of 2.4% compared with 1.4% in Asia, compared to the global average of 1.3% and only 0.3% in many industrialized countries) (UN Population Division, 2007). In sub-Saharan Africa, the population is projected to increase from about 770 million to nearly 1.7 billion by 2050. The Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat estimated the growth of world population by 34% from 7 billion today to 9.3 billion in 2050, this will particularly take place in urban areas (Figure 63) (UN Population Division, 2007).

5.1.15. Global Competition on International Commodity Market

Authors: AWI: Christoph Tribl, Josef Hambrusch, Karl Ortner

In general, markets as well as market prices are working on the basis of offer and demand. Markets are also characterised by the power of sellers and buyers in a specific commodity market- *buyer's market* und *seller's market*. A buyer's market consists of a oligopoly of buyers and a polypoly of sellers. National agricultural markets normally claim a buyer's market, meanwhile in world markets the situation is totally different for most agricultural commodities.

Since 1994, when WTO (World Trade Organization - in which GATT was institutionalized) came into force, export subsidies for agricultural shipments had to be lowered and finally abolished. This resulted in the diminishing of sellers on world markets and less competition for those who are subsidizing commodity prices by giving direct payments to their producers, which are in line with the WTO - A.o.A (Agreement on Agriculture) and allow lower shipment prices for export reasons.

Growing Population

Food demand will rise significantly in the time leading up to 2050, because of growing populations and incomes in emerging and developing countries. In the chapters above it can be deduced that especially in developing and least developed countries the growth rate of population is much higher than the growth rates of production, which means more import quantities. The consequences will be higher demand on world markets, which normally leads to higher competition and price. By 2050 world's population is expected to exceed 9 billion people, causing an increase of food demand by between 70% and 100%, compared with today's demand. Latest medium term outlooks done by OECD/FAO this will end up in higher prices for crops and most livestock products as well as nominal terms during this decade. Prices will be significantly higher than they were before the 2007/2008 price spikes. This situation combined with already tight supply - demand balance and a demand or supply shock will finally lead to increased volatility toward the upward trend.

Higher Yield Variability

Changing weather conditions - climate change and more frequent occurrence of droughts, floods and other weather related events can lead to sharp shifts in yields, which will have striking consequences on available food offer and finally on commodity prices. In the past low stocks relative to use, as well as uncertainty about stock levels in some parts of the world, contributed strongly to the 2007/2008 price spike - a situation that can occur in any year to come. As soon as stocks have been depleted, supply cannot be increased until the next harvest. Even negative expectations of weather conditions and consequently lower yields express in higher prices and export restrictions in the producer countries possibly affected. On the other hand even expectations of depleted stocks already lead to sharply rising commodity prices as it occurred already in the past.

Rising Demand

Demand is not only rising because of growing world population but also because of growing demand for animal products, which - depending on the animal - need more or less kilograms of input for one kilogram of animal protein output. This rising demand also depends on the general economic evolution in developing as well as in emerging national economies. Positive economic development results in changing diets, including higher calorie intake per capita and day as well as more diets based on animal. Combined with the growing world population, this finally results in exponential growth of demand for primary agricultural products, leading to higher prices for the latter.

On the other hand there is growing demand for raw material in the bio fuels industry, which got competitive by rising petrol prices, as well as for environmental reasons, which led to new legal obligations for adding bio fuels to motor fuels in cars and trucks.

Growing Sensitivity to Stock Changes

In 2007/2008 weather conditions had already contributed definitely to the price rises. In the case of wheat prices the drought, which hit Australia, an important supplier of world wheat markets, indisputably had a big claim on the steep price rises of 2008. Canada also experienced weather related low yields in 2008 not only concerning wheat but several other crops, being another very important supplier. In 2010 and early 2011 the market saw strong market reactions and booming prices after periods of drought, which were followed by fire catastrophes which devastated the Russian Federation and its cereal production severely, insecurities about Argentinean and once again Australian crop production in addition to several downward revisions of US crop forecasts. Following the basic law of price fixing - demand and offer build the market price - stocks went down to historical low quantities and growing demand boosted prices and many countries tried to keep their stocks to be able to provide their populations with the necessary grain.

Following the fact that most of industrialized countries do not have big public stocks anymore - having introduced the wrong OECD philosophy that private markets will always provide sufficient food at reasonable prices - countries like the USA and the EU as well as Russian Federation introduced export prohibitions and/or a system of export licenses.

All these incidences mostly and very seriously hit the most vulnerable developing countries in all the world.

It’s a fact, already proven by above mentioned recent events, that prices for the main food crops traded on world markets, like maize and wheat are strongly and inversely linked to changes in stocks-to-use ratios. In the case of ratio increases, e.g. strong supply and/or low demand, prices normally decrease. The opposite is the case when ratio drops. Price elasticity increases if stocks decrease.

Growing Price Variability

If we follow the above information that showed factors influencing prices over time, we can conclude that price volatility is not only a current fact, but one that increases over time, which hardens the situation not only for consumers but also for producers. International organizations like FAO, World Bank and OECD agree on the proven fact that agricultural commodity prices as well as agricultural input prices are here to stay!

Across commodity markets in general there are some common factors that appear to be at play, added to these there are existing specific factors related to agricultural production - linkage to food security, environment, dependency on life cycles, weather conditions and seasonality, sanitary conditions, etc. - which further complicate to substantiate and predict exact future price movements.

One of the basic questions is if the weather disasters in the past years have only been consequences of El Niño and La Niña, being punctual occurrences or the first consequences of what is described as climate change.

In any case, efforts to increase agricultural production must be multiplied in the years to come in order to be able to guarantee an adequate diet and nutrition for all of the world's population at accessible prices and not only for those people living in countries with sufficient purchasing power.

5.1.16. Acquisition of Agricultural Land in Exporters to Austria

5.1.16.1. Current Situation

Land grabbing is the contentious issue of large-scale land acquisitions by either buying or leasing of large pieces of land in developing countries, by domestic and transnational companies, governments, and individuals. While used broadly throughout history, land grabbing as used today primarily refers to large-scale land acquisitions following the 2007-2008 world food price crisis.[113] By prompting food security fears within the developed world and newfound economic opportunities for agricultural investors and speculators, the food price crisis caused a dramatic spike in large-scale agricultural investments, primarily foreign, in the Global South for the purposes of food and biofuels production. Initially hailed by investors and some developing countries as a new pathway towards agricultural development, investment in land has recently been criticized by a number of civil society, governmental, and multinational actors for the various negative impacts that it has had on local communities.[114]

[113] Borras Jr., S.M.; Hall, R.; Scoones, I.; White, B. & Wolford, W. (2011): "Towards a better understanding of global land grabbing: an editorial introduction". The Journal of Peasant Studies 38 (2): 209.

[114] Obtained from Wikipedia: http://en.wikipedia.org/wiki/Land_grabbing (last visited: 17 February 2012.

The term "land grabbing" is itself a controversial issue. Borras and others describe that "the phrase 'global land grab' has become a catch-all to describe and analyse the current explosion of large scale (trans)national commercial land transactions".[97]

Meanwhile, Ruth Hall of the Institute for Poverty, Land and Agrarian Studies notes that "the popular term 'land grabbing', while effective as activist terminology, obscures vast differences in the legality, structure and outcomes of commercial land deals and deflects attention from the roles of domestic elites and governments as partners, intermediaries and beneficiaries".[115]

The most comprehensive estimate of the scope of land acquisition, published in September 2010 by the World Bank, showed that over 46 million ha in large scale farmland acquisitions or negotiations were announced between October 2008 and August 2009 alone, with two-thirds of demanded land concentrated in Sub-Saharan Africa.[116] It is important to note that of the World Bank's 464 examined acquisitions, only 203 included land area in their reports, implying that the actual total land covered could more than double the World Bank's reported 46 million ha. The most recent estimate of the scale, based on evidence presented in April 2011 at an international conference convened by the Land Deal Politics Initiative, estimated the area of land deals at over 80 million ha.[117]

Of these deals, the median size is 40,000 ha, with one-quarter over 200,000 ha and one-quarter under 10,000 ha. 37% of projects deal with food crops, 21% with cash crops, and 21% with biofuels. The target locations of most land grabs lie in the Global South, with 70% of land grabs concentrated in Sub-Saharan Africa. Other primary areas of note are in Southeast Asia and Latin America. Some affected countries respond to the increasing land purchases:

- Since 2010 Brazil has been stricter in enforcing an existing law that limits the size of farmland properties foreigners may purchase. This has halted a large part of projected foreign land purchases.118

115 Hall, R. (June 2011): "Land grabbing in Southern Africa: the many faces of the investor rush". Review of African Political Economy 38: 193.

116 Deininger, K. and Derek, B. (2010): Rising Global Interest in Farmland: Can it Yield Sustainable and Equitable Benefits?, The World Bank. (last visited: 8 January 2012).

117 Borras, J.; Scoones and Hughes, D. (2011): "Small-scale farmers increasingly at risk from 'global land grabbing'", The Guardian.co.uk: Poverty Matters Blog Retrieved 22 August 2011.

118 Voss, P. (2011): Farmland Investment, a farmland brokerage. Retrieved 30 November 2011. "restrictions now limiting the size of farm land..." http://www.argentina-estancias.com/inflationhedge-farmland.htm (last visited: 14.1.2012).

- In Argentina, as of September 2011, a projected law is being discussed in parliament that would restrict the size of land foreign entities can acquire to up to 1000 hectare.[102]

Austria's foodstuff imports are mainly provided by EU members (for detailed information see WP1). However, there are two sectors that are strongly dependent on non-EU countries, i.e., soy and bananas. Land grabbing may cause decreased production in the exporting countries and therefore decreased export capacity. As a result imports from these countries may generate higher costs, decrease in volume or even stop. In the following pages the extent of current land grabbing for the exporters of bananas and soy to Austria is evaluated.

5.1.16.2. Argentina

About 17-30 million ha of land are purchased by non nationals, which corresponds to 6-10% of the total land in Argentina. The largest land owner is the *America International Group* (AIG), possessing 1.5 million ha followed by Lucio Benetton from Italy (0.9 million ha).[119]

In 2011 a law on land grabbing and the laws of non-nationals were debated, including following features:

- Size of the property,
- requirements for non-national companies or individuals allowed to purchase land,
- restrictions associated with location and characteristics of the property (borders, coasts, river basins, wetlands, etc.),
- terms of compliance of current owners with the new legislation,
- minimization of the risk of losing control of natural resources.

The proposed laws do not affect existing land holdings. It would limit the maximum amount of land a foreigner can purchase to 1,000 hectare in the agricultural heartland. Further, it limits the maximum share of the entire land, single provinces and single municipality to 15%, respectively. As of 2011 none of the 8 proposed laws were passed.[120]

National Resilience: 4

[119] Cap, J.E. and Malach, V.N. (2011) Land Grabbing in Argentina, HFFA annual meeting, Berlin, January 2011.

[120] Voss, P. (2011): "Farmland Investment", a farmland brokerage. Retrieved 30 November 2011. "discussed in congress that would limit the maximum..."http://www.argentina-estancias.com/inflationhedge-farmland.htm (last visited: 14 January 2012).

Conclusions: Argentina has not yet introduced laws to limit the area that might be purchased by foreigners. However, the arable land that is still unused (non forest, population density below 25/km and unprotected) accounts only for around 10% of the total land. Therefore, the threat level of reduced soy export to Austria due to land grabbing is considered medium.

5.1.16.3. Brazil

Currently around 4 million ha of land are in the hands of non-nationals which corresponds to 0.47% of the total area of Brazil. Since August 2010, Brazil has enforced a long existing law in a stricter way that limits the size of farmland properties foreigners may purchase, having halted a large part of projected foreign land purchases. The restrictions now limit the size of farm land foreign entities can buy. The maximum amount of land a foreigner can purchase ranges from 250 ha in densely populated, intensively farmed regions up to 5,000 ha in sparsely populated regions like Amazonia.[121] As in Argentina, established holdings are not affected. The law actually dates from 1971, however, until recently there did not exist not the political will to exercise it.[122]

National Resilience: 4

Conclusions: The area of Brazilian land purchased by foreigners is relatively small (0.47% of total land). The unused arable land (non forest, population density below 25/km and unprotected) accounts for around 5% of the total land. Further, an old law limiting the area that a foreigner may buy has been enforced since August 2010. Therefore, the threat of reduced soy export to Austria due to land grabbing is considered low.

5.1.16.4. Colombia

About four million Colombian people have been displaced from an estimated 5.3 million ha of land in the last decade.[123]

The Colombian agricultural sector needs bold reforms. Around 21.5 million ha of arable land lie idle while an area of not more than 4.9 million ha is cultivated. On the other hand 5.8 million ha are dedicated to mining and 31.6 million ha to livestock production.[124] There are two main reasons hindering agricultural development:

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[121] Obtained from Wikipedia: http://en.wikipedia.org/wiki/Land_grabbing (last visited: 16 February 2012).

[122] http://www.argentina-estancias.com/inflationhedge-farmland.htm (last visited: 16 February 2012).

[123] Ojeda, D. (2011): Whose Paradise? Conservation, tourism and land grabbing in Tayrona Natural Park, Colombia. PDPI International Conference on Global Land Grabbing. Brighton, UK.

[124] Castaneda, S. (2011): Preventing foreign land grabs in Colombia. Reports, 30 September 2011, http://colombiareports.com/opinion/117-cantonese-arepas/19364-preventing-land-grabs-by-foreigners-in-colombia.html (last visited: 8 January 2012).

- Land grabs by illegal armed groups.
- Land without legal titles.
- According to the Colombian government an estimated area of 6 million ha is controlled by paramilitaries, guerrillas and other armed groups. NGO estimates are higher still.125
- Land without legal titles is a big problem. According to the Ministry of Agriculture, of the 3.7 million land properties in the country, 40% present land or title-related problems. As a result, owners do not realize the economic value of their land: Small farmers could borrow money from banks against land titles to acquire machinery and increase efficiency and profitability. Government's taxes intake do not correspond to the production. Further, the untitled land increases violence, since armed groups aim to control these areas.

These realities contribute to Colombia's extreme land inequality. According to a report by the United Nations Development Programme (UNDP), 1.15% of Colombia's population owns 52% of the country's land. Paradoxically these internal problems have to some extent benefited Colombia by hindering the phenomenon of foreign land grab.[126]

National Resilience: 4

Conclusions: In Colombia there are vast amounts of cultivable areas that are not used yet. Land grabbing is not a big issue at the moment, since Colombia struggles with internal problems. However, when these problems are overcome there are no laws prohibiting foreigners from buying and leasing vast areas of potential agricultural land. Therefore, the threat level for reduced banana export to Austria due to land grabbing is considered low at present.

5.1.16.5. Costa Rica

Purchasing and registering of an estate is well organized in Costa Rica.[127] The presence of foreign investment is rather low when compared to other Latin American countries. There is little to no occurrence of foreign land grabbing and the impact of investment on the food security of the recipient country is negligible. Further, Costa Rica itself is a major investor into other countries in the region.[128]

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[125] Santos, J.M. (2011): El Pais, http://www.elpais.com.co/elpais/colombia/noticias/juan-manuel-santos-denucio-robo-tierras-en-meta (last visited: 13 February 2012).

[126] Bargent, J. (2011): Colombian rural reforms needs more state intervention: UNDP. Colombia Reports.

[127] Obtained from: http://www.bauminvest.de/nachhaltigkeit/im-fokus-land-grabbing/ (last visited: 14 February 2012).

[128] FAO (2011): The State of Food Insecurity in the World 2011. http://www.fao.org/publications/sofi/en/ (last visited: 12 February 2012).

National Resilience: 3

Conclusions: Costa Rica's food security is not threatened by land grabbing. Therefore, the threat level for reduced banana export to Austria due to land grabbing is considered low at present.

5.1.16.6. Ecuador

The arable land that is still unused (non forest, population density below 25/km and unprotected) accounts for solely 2.4% of the total land.

According to FAO[129] there are currently large investments in Ecuadorian land. Also, the presence of land grabbing is rated high in comparison to other Latin American countries. The biggest investors are Japan and Ecuador. However, their impact on food security is rated negligible.

National Resilience: 4

Conclusions: Ecuador's food security is not threatened by land grabbing, despite of the rather large scale of ongoing investments. Therefore, the threat level for reduced banana export to Austria due to land grabbing is considered low at present.

5.1.16.7. USA

The arable land in the US that is still unused (non forest, population density below 25/km and unprotected) accounts for less than 1% of the total land. Nevertheless, the United States are a net "land-investor", i.e., they invested in land in several countries:

National Resilience: 2

Conclusions: The United States are no target for land grabbing. Therefore, the threat level for reduced soy export to Austria due to land grabbing is considered low.

5.2. Assessment of potential future political, military and other security threats in 2030 and 2050, assessment of potential future socio-economic threats in 2030 and 2050

The price of food started rising significantly in late 2006. This price increase continued in 2007 and reached its maximum value in 2008. As a result, millions of people living at or

[129] FAO (2011): The State of Food Insecurity in the World 2011. http://www.fao.org/publications/sofi/en/ (last visited: 12 February 2012).

near the poverty line in urban areas could no longer afford to purchase their daily food. As one of the consequences riots over affordable food occurred in several countries, e.g., Haiti and Mozambique.

Various factors put increasing pressure on food production. On the one hand, population growth requires a significant increase in food production. The Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat estimated the growth of world population by 34% from 6.8 billion in 2010 to 9.1 billion in 2050.[130] This growth will take place predominantly in urban areas. On the other hand, skyrocketing speculations on agricultural commodities destabilize the market. According to a UN report, the total value of the speculative investments in commodity indexes has increased an estimated twentyfold in five years: From an estimated $13 billion in 2003 to around $260 billion by the end of 2008.[131] Rising food prices are usually linked to demand and supply factors, respectively. These are, e.g. population growth, ethanol and bio fuel production, land and water constraints or seasonality. While these factors are relatively predictable, trade policies and speculations on commodities are identified as contributors to price volatility. Further, bio fuel production, increasing meat consumption in growing populations like China, and the imminent climate change pose additional challenges.

This report aims to assess the future stability of Austria’s trading partners with respect to the commodities of high strategic importance. Austria is heavily dependent on imports of protein feedingstuff, energy and fertilizer. These imports are the key to currently relatively high self-sufficiency rates for animal products. To assess the risk of future shortages with respect to imports of high strategic importance, the probability of future military conflicts and social unrest, and a variety of other problems that potentially threaten Austria’s suppliers are addressed.

5.2.1. Objectives of the Work Package

Chapter 5.2 (WP 2) aims to identify, describe and assess potential future political, military, socio- economic and other security threats of exporting regions relevant for the feed, food and energy supply of Austria. In view of its membership in the European Union, all EU Member States exporting feed, food or energy to Austria are considered as stable trading partners and therefore excluded from this analysis.

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[130] United Nations (2007): World population prospects – The 2006 Revision, Highlights. Department o Economic and Social Affairs. Working paper No. ESA/P/WP.202. http://www.un.org/esa/population/publications/wpp2006/WPP2006_Highlights_rev.pdf (downloaded: 25 April 2012).

[131] Institute for Agriculture and Trade Policy (2008): Commodities Market Speculation: The Risk to Food Security and Agriculture, p.7. IATP, Minneapolis, Minnesota. http://www.iatp.org/files/451_2_104414.pdf (downloaded: 25 April 2012).

5.2.2. Methodology

This report analyses the potential security threats to the main exporters of crude oil, natural gas, soy and phosphate fertilizer to Austria in the year 2015, 2030 and 2050.

The potential interruption of exports of bananas, vitamins, essential amino acids, potassium fertilizer and pesticides are not considered of strategic importance. Exporters of these commodities to Austria are already EU member states or current non-EU exporters which can be replaced by EU member states with relative ease, should the need for substitution arise in the future.

5.2.3. Assessment of Potential Future Political, Military, Socio-Economic and Other Security Threats to Exporting Countries

5.2.3.1. Crude Oil

Potential future security threats to crude oil exporting countries to Austria are listed and analysed in this section. Forecasts are made for the years 2015, 2030 and 2050. The main crude oil suppliers to Austria are (in descending order with respect to amount of the respective good):[132]

- Kazakhstan
- Libya
- Nigeria

Table 46 describes Austria's crude oil suppliers' current resilience with respect to political and social threats, respectively, as well as the countries' reliability as a supplier in a quantitative manner. For comparison, also the values for Austria are given. Values for Political Resilience (PR), Social Resilience (SR) and National Resilience (NR) range from 1 to 5 each. The lower the value, the higher the resilience of the country. Political and Social Resilience are both based on a set of 4 "sub-indices" that are themselves based on a variety of indices, which were previously defined and developed by renowned organizations. The National Resilience summarizes the values of PR, SR and additionally takes into account the country's resources of the respective good. Details on the derivation of the numerical values are given in WP 2 (Chapter 3.1).

Table 29: National resilience score with regard to crude oil for Austria's key suppliers and, for comparison, Austria

	Political Resilience (PR)	Social Resilience (SR)	National Resilience (NR)
Austria	1	1.25	**3**

[132] For more details on supplying countries: see WP 1.

Kazakhstan	2	3.3	3
Libya	5	4	5
Nigeria	4	4.5	4

Kazakhstan

Forecast 2015

With Kazakhstan having the second largest oil reserves and the second largest oil production among the former Soviet republics after Russia,[133] its large reserves of natural gas, and steadily increasing production of both oil and gas, the country is on its way to become one of the key global suppliers of hydrocarbons by 2015.

Internal security is high and is likely to continue at the same level in view of the stable domestic political situation under President Nursultan Nazarabyev, the continual strengthening of its political and economic ties with neighboring Russia and China and the absence of any current conflict situation with these countries.

Forecast 2030

Following the dissolution of the Soviet Union, Kazakhstan gained independence in 1991. Since 2000 the country has experienced the fastest economic growth in the region, with an average annual GDP growth rate of about 8.5%.[134] The political leadership has been dominated by President Nazarabyev ever since gaining independence, reconfirmed in his re-election in April 2011 making him president until 2016. However, in view of his age (70 years) change is due to happen in the second half of this decade, i.e., by 2030 a new leadership will rule the country. The only political party ruling the parliament at present is the Nur Otan Party. Due to the lack of any comparable political opposition, it is safe to assume that also in the decade following President Nazarbayev's time in office the Nur Otan Party will be responsible for selecting the successor. Also, in view of the currently genuine support by a wide sector of the public for the politics offered by the Nur Otan Party Kazakhstani citizens are unlikely to jeopardize the prosperity and stability gained under its programmatic leadership. Therefore, internal unrest is improbable for the period until 2030.[135]

[133] US Energy Information Administration (November 2010): Kazakhstan http://205.254.135.7/countries/cab.cfm?fips=KZ (last visited: 14 January 2012).

[134] Kazakh British Chamber of Commerce (2009): Kazakhstan Economy Outlook http://kbcc.org.uk/en/business-info/kazakhstan-economy-outlook/ (last visited: 1 March 2012).

[135] Business Monitor International (2011): Q3 2011: Kazakhstan and Central Asia Business Forecast. Released: 2 June 2011.

External security threats could hypothetically arise from its neighboring Russia and China (P. R.). However, Russia, Belarus and Kazakhstan have agreed to establish a Eurasian economic union, similar to the European Union by 2015. With regard to China economic and political ties are deepening, e.g., the National Bank of Kazakhstan intends to diversify its foreign exchange reserves into Chinese Yuan and doubling bilateral trade up to $40 billion by 2015.[136]Furthermore, Kazakhstan and China are part of the mutual-security oriented *Shanghai Cooperation Organisation*. Therefore, the probability of a security conflict of Kazakhstan with either country is low over the next two decades.

A potential security conflict could arise from Kazakhstan's dependence on transit rights for its pipelines to the Black Sea and Mediterranean Sea, e.g., political pressure originating from Azerbaijan, Turkey or Georgia. However, in the past five years Kazakhstan has had one of the fastest growing military budgets in the world, reflecting its aim to change the current – largely Soviet area based - military structure in line with its growing responsibility for securing the integrity of the country and its wealth in natural resources (oil, gas, uranium, rare earths, gold, etc.).[137] This includes ensuring the security of pipelines and associated transit routes for oil- and gas exports. Taking into account the importance of oil- and gas exports for Kazakhstan's national GDP, the country will surely pay major attention to minimizing any such security threat to its hydrocarbon exports also in years up to 2030.

Forecast 2050

The subsequent period 2030 to 2050 can be characterised by an assumed further economic growth period, based on the commodities sector and increasingly also on diversification into other sectors. This growth pattern will also result also in an increased national demand for energy by its citizens, likely to increase significantly from its current level. Unless the national infrastructure can adapt to this higher national demand for oil and gas, the fraction available for export will decrease. Therefore, the export quota dedicated for Austria in 2050 may be lower than when compared to 2030.

Expectations

In Central Asia Kazakhstan can be expected to be a stable trading partner for oil- and gas exports to Austria in 2015 and in the subsequent period to 2030.

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[136] Kazakhstan, China to double bilateral trade by 2015. By SRI, posted 27 September 2011, Silkroadintelligencer. http://silkroadintelligencer.com/2011/09/27/kazakhstan-china-to-double-bilateral-trade-by-2015/) (last visited: 1 March 20012).

[137] American expert talks about future of Kazakhstan army. Tengri News, 8 February 2012 http://en.tengrinews.kz/military/7455/ (last visited: 2 March2012).

Kazakhstan's continuing role as an important oil- and gas exporter to Austria up to 2050 will depend largely on the further domestic economic development in Kazakhstan and the ability of the country to match the correspondingly larger demand at the national level. There is no reason to assume that the national oil- and gas exploration and distribution infrastructure will not be adapted to meet the likely increased national demand. Therefore, the high level of reliability in hydrocarbon exports to Austria can also be expected to continue until 2050.

Libya

<u>Forecast 2015</u>

Prior to the killing of Libya's political leader Col Muammar Gaddafi the country had the third highest Gross National Income (GNI) per capita, the highest human development index (HDI) in Africa, resulting, for example, in the provision of free universal health care and free education to its citizens.[138] However, after the cessation of hostilities most formal business activity has been impeded to a significant extent and national oil output is estimated to have fallen by 70% in 2011. Since the economy contracted an estimated 27.9% in 2011[139], it is unlikely that the former social security network will be fully re-established by 2015. This represents an inherent risk potential for future social unrest.

The National Transitional Council (NTC) and its interim government face a significant internal threat over the next few years, represented by the former rebel forces roaming largely uncontrolled in the streets and urban areas at present. These groups, partially heavily armed, will have to be disarmed and re-integrated into civil society. Parallelly, the NTC needs to rebuild the shattered economy and create functioning institutions in order to fulfill its promise of transition to democracy. Furthermore, in the recent past ethnic clashes in the remote south of the country are threatening to disrupt the timetable for elections in early 2012, for example:

- **2012** January - Clashes erupt between former rebel forces in Benghazi ss a sign of discontent with the pace and nature of change under the governing NTC. The deputy head of the NTC, Abdel Hafiz Ghoga, resigns. Clashes break out between NTC militiamen and armed locals in the former Gaddafi stronghold of Bani Walid.
- **2012** February - Scores killed in clashes between Arab Zawi and African Tebu groups in Al-Kufra in the remote south-east.

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[138] AEO(2011): Libya. OECD Development Centre, Issy les Moulineaux, France. http://www.africaneconomicoutlook.org/en/countries/north-africa/libya/ (last visited: 1 March 2012).

[139] The Economist Intelligence Unit (EIU, 2011): Libya http://viewswire.eiu.com/index.asp?layout=VWCountryVW3&country_id=1200000320&rf=0 (last visited: 1 March 2012).

Although the war in 2011 caused a near halt of Libya's oil production, at present oil sites are guarded by fighters. Libya has boosted oil production to 1.4 million barrels per day (bpd) in February 2012 and there are plans to increase oil production capacity to 2.5 million bpd by 2015.[140] Since many oil sites were not as badly damaged as previously assumed, recovery may be relatively quickly. For example, the important Zawiya oil refinery is currently refining at a similar output as before the war. If the NTC is able to maintain national security despite the strong centrifugal forces aiming to split the country along ethnic lines and impacting on the power over oil-rich regions, it can be assumed that the national oil output may recover again to pre-conflict output levels of 2012. Thereby, the revenue earned from the energy sector will be available to finance the reconstruction efforts in the near term. Under these assumptions it is estimated that growth will recover rapidly in the next few years, averaging 12.2% a year in the 2012-16 forecast period.[141]

Forecast 2030

Regional schism will represent the main security threat in the meantime. This is clearly reflected in the increased tension building up already between the different regions over the election law. When the NTC published the final draft of its election law, it awarded 102 of the assembly's 200 seats to the west, allocating just 60 to the east. If this would be followed through, the west would have the power to overrule the rest of the country in a vote. Expectedly, this resulted in a conference of tribal leaders and militia commanders, who declared unilaterally a semiautonomous state in Libya's oil-rich east.[142] Since this attempted secession is unlikely to be accepted by the political powers in Tripolis and throughout western Libya, increasing political tension over the autonomy of certain regions is due to be on the political agenda for years to come. It cannot be excluded that the country will see a revival of the pre-Gaddafi three-state system, with Libya governed on the basis of the old Roman provinces of Tripolitania in the west, Fezzan in the southwest and Cyrenaica in the east.

An equally important issue over the next two decades will be the correction of the potential tribal-based political discrimination and transform the country into a party-based system. This requires that the NTC enables Libya's society to pass three critical stages in a peaceful and transparent manner: (1) starting point, (2) transitional period, and (3)

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[140] AEO(2011): Libya. OECD Development Centre, Issy les Moulineaux, France. http://www.africaneconomicoutlook.org/en/countries/north-africa/libya/ (last visited: 1 March 2012).

[141] The Economist Intelligence Unit (EIU, 2011): Libya http://viewswire.eiu.com/index.asp?layout=VWCountryVW3&country_id=1200000320&rf=0 (last visited: 1 March 2012).

[142] Benghazi Breakaway Highlights Libya's Uncertain Future. By A. Hauslohner, Time World, 7 April 2012. http://www.time.com/time/world/article/0,8599,2108425,00.html?xid=gonewsedit (last visited: 10 March 2012).

consolidation in order to become the desired fully fledged democracy.[143] So far, only phase one has been successfully accomplished. Since Libya did not have any multi-party system for about four decades, its lack of experience in such a system is improbable to be overcome in two decades only. Therefore, reoccurring phases of political instability are more likely than not.

Forecast 2050

This period will probably suffer from continuing tensions between Islamists and secularists in Libya's society. Mustafa Abdul Jalil, who presides over the NTC and who was Col Gaddafi's justice minister, made it clear from the onset of his work for the NTC that Islamic law would be the foundation of future national legislation.[144] If the current tendency of Libya to become increasingly a haven for hard-line Islamic extremists is not curtailed, a new generation of Libyan youth – suffering from high unemployment rate – may well be inclined to follow the proven track record of Islamic parties, such as Hamas, to provide an alternative for this otherwise no-future generation. This has the potential to cause extreme internal tensions with a hitherto rather limited role of religion in every day affairs of large segments of the currently largely secular Libyan society.

Expectations

Libya's future development is highly uncertain due to the physical and political devastation caused by the regime change induced by Western powers in 2011. The country will remain threatened along multiple internal fault lines, ranging from political centrifugal forces potentially splitting the country along tribal groups, to high social tensions caused by increasing impoverishment of the youth, and religiously motivated clashes between Islamic extremists and secular segments of society. All of these internal factors can impede the reliability of hydrocarbon exports from Libya to Austria over the next years and even decades to come. If the latent conflict potential with its neighbors is taken into account as well, the uncertainty in terms of national security is significant and Libya's ability to act as a reliable exporter to Austria is rather questionable.

Nigeria

Forecast 2015

[143] Libya: A Look At The Post-Gaddafi Future. By P.R. Ghosh, International Business Times, 3 Septemer 2011. http://www.ibtimes.com/articles/208074/20110903/libya-rebels-tnc-gaddafi-future-africa-arabs-war-oil.htm (last visited: 10 March 2012).

[144] Lybia Profile. BBC News Africa, 26 January 2012. http://www.bbc.co.uk/news/world-africa-13754899 (last visited: 12 March 2012).

Nigeria, the most populous country in Africa and also Africa's biggest oil producer, will remain highly dependent on the oil and gas sector as the basic contributor to its GDP. Income from Liquefied Natural Gas (LNG) will probably be higher than that of oil revenues, i.e., the financial situation will improve further. Lack of transparency and rampant corruption will remain a major issue. Deficits in applying the rule of law in the Niger-Delta, coupled with increasing religiously motivated violence, will continue over the next few years and may even intensify. Renewed rows over borders with Cameroon, Niger and Chad over Lake Chad cannot be excluded in the near term.

Forecast 2030

Nigeria will face increasing security threats due to internal ethnical and religious conflicts. Below major security-pertinent events in the recent past are summarized:[145]

2010 December - Christmas Eve bomb attacks near central city of Jos kill at least 80 people. Attacks claimed by Islamist sect Boko Haram spark clashes between Christians and Muslims. Some 200 killed in reprisal attacks.

2011 July - Government indicates the start of negotiating with the Boko Haram Islamist group blamed for a series of recent attacks across northern Nigeria.

2011 August - Suicide bomb attack on UN headquarters in Abuja kills 23 people. Radical Islamist group Boko Haram claims responsibility.

2011 November - At least 63 people are killed in bomb and gun attacks in north-eastern town of Damaturu. Boko Haram claims responsibility. President Jonathan sacks the head of Nigeria's anti-corruption agency, saying that the body has failed to get to grips with graft during her tenure.

2011 December - Nearly 70 people are killed in days of fighting between security forces and Boko Haram militants in north-eastern states of Yobe and Borno. Christmas Day bomb attacks kill about 40 people. Boko Haram claims responsibility. President Jonathan declares state of emergency to contain violence by Boko Haram.

2012 January – A fuel price strike causes major disruption. Unions suspended action when the government reversed a decision to drop fuel subsidies. More than 100 killed in single day of coordinated bombings and shootings in Kano, shortly after Boko Haram tells Christians to quit the north.

[145] Nigeria Profile. BBC News Africa, 24 January 2012. http://www.bbc.co.uk/news/world-africa-13949550 (last visited: 26 January 2012).

Although Nigeria is Africa's leading oil producer; more than half of its people live in poverty. A significant portion of Nigeria's oil production sector is subject to political and ethnic violence against citizens as well as foreigners.

In view of widespread corruption the current administration under President Goodluck Jonathan has introduced several measures aimed at strengthening good governance of the country, such as by improving transparency and efficiency. Furthermore, the administration aims at further developing Nigeria's gas reserves.[146] However, traditionally weak political institutions and the country's overall low level of infrastructure nationwide pose major constraints on a significant change of the present dissatisfactory situation in the mid-term. Coupled with a high crime rate, national security outlook in general and in the energy sector in particular are characterised by the potential for significant instability in 2030.

Forecast 2050

Concerning Nigeria's security situation beyond 2030, the nexus between demographic trends, energy supply and economic development has to be taken into account.

In terms of *population growth*, the %age of the working age population will rise from 54% in 2012 to around 60% in 2030.[147] It can be anticipated that – unless strict birth control measures will be enforced at the national level – this trend will continue unabatedly. In view of the increasing influence of Islamic extremism and inadequate public infrastructure, adequate *planned parenthood* at the national level is rather improbable. Extrapolating from current unemployment, which has already reached intolerable levels especially among college graduates, it is difficult to envision a major change in the next few decades, particularly accounting for the continuing demographic pressure. Although Nigeria has significant economic potential due to a large domestic market and abundant natural resources, a positive outlook is highly dependent on improving the currently inadequate use of oil revenues. At present the distribution of wealth is clearly one sided, with emphasis on further strengthening of the wealthy elite, thereby fueling further social tensions.

Despite Nigeria having an array of conventional energy resources - crude oil, tar sands, natural gas, hydro and coal - the country suffers from a chronic shortage of electric energy;[148] for example, over 80% of Nigerian businesses identify the lack of electricity as

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[146] Credit Rating Agency Upgrades Nigeria's Outlook. Voice of America, 9 December 2011. http://www.voanews.com/english/news/africa/Credit-Rating-Agency-Upgrades-Nigerias-Outlook-136382208.html (last visited: 13 March 2012).

[147] Nigeria: A Burgeoning Emerging Market. By A. Cameron, Business Monitor International.

[148] Sub-Committee of the Presidential Advisory Committee (2006): A Draft Report on Nigeria's Electricity Sector. Abuja, Nigeria, January 2006. http://www.link2nigeria.com/E-books-

their biggest constraint, with national power supply equivalent to that used by the UK city of Birmingham.[149]In the long term major oil consumers, such as the United States, China, India, are likely to exert pressure on Nigeria in ensuring uninterrupted crude oil- and natural gas supply to their countries. Therefore, Austria, as well as other EU member states, should be prepared to anticipate significant international competition in continuing its present supply quota also in 2050.

The overall *economic development* of Nigeria is expected to remain strong also in the future.[150] Since it can be assumed that the "peak-oil effect" will lead to further price increases in hydrocarbons, such price increases will positively impact Nigeria's national income for many years to come. However, inadequate distribution of income from the energy exports will further increase of social and religious tensions in society. Unless the government is able to strengthen the currently weak political and judicial institutions in the country, the Nigerian political system is likely to remain underdeveloped for many years to come.[151]. Since an improvement of this dissatisfactory situation will require a major socio-economic change nationwide across all religious and social barriers, it is difficult to see how this can be achieved to the extent necessary by 2050.

Expectations

Nigeria will remain a highly potent, but also an uncertain exporter of hydrocarbons to Austria for decades to come. The country needs to address major socio-political inadequacies, religious differences and economic imbalances between various segments of society in order to ensure adequate security for its citizens and the foreign work force active in the energy sector. Unless future Nigerian administrations can assure the Nigerian private sector and foreign investors, interested in tapping into the large energy resources, of sufficient security and safety, the country will remain a liability well beyond 2030.

5.2.3.2. Natural Gas

Potential future security threats to countries exporting natural gas to Austria are listed and analysed in this section. Forecasts are made for the years 2015, 2030 and 2050. The

Nigeria/Draft%20Final%20Report%20on%20Electricity%20Sector%20-%2025%20Years%20Power%20Generation.pdf (last visited: 15 March 2012).

[149] UK Department for International Development (2011): Nigeria Operational Plan 2011-2015. DFID, Westminster, United Kingdom.

[150] Credit Rating Agency Upgrades Nigeria's Outlook. VOA News, 29 December 2011.

[151] BTI (2012): Nigeria Country Report. The Bertelsmann Stiftung, Güterloh, Germany. http://www.bti-project.org/fileadmin/Inhalte/reports/2012/pdf/BTI%202012%20Nigeria.pdf (last visited : 15 March 2012).

main natural gas suppliers to Austria are (listed in descending order with respect to amount of the respective good):[152]

- Russia
- Norway

Table 30 describes Austria's natural gas suppliers' current resilience with respect to political and social threats, respectively, as well as the countries' reliability as a supplier in a quantitative manner. For comparison, the values for Austria are also given. Values for Political Resilience (PR), Social Resilience (SR) and National Resilience (NR) range from 1 to 5 each. The lower the value, the higher the country's resilience. Political and Social Resilience are both based on a set of 4 "sub-indices" that are themselves based on a variety of indices which were previously defined and raised by renowned organizations. The National Resilience summarizes the values of PR, SR and additionally takes into account the country's resources of the respective good. Details on the derivation of the numerical values are given in WP 2.

Table 30: National Resilience Score with regard to natural gas for Austria`s key suppliers and, for comparison, Austria

	Political Resilience (PR)	**Social Resilience (SR)**	**National Resilience (NR)**
Austria	**1**	**1.25**	**3**
Russia	**3**	**3.5**	**3**
Norway	**1**	**1**	**1**

Russia

Forecast 2015

The recent parliamentary and presidential elections in Russia have solidified the political power structure in the country for the near-term. The official results gave Vladimir Putin about 64% of the vote in the presidential election. Web cameras were installed in polling stations in order to ensure transparency and ward off allegations of ballot tampering and fraud. Voting was broadcast live through the website www.webvybory2012.ru.[153]The monitors of the CIS Inter-Parliamentary Assembly have registered no major voting irregularities during the presidential election in Russia.[154] Contrary reports by *The League*

[152] For more details on supplying countries: see WP 1.

[153] Russia's election, Kony2012 and online voyeur justice. By S. Kendzior, Aljyzeera News, 11 March 2012. http://www.aljazeera.com/indepth/opinion/2012/03/201231112827506212.html (last visited: 20 March 2012).

[154] No major voting irregularities in Russian election – monitors. By Tass, The Voice of Russia, 5 March 2012. http://english.ruvr.ru/2012_03_05/67565247/ (last visited: 15 March 2012).

of Voters, a civic group set up after parliamentary elections in December 2011, claimed his share of the vote was inflated by more than 10%. However, even taking into account reported irregularities, it is estimated – based on exit polls - that his real share of the votes was still significantly above the 53% mark, with the other four opposition candidates each trailing far behind.[155] This internal political stability will continue unabatedly as long as the majority of the society prefers a strong leadership over any fully fledged Western style democracy.

In the near future the potential for external threats to Russia will continue over issues such as, Southern Kuril Islands with Japan, Abkhazia and South Ossetia with Georgia, Caspian Seabed with Iran, Baltic States and Ukraine over border disputes, and the issue of the Continental Shelf with USA, Denmark and Norway. However, a complete view of the multiple diplomatic efforts underway to resolve the issues (e.g., negotiations with NATO or CLCS), or the military resolve demonstrated by Russia at the regional level (e.g., towards Georgia), makes it unlikely to escalate to a large military conflict in the short term.

Internal stability is largely ensured in light of Putin's clear popularity among the majority of the voters, it can be safely assumed that there is a high probability of another reelection of Putin as president for yet another term.

Expectations

Russia has broadly recovered from the 2008-09 economic and financial global crisis better than many other countries. No imminent internal or external risk factors can be identified in the near-term. Therefore, Russia can continue to be viewed as a stable exporter of crude oil and gas for Austria until 2015.

Forecast 2030

Russia's economic growth rate in 2011 was about 4%. In the same year Russia's GDP deficit was only 1%. The public debt of the Russian Federation is one of the lowest in the world. In 2012 the International Monetary Fund cut Russia's 2012 growth forecast to 3.3% from 4.1%, indicating that Russia may be vulnerable to a slowdown in global growth in the coming years.[156]

Russia is likely to enter the next decade as an economically strong and relatively stable country on a social level. However, Russia's economic future depends to a large extent on

[155] Their View: Shedding a tear for future of Russia. Silver City Sun News, 6 March 2012. http://www.scsun-news.com/ci_20153108 4w (last visited: 16 March 2012).

[156] Russia: IMF forecast darkens outlook . By Charles Clover, Financial Times, 25 January 2012. http://blogs.ft.com/beyond-brics/2012/01/25/russia-imf-forecast-darkens-outlook/#axzz1otW6fQtY (last visited: 16 March 2012).

the price development of commodities, such as hydrocarbons. The oil price needed to balance Russia s budget has risen from $34 a barrel in 2007 to $117 in 2012; estimates of the price that Russia will require to meet the planned financial expenditures range from $130 to $150 per barrel.

In order to understand the potentially diminishing significance of the European Union from the viewpoint of the Russian administration, one needs to be aware of the fact that Russia is acknowledging the importance of Asia as the future global powerhouse.[157] A clear favorite in this equation is China (P.R.). In 2010 China became Russia's largest trading partner. In 2011, trade between the two countries was 80 billion dollars. It is the declared intention of the Russian administration to increase the trade with China to 100 billion dollars by 2015, and to 200 billion dollars by 2020.[158] This implies that - with regard to exports of hydrocarbons - China will become an increasingly strong competitor to the European Union. Already, Russia and China have signed long-term agreements for the supply of oil and gas.

In the mid-term internal threats to Russia may arise from a potentially growing dissatisfaction by the growing middle-class, should there exist a further noticeably skewed distribution of wealth among Russian citizens resulting from the flourishing export of Russian raw materials.

External threats can originate in a further rift between the West and Russia over the Caucasus, the Middle East, and the perceived or actual threat of encirclement by NATO. Security-sensitive topics in the mid-term will be:

- Missile defense system to be established in the EU
- Iranian nuclear program
- Russian disdain for foreign intervention in Syria
- Increasing number of NATO military basis around Russia's Western and Southern flank.

Russia has already indicated that it perceives the situation as disadvantageous and has announced a doubling of its military expenditures to $790 billion by 2015.[159].

Russia's dependence on exporting raw materials at a given minimum price in order to have a stable national economy, together with an increasing disagreement with Western

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[157] For example, in September 2012 Russia will host the annual meetings of the Asia-Pacific Cooperation.

[158] Putin's Victory A Catalyst For Increasing Asia's Strength And West's Decline. By S. Singh, LINK Newspaper, 10 March 2012. http://thelinkpaper.ca/?p=14842 (last visited: 16 March 2012).

[159] Russia - India - China: the rearmament era. By Pavel Pomytkin, topwar.ru (Russia & India Report), 7 March 2012. http://indrus.in/articles/2012/03/07/russia_-_india_-_china_the_rearmament_era_15075.html (last visited: 15 March 2012).

security policies, represent a major challenge to its national stability. It depends largely on the skills of the Putin-lead administration and the resonance by the European Union member states to what extent this will impede on Russia's willingness to continue to meet EU's energy needs. Since there will be an increasing demand from Asian parties for these commodities, Russia will find itself in a strong negotiating position towards EU countries, such as Austria.

Forecast 2050

Russia has two assets in comparison to the European Union: an abundance of natural resources and a huge land mass. Despite significance disturbances after the collapse of the Soviet Union, Russia managed to stay intact, i.e., it did not disintegrate. In fact, by 2050 Russia is likely to have revitalised itself due to the uninterrupted, if not growing, global need for its commodities. It can be assumed that this will be accompanied by a further rise in living standards, mostly paid for by hydrocarbon exports. Russia's continuing dependency on income from these exports will force any administration to ensure success in meeting these demands by a high reliability of its export obligations.

The external threat to Russia will be rooted in its fundamental weakness in protecting its borders. The lack of natural borders in the North-West (Ukraine, Belarus, and Moldavia) and South (east of Carpathian Mountains) will continue to represent a security weakness. With NATO having come closer than ever before[160], coupled with poor transport infrastructure over vast distances, Russia would find it difficult if it had to respond to multiple, coordinated attacks on its territory.

The main internal long-term threat results from its demographic situation of an aging population. By 2050 it is estimated that Russia's population will have been reduced from the current 145 million inhabitants to somewhere between 90 million and 125 million.[161] Added to this problem is the more rapid decline of the Russian ethnic groups compared to non-Russian ethnicities.

By 2050 it is assumed that – in view of the buffer capacity of its vast riches in natural resources - the Russian economy will have been able to weather a future potential global economic crisis better than others. Phenomena, like the Peak-oil Effect, will have contributed to high price levels of commodities in general, and for hydrocarbons in particular. This will assist the Russian Government in bolstering the national budget and enabling it to serve the growing demands by the middle-class. Thereby, Russia will be in a relatively strong position to handle downside risks. If this is coupled with strengthening

[160] Already now NATO troops are less than 200 km from St. Petersburg.

[161] S. Pirozhkov and G. Safarova (2006): Demographic development of Russia and Ukraine: Fifteen years of independence. European Population Conference, Liverpool, UK, 21-24 June 2006.

policy frameworks and reinvigorating structural reforms as promised by the current (most likely long-term) leadership, Russia should be able to master the future reasonably well.

Expectations

Russia will have to master major external as well as internal threats in the long term. If the administrative efforts under the presumably strong leadership in the previous two decades to implement the planned reforms are successful, Russia will find itself in able to basically select the customer to whom it will export its hydrocarbon. Provided Austria will continue to maintain, or even strengthen the positive relationship developed over the past several decades, it is likely to find itself among Russia's customers.

Norway

Forecast 2015

Norway, a key player in the Scandinavian hydrocarbon export market, has fully recovered from the global economic crisis of 2008/2009. This makes it probable that growth will continue over the next few years, since there is strong private consumption and investment. An anticipated acceleration of output and increasing pressures on production capacity will be able to assist Norway in the near future to compensate even stagnating oil and gas exports. Coupled with low inflation, low unemployment rate, and an increasing labor demand, there is only a very low probability of internal threats to the national stability until 2015. The exemplary reaction of the Norwegian public and administration to the terror attack by a right-wing extremist in 2011 provided further proof of the country's extremely high social and political resilience.[162] Norway is not threatened by any disputes with any of its neighbors, i.e., no external threats are apparent until 2015.

[162] On July 22 2011, Norwegian Anders Breivik, 32, bombed government buildings and then went to an island where socialist youth were holding a retreat and calmly shot guests dead for ninety minutes until police arrived and he surrendered. Read more at Suite101: http://www.suite101.com/news/oslo-terrorist-anders-breivik-in-his-own-words-a381581#ixzz1pb249tVn (last visited: 12 March 2012).

Forecast 2030

In 2011 Norway's oil and gas industry further strengthened its position as a hydrocarbon exporter when one of world's largest recent oil discoveries (Avaldsnes Aldous field) was revealed in the North Sea, followed by an increase in capital spending and a new high in licensing.[163] The reserves estimates for Avaldsnes Aldous range from 1.7 to 3.3 billion barrels of oil equivalent, which means the field could be the third largest Norwegian find of all times, valued at $12.3 billion. It is anticipated that further progress will be made over the next two decades to open up the East Barents Sea area for exploration and to get it on line. By then, the areas around the Lofoten Islands will have also gone into production. All of the above indicate an increasing role of Norway as a key European hydrocarbon exporter.

Forecast 2050

Norway had already established the *Petroleum Fund* in 1990 in order to smooth the highly fluctuating prices of crude oil. Subsequently, the *Government Pension Fund - Global* was created to contain the surplus wealth produced by the Norwegian income from hydrocarbon profits. As of 31 December 2011, its total value was estimated at $573 billion, holding 1% of global equity markets.[164] Since Norway has ensured that profits from oil- and gas exports, as well as licensing fees, are viewed as national long-term savings, it can be anticipated that these national wealth funds will be carefully guarded against any potential misuse now and in the long-term. In sight of the lack of any major external or internal social or political threats, Norway fulfills all the preconditions for a stable period until 2050.

Expectations

Norway has extensively proven as well as newly discovered oil- and gas reserves. This will enable its industry to supply hydrocarbons to its customers at a stable rate for at least the next four decades. Austria, as one of Norway's customer for crude oil, can expect to continue to rely on Norway as an exporter until 2050.

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[163] Outlook is bright for Norway in 2012. Oilonline, 12 January 2012. http://www.oilonline.com/default.asp?id=259&nid=37179&name=Outlook+is+bright+for+Norway+in+2012 (last visited: 12 March 2012).

[164] The Government Pension Fund of Norway. Wikipedia: http://en.wikipedia.org/wiki/The_Government_Pension_Fund_of_Norway#cite_note-0 (last visited: 19 March 2012).

5.2.3.3. Crude Oil & Gas

In Central Asia, Kazakhstan can be expected to be a stable trading partner for oil- and gas exports to Austria in the near-term and in the subsequent period to 2050.

In North Africa, Libya's future development is highly uncertain due to the physical and political devastation caused by the regime change in 2011. Internal as well as external threats can impede the reliability of hydrocarbon exports from Libya to Austria in the next few years, possibly even over several decades.

In West Africa, Nigeria will remain a highly potent, but also an uncertain exporter of hydrocarbons to Austria until at least 2015 and most likely beyond then.

Russia has no imminent internal or external risk factors in the near-term and can continue to be viewed as a stable exporter of crude oil and gas for Austria until 2015. In the mid-term there will be an increasing demand from Asian parties for these commodities, i.e., Austria will have to be prepared to face increasing competition.

Norway, one of the most stable Scandinavian countries, has extensively proven as well as newly discovered oil- and gas reserves. This will enable its industry to supply hydrocarbons to Austria with high reliability until 2050.

5.2.3.4. Phosphate

Potential future security threats to Morocco, the main phosphate-exporting country to Austria, are analysed in this section. Forecasts are made for the years 2015, 2030 and 2050. Though Morocco is not the only phosphate exporting country to Austria, it is by far the largest, accounting for more than 90% of all phosphate imports to Austria.

Table 31 describes Morocco's current resilience with respect to political and social threats, respectively, as well as the country's reliability as a supplier in a quantitative manner. For comparison, also the values for Austria are given. Values for Political Resilience (PR), Social Resilience (SR) and National Resilience (NR) range from 1 to 5 each. The lower the value, the higher the country's resilience. Political and Social Resilience are both based on a set of 4 "sub-indices" that are themselves based on a variety of indices which were previously defined and raised by renowned organizations. The National Resilience summarizes the values of PR, SR and additionally takes into account the country's resources of the respective good.

Table 31: National Resilience Score with regard to phosphate for Austria`s key supplier and, for comparison, Austria

	Political Resilience (PR)	Social Resilience (SR)	National Resilience (NR)
Austria	1	1.25	**3**
Morocco	3	4.5	**4**

5.2.3.4.1 Morocco

Forecast 2015

Internally the country will face the consequences of the massive anti-government demonstrations in 2011. There is no reason to assume that this instability will seize in the near term. In particular, the “February 20 Movement” is expected to increasingly disagree with the extent of constitutional reforms that were introduced by the government in July 2011.[165] Major business upheaval may result from these future demonstrations.

Morocco is traditionally heavily linked to the economic development of Spain. In view of the financial crisis in Spain, anticipated to last well into the second decade of the 21st century, Morocco’s economic development may also be impacted negatively by the Spanish financial crisis over the next few years. Significant inflows of foreign aid from the GCC and other organizations in 2012 will be needed to reduce these risks to the country.

External security issues are likely to remain unresolved in the near future and will continue to await a diplomatic resolution. There are no immediate signs for a negotiated resolution to the lingering dispute over the Western Sahara. The current ceasefire is fragile and carries the risk of breaking down, should there be a one sided recognition of the administrative rights over the disputed territories of Saguia el-Hamra and Rio de Oro. This security threat will intensify, irrespective of whether such a solution will favor either the government, or the self-declared Sahrawi Arab Democratic Republic.

The power struggle between moderate reformers at the government level and those in the more radical civilian segments of society will continue in all likelihood. Together with the unresolved issue of control over Western Sahara, the country will continue to face a certain level of political instability over the next few years. Both causes for instability can negatively impact exports of phosphates to Austria.

Forecast 2030

Morocco will have to resolve its significant demographic challenges in order to increase internal stability in the mid-term, i.e., it will face a combination of high population growth and large segments of the population with low education, coupled with high unemployment. In 2010 Morocco’s population was 31.972 million, and it is expected to

[165] BMI (2012): Morocco Business Forecast Report Q1 2012. Morocco Tomorrow 23 November 2011. http://moroccotomorrow.org/2011/11/23/morocco-business-forecast-report-q1-2012business-monitor-international/ (last visited: 13 march 2012).

grow to 33.353 million by 2015.[166] At the same time, the official unemployment rate was 9.6% in 2010 and is expected to remain at about 9.1% until 2015. Parallel to a labor force of 11.5 million, working primarily in agriculture, industry, and service sectors, the country still suffers from a high number of illiterate people. This group, with its low education, will continue to contribute significantly to the high unemployment level in the future. Furthermore, the country suffers from a high level of brain-drain by the well-educated members of its society. In addition to the traditionally large numbers of low skilled emigrants to Europe, lately there is also migration of highly-skilled Moroccans to Northern America and Europe, which has increased by 78% in the last decade of the 20th century. Unless there is a major improvement in the national labour market, this trend will continue well into the next two decades.

If the experience gained over the past two decades can be extrapolated to 2030 0, it cannot be expected for the pace of the necessary reforms to accelerate significantly. Under this assumption the government will be facing the following internal threats to its stability:[167]

- Servicing the country's large external debt
- Improving living standards, which have steadily declined over the last few decades
- Creating new employment opportunities for the youth, accounting for over 50% of the population.

If these issues are not resolved in time, the high %age of unemployed youth is likely to be the recruiting reservoir for political and religious extremists. The large number of potential followers will represent a growing source of political instability and a credible challenge to the Moroccan government, be it under royal or civilian rule.

Morocco will simultaneously face a mixture of threats to its internal stability, stemming from a rather volatile economic growth pattern, persisting social inequalities, and high unemployment rates. Since these problems are structural issues requiring strong leadership, the unclear result of the ongoing power struggle and the associated challenges to its domestic security make it difficult to foresee a period of stability in the country in the mid-term. All of the above can threaten the uninterrupted export of phosphates to Austria until 2030.

Forecast 2050

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[166] Morocco Economic Forecast. By EconomyWatch Content Team, Economy Watch, 17 June 2010. http://www.economywatch.com/world_economy/morocco/economic-forecast.html (last visited: 13 March 2012).

[167] Morocco – Future Trends. Encyclopedia of the Nations. http://www.nationsencyclopedia.com/economies/Africa/Morocco-FUTURE-TRENDS.html (last visited: 13 March 2012).

In the long term Morocco has to give priority to resolving the currently inadequate national water management and energy supply, if it wants to ensure internal stability.

Severe pressure on the national water resources result from the following main factors: (a) Urbanization; (b) Extension of irrigated perimeters; (c) Periodically re-occurring drought years; (d) Population growth. The volume of water that can be mobilized per capita under normal climatic conditions has already reached its maximum.[168] The per-capita availability of water resources decreased from 1,000 m3/person/year in 1970, to 500 m3/person/year in 2000 and is projected to decrease to 250 m3/person/year in 2025; by comparison, the scarcity threshold is defined by the United Nations Development Programme as 1,000 m3/person/year.

With regard to energy, Morocco lacks any major conventional energy sources, such as oil, natural gas, and coal, i.e., 95% of its energy needs are imported. This energy vulnerability has forced the responsible authorities to diversify the energy resources of the country (natural gas, oil, oil shales and renewable energies). Morocco has one of the world largest oil shale reserves in the deposits of Timahdit and Tarfaya. However, the exploitation of these deposits has so far not been undertaken due to an unfavorable cost-benefit ratio.

Concerning Morocco's long term role as exporter of phosphates, it is necessary to assess the reserve-to-production (R/P) ratio. This value determines the lifetime of phosphate rock reserves and, in turn, the global distribution of both reserves and production in the future. The results of an in-depth analysis show that 70% of global production is currently produced from reserves which will be depleted within 100 years.[169] Combining this with increasing demand, it will result in a significant global production deficit, which by 2070 will be larger than current production.[170] Morocco has nearly 77% of global reserves. The country will need to increase production by around 700% by 2075 in order to meet most of this deficit. If this should be possible at all, Morocco will obtain a much greater share of worldwide production, from around 15% in 2010 to around 80% by 2100. Thereby, Morocco will be able to exert more control over market prices. Also, since Morocco operates the highest R/P ratio throughout the analysis period, its share of the global reserves will continue to increase, i.e., from 77% in 2011 to 89% by 2100.

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[168] ADU RES(2006): Institutional and Policy Framework Analysis: MOROCCO. ADU-RES Project, WP 7, Prepared by: FM21, Foundation Marrakech 21, May 2006. http://www.adu-res.org/ADU-RES%20Deliverables/ADU-RES_D7_2_Morocco.pdf (last visited 13 March 2012).

[169] ADU RES(2006): Institutional and Policy Framework Analysis: MOROCCO. ADU-RES Project, WP 7, Prepared by: FM21, Foundation Marrakech 21, May 2006, http://www.adu-res.org/ADU-RES%20Deliverables/ADU-RES_D7_2_Morocco.pdf (last visited 13 March 2012).

[170] J. Cooper, L. Rachel, D. Boardman and C. Carliell-Marquet (2011): The future distribution and production of phosphate rock reserves. Resources, Conservation and Recycling, Vol. 57, 78-86.

In view of the forecast population growth Morocco will have to resolve its national deficiencies in the water- and energy sector, if it wants to ensure long term internal stability.

Within the global phosphate market, Morocco is expected to become the most important global player in the 21st century, unless (a) additional sources of phosphorus can be identified and mined at a reasonable price, and (b) import-dependent countries, such as Austria, can significantly increase phosphorus recycling. This monopoly position of Morocco will lead to a highly competitive global situation, which Austria will have to prepare for in order to ensure an uninterrupted export for its agriculture sector.

Expectations

Morocco will continue to face internal and external threats to its security, and thereby to its national stability. This in turn may impede its ability to function as a reliable exporter of phosphates to Austria in the short- as well as long-term. In addition, the country will have to cope with simultaneous demographic, societal and environmental pressures over the coming decades. Together with Morocco's increasingly monopoly-like position as the world's leading 21st century phosphate supplier, Austria needs to consider alternatives, in case Morocco cannot or will not adhere to its contractual obligations of exporting the amounts of phosphate needed by Austrian agriculture.

5.2.3.5. Soy

Potential future security threats to countries exporting soy to Austria are listed and analysed in this section. Forecasts are made for the years 2015, 2030 and 2050. The main soy suppliers to Austria are (in descending order with respect to amount of the respective good):[171]

- Brazil
- USA
- Argentina

Table 32 describes Austria's soy suppliers' current resilience with respect to political and social threats, respectively, as well as the countries' reliability as a supplier in a quantitative manner. For comparison, the values for Austria are also given. Values for Political Resilience (PR), Social Resilience (SR) and National Resilience (NR) range from 1 to 5 each. The lower the value, the higher the country's resilience. Political and Social Resilience are both based on a set of 4 "sub-indices" that are themselves based on a variety of indices which were previously defined and raised by renowned organizations.

[171] For more details on supplying countries: see WP 1.

The National Resilience summarizes the values of PR, SR and additionally takes into account the country's resources of the respective good..

Table 32: National Resilience Score with regard to soy for Austria`s key suppliers and, for comparison, Austria

	Political Resilience (PR)	Social Resilience (SR)	National Resilience (NR)
Austria	1	1.25	**3**
Brazil	3	3.8	**3**
USA	2	1.5	**2**
Argentina	3	3.3	**4**

Brazil

Forecast 2015

Brazil is currently producing 170 million tons of grains, making inter alia a leading exporter of soy.[172]

The country, member of the group of countries rising to global key player status and referred to as the BRIC countries, is expected to be the fifth or sixth economy in the world by 2015, overtaking France as well as the United Kingdom.[173] This rise is due to continuing economic stability, pronounced political continuity and the strategically designed diversification of foreign relations. Thereby, Brazil has increasingly distanced itself from the traditionally favored transatlantic relationship, partially resulting from the failed negotiations with the EU. This decline in trade relations with the EU is reflected in the reduced imports and exports with Brazil, e.g., lower by 23.7% in 2009.

In light of the promising national strategy on eradication of extreme poverty, *Brasil sem Miséria*, the nation will reduce the probability of internal security threats by lifting 16 million people from extreme poverty by 2014.

There are no discernible external security threats Brazil is facing in the near-term. Overall, Brazil can be expected to remain a reliable exporter of soy to Austria until 2015.

Forecast 2030

[172] Brazil could reach 2050 producing 400 million tons of food . Embrapa Labex Korea, 21 February 2012. https://labexkorea.wordpress.com/2012/02/21/brazil-could-reach-2050-producing-400-million-tons-of-food/ (last visited: 15 March 2012).

[173] Brazil and Europe: towards 2015. By S. Gratius, FRIDE, No. 67, February 2011. http://www.fride.org/publication/886/brazil-and-europe-heading-towards-2015 (last visited: 14 March 2012).

Provided Brazil is able to complete the process of modernization by enacting structural reforms in various areas, such as tax, politics, social security and the labor market, this will enable the country to position itself as an economic superpower by 2030.[174] By then Brazil probably will be exercising greater regional leadership, as first among equals in South America. In addition it will have a growing role as an energy producer. Also, the country will demonstrate its ability to project beyond the continent as a major player in world affairs.[175] Its progress in consolidating democracy and diversifying its economy will serve as a positive regional model.

All of the above should ensure a continuation of internal stability, thereby resulting in a high degree of reliability as trading partner, e.g., as exporter of soy to Austria.

Forecast 2050

The long-term prosperity and inherent stability of the country will depend on the successful implementation of two endeavors: (a) Further consolidation of democracy; (b) Increased diversification of its economy. In the mid-term Brazil has a high probability of improving its rather disappointing capability of crisis management in the past by maintaining a high degree of economic consensus among all national players, based on smooth political transitions, advocating moderate policies, and exercising a responsible fiscal and monetary policy.

An additional, potentially stabilizing factor is associated with the future impact of Brazil's recent preliminary finds of possibly large offshore oil deposits. This will have the potential to put Brazil on an accelerated economic growth path. The oil discoveries in the Santos Basin - potentially holding tens of billions of barrels of reserves - could make Brazil a major oil exporter by 2050, when these fields are fully exploited. It is emphasized that the hydrocarbon industry would only complement already existing large sources of national wealth. If this is successfully coupled with progress on social issues, such as reducing crime, corruption and poverty, the probability of Brazil's future leadership status will be high.

All of the above would ensure the Brazil's chances to continue as a reliable exporter of soy to Austria also by 2050.

Expectations

[174] Viewpoint: Brazil's growing international presence. By L. Throssell, BBC News, 24 May 2010. http://www.bbc.co.uk/news/10146223 (last visited: 15 March 2012).

[175] NIC(2008): Global Trends 2025: A Transformed World, National Intelligence Council Report(2008) ISBN 978-0-16-081834, http://www.dni.gov/nic/PDF_2025/2025_Global_Trends_Final_Report.pdf (last visited 19 March 2012).

Brazil is a success story of a country rising in regional and international importance, reflecting its high internal stability and lack of major external threats in the near- and long-term. These characteristics reduce the likelihood of Brazil failing to live up to its commitments as reliable soy exporter to Austria also until 2050.

USA

<u>Forecast 2015</u>

The United States of America is in the fourth economic crisis since World War II: (1) Municipal bond crisis of the 1970s, (2) Third World Debt Crisis; (3) Savings and Loan Crisis of the 1980s, and (4) Investment banking crisis. Each crisis represented excessive risk-taking in the financial community. Subsequently this was followed by a federal bailout, basically using privately held assets through printing money and taxation. Also, it is noteworthy that each crisis resulted in recessions.[176]Therefore, it is unlikely that the US will achieve typical post-recession levels of growth in the next few years. This is due largely due to three factors:[177](a) The US domestic market remains weak, impeded by the continued weakness of the US housing market; (b) An ongoing reduction in debt levels by US households, thereby reducing private consumption, accounting for about 60% of US GDP it is the main driver of the US economy; (c) US exporters are being impacted by these slowdowns in key export markets, removing another potential avenue of growth for the US economy. This implies that US will have to struggle to return to its role as the world's pre-eminent engine of economic growth in the coming years.

With regard to security issues the US will probably reduce its worldwide aggressive operations, emphasizing more the model of regional balances of power, preferably manipulating regional players if viewed as advantageous. An important international issue for the United States will be – besides the Islamic world and Russia - Mexico for the following reasons: (1) Mexico is a rapidly growing but unstable power on the U.S. border; (2) Mexico's organized crime cartels are gaining power and influence in the United States.; (3) The US will be trapped between a massive Mexican immigrant population and an economy that cannot manage without it.

[176] Stratfor (2010): Decade Forecast: 2010-2020. Published 21 January 2010, Stratfor Global Intelligence, Austin, Texas.

[177] Can the US be an Engine of Economic Growth in 2012? International Strategic Analysis, 13 March 2012. http://www.isa-world.com/ (last visited: 13 March 2012).

Forecast 2030

External security on a global scale has and will continue to be of uttermost importance to the United States in its hitherto unquestioned role as strongest military power in the current world order. However, the period between 2015 and 2030 will see the appearance of several key players on a global scale besides the United States, such as Brazil, China, India, Japan and Russia, indicative of the emergence of a multi-polar world. Expanded adoption of irregular warfare tactics by both state and non-state actors, proliferation of long-range precision weapons, and growing use of cyber warfare attacks will increasingly constrict the US' freedom from taking unilateral action.[178] Overall, this will imply a reduced role for the United States on the global security scale. The global influence of the US will further diminish because of Latin America's broadening economic and commercial relations with Asia and the European Union. The significant burden due to its oversized national debt will pose a considerable constraint on the degree of freedom for far reaching decisions by the US leadership, having to account more and more on how to afford high military costs.

At the national level the US will have to address a significant threat to public health, i.e., a dramatic increase in diabetes between 2010 and 2050, impacting US society in multiple ways. Futures diabetes model estimates that the number of Americans living with diabetes (diagnosed and undiagnosed) will increase 64% by 2025 from 32,300,000 to 53,100,000, representing about 15% of the US population. The resulting medical and societal cost of diabetes is estimated to reach $514 billion – a 72% increase from 2010.[179]

Forecast 2050

The long-term internal security of the US will depend on how it manages (a) the integration of a large number of immigrants into its society; (b) the accelerated aging of the population at large.[180]

If current trends continue, the population of the United States will rise to 438 million in 2050, from 296 million in 2005, and 82% of the increase will be due to immigrants arriving from 2005 to 2050 and their U.S.-born descendants. Of the 117 million people added to the population during this period due to the effect of new immigration, 67 million will be the immigrants themselves and 50 million will be their U.S.-born children or grandchildren. By

[178] NIC(2008): Global Trends 2025: A Transformed World. National Intelligence Council, November 2008, Washington DC, ISBN 978-0-16-081834-9. www.dni.gov/nic/NIC_2025_project.html (last visited: 13 March 2012).

[179] Institute for Alternative Futures (2011) Diabetes 2025 Forecasts, United States' Diabetes Crisis: Today and Future Trends.

[180] J. Passel and D'Vera Cohn (2008): Immigration to Play Lead Role In Future U.S. Growth

2025, the immigrant share of the population will have surpassed the peak during the last great wave of immigration a century ago. Nearly one in five Americans (19%) will be an immigrant in 2050, compared with one in eight (12%) in 2005.

The Latino population, already the nation's largest minority group, will triple in size and will account for most of the nation's population growth from 2005 through 2050. Hispanics will make up 29% of the U.S. population in 2050, compared with 14% in 2005. This will add to the need for a security-centered policy towards Mexico. The non-Hispanic white population will increase more slowly than other racial and ethnic groups; whites will become a minority (47%) by 2050.

The nation's elderly population will more than double in size from 2005 through 2050, as the baby boom generation enters the traditional retirement years. The number of working-age Americans and children will grow more slowly than the elderly population, and will shrink as a share of the total population.

New global powers, e.g., China, India, Japan and Russia in Asia, respectively Brazil in South America, will increasingly challenge the US dominance in these regions.

<u>Expectations</u>

The United States will find themselves in an competitive role with other rising nations, challenging the hitherto unipolar dominance of the US as the single global superpower. In addition to these global challenges, the US will have to address the increasing security threat from its southern neighbor Mexico.

Internally diabetes, immigration and an aging population will pose major challenges to its societal and financial stability. The magnitude of these potential threats can be such that it is uncertain whether the United States will be able to cope with them, taking into account its increasingly limited financial capabilities in servicing its large national debt. While these uncertainties are unlikely to have any significant influence on its ability to serve as reliable exporter to Austria in the short-term, the USA's long-term reliability as an exporter of soy to Austria is not a foregone conclusion.

Argentina

<u>Forecast 2015</u>

Agricultural production has dominated Argentina's economy ever since the beginning of the 19th century and continues to do so today: Agricultural goods, whether raw or processed, earn over half of Argentina's foreign exchange.[181] A main pillar of Argentina's

[181] Agriculture in Argentina. Wikipedia: http://en.wikipedia.org/wiki/Agriculture_in_Argentina (last visited: 21 March 2012).

export is represented by unprocessed agricultural primary goods, mainly soybeans, wheat and maize. Official forecasts predict a 2011/12 soy harvest to range from 43.5 million to 45 million t[182]; by comparison, corn crop is officially forecast at 21 to 22 million t. This dominant role of agricultural production ensures that soy export will remain of strategic interest to the Argentine Government also in the immediate future.

Internal threats will be become more dominant in the near future due to an increase in social tension over growing inflationary tendencies. The median projection for inflation over the next 12 months is 30%.[183]This is in sharp contrast to the official data provided by the national statistics agency (*Indec*), rating annual inflation totals at below 10%.

External threats result mainly from the unresolved dispute with the United Kingdom over the Falkland Islands. Although thirty years have passed since the outbreak of military hostilities between the two countries over the islands, costing the lives of altogether over 900 soldiers on both sides, Argentina has vigorously reiterated its 200-year-old-claim in 2012.

<u>Forecast 2030</u>

Over the next two decades Argentina will face a triple threat to its economic stability, resulting from an increasing distortion of its domestic economy, its dominant dependency on agricultural exports to a global market, and inadequacy of controlling its balance-of-payment problem.[184] If inflation will continue at the current pace over the next few years, the avoidance of rapid forced adjustments brought on by high inflation and peso distortions will lead to a further weakening of its external position. This could be coupled with a reoccurrence of a rapid depreciation of the peso against the US dollar, not unlike the disastrous depreciation in 2002. This could then be accompanied by a string of budget deficits for many years to come.

Unless major reforms are implemented, internal social unrests may become more frequent, similar to the indefinite strike called by the truckers in Argentina demanding higher pay rates in 2012.[185] Since exporters were counting on them to haul freshly

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[182] Argentine truckers strike as soy harvest starts. By H. Bronstein, Reuters, 19 March 2012.

[183] Argentina's March Inflation Expectations Rise To 30% -UTDT. By T. Turner, Dow Jones Newswires, 20 March 2012.

[184] EIU (2012) Country Forecast Argentina March 2012 Updater. Market Research Report. http://www.reportbuyer.com/countries/south_america/argentina/country_forecast_argentina_march_2012_updater.html (last visited: 21 March 2012).

[185] Argentine truckers strike as soy harvest starts. By H. Bronstein, Reuters, 19 Mar 2012 http://www.reuters.com/article/2012/03/20/argentina-grains-truckers-idUSL1E8EJ0Y620120320 (last visited: 29 March 2012).

harvested soybeans to port, the world ‘s no.1 supplier of soy oil, also the top soybean and corn exporter, may find it difficult to fulfill its contractual obligations.

External threats will depend on, whether the issue of the Falkland Islands will have been resolved diplomatically over the next two decades. In light of the dispute’s rehashing in the first decade of the second millennium, it will become increasingly clear that this dispute is driven by more than just patriotic motives on either side. A likely scenario is the intention by either side to gain control over the disputed islands and their suspected vast amounts of hydrocarbon reserves, in addition to their already known economic attractions, such as fishing industry and, to an albeit much smaller extent, tourism.[186]

Forecast 2050

Unless major political reforms have been successfully implemented by 2030, the subsequent period will likely be characterised by an increasing gap between the poor and wealthy classes, simmering territorial disputes and growing overall distrust in the government capabilities. A major deciding factor on the issue of national stability will be the capability of the government to resolve the hitherto dissatisfactory situation in the energy sector. Argentina has run a large energy sector trade deficit for an extended period of time. Based on the analysis of several possible scenarios, there will certainly be a dramatic increase in energy demand at the national level.[187] In order to ensure sustainable social and economic growth, even in the agricultural sector, Argentina will have to succeed in a transformation of the present energy mix. This will imply a great need for new investments in the power generation sector alone. Taking into account Argentina’s strong indigenous nuclear industry, the country is likely to emphasize – in addition to hydro electrical plants – nuclear energy production in order to reduce its CO_2 footprint. Both technologies are investment intensive and it is unclear how the country will be able to meet these financial demands with its traditional foreign exchange reserve problems.

Agriculture will maintain its dominant role in the country’s economy. With an expanding world population it is difficult to foresee anything but a further increase in global food demand, expected to double by 2050.[188] This will put Argentina in a favorable negotiating position with regard to soy exports to Austria.

[186] Future of the Falklands: Remote prospects. By J. P. Rathbone, Financial Times, 15 March 2012. http://www.ft.com/intl/cms/s/0/89b1ef2c-6d12-11e1-a7c7-00144feab49a.html#axzz1 pqKi5CkM (last visited: 19 March 2012).

[187] N. D. Chimale and G. F. Acosta (2010): Transitioning to a sustainable and prosperous future – Argentine’s energy outlook 2010 to 2100. University of Buenos Aires (UBA), Oil & Gas Institute, School of Engineering.

[188] Argentine truckers strike as soy harvest starts. By H. Bronstein, Reuters, 19 Mar 2012. http://www.reuters.com/article/2012/03/20/argentina-grains-truckers-idUSL1E8EJ0Y620120320 (last visited: 29 March 2012).

Expectations

Argentina's farm belt is larger than the territory of France. This implies that the country will remain a key exporter of agricultural products in general, and of soy in particular. Neither its policy uncertainty nor its chronic labor disruptions will change this status significantly in the long term. However, Austria needs to be aware that there are several internal and external factors which place Argentina into a category of soy exporters with a certain degree of unreliability. Also, the global competition for Argentine soy exports is likely to increase rather than decrease.

5.2.3.6. Conclusions

Austria is heavily dependent on imports of high strategic importance originating from non-EU countries. These are energy (crude oil, natural gas), phosphate fertilizer and protein feedingstuff, especially soy.

Energy

The main crude oil suppliers to Austria are (in descending order with respect to amount) Kazakhstan, Libya and Nigeria. Gas is mainly imported from Russia and Norway.

In Central Asia, Kazakhstan can be expected to be a stable trading partner for oil- and gas exports to Austria in the near future, leading up to 2050. In North Africa, Libya's future development is highly uncertain due to the physical and political devastation caused by the regime change in 2011. Internal as well as external threats can impede the reliability of hydrocarbon exports from Libya to Austria in the next few years, possibly even over several decades. In West Africa, Nigeria will remain a highly potent, but also an uncertain exporter of hydrocarbons to Austria until 2015 and most probably beyond that.

Russia has no imminent internal or external risk factors in the near-term and can continue to be viewed as a stable exporter of crude oil and gas for Austria until 2015. In the mid-term there will be an increasing demand from Asian parties for these commodities, i.e., Austria will have to be prepared to face increasing competition. Norway, one of the most stable Scandinavian countries, has extensive proven as well as newly discovered oil- and gas reserves. This will enable its industry to supply hydrocarbons to Austria with high reliability until 2050.

Phosphate

Morocco is by far the largest phosphate supplier worldwide, accounting for more than 90% of all imports to Austria. Within the global phosphate market, Morocco will become the most important global player in the 21st century. Morocco's monopoly position will lead to a highly global competitive situation, which Austria will have to prepare for in order to ensure uninterrupted exports for its agriculture sector. Further internal and external security threats, as well as demographic, societal and environmental pressure, threaten Morocco's stability in the short- as well as in the long-term.

Soy

Austria is heavily dependent on reliable soy exports from the Americas, originating from Brazil, USA and Argentina.

Though it still suffers from problems with poverty, corruption and crime, Brazil is a success story of a country rising in regional and international importance, reflecting its high internal stability and lack of major external threats in the short- and long-term. These characteristics reduce the likelihood of Brazil failing to live up to its commitments as reliable soy exporter to Austria also until 2050.

The future of the United States as a reliable soy supplier is uncertain. Its hitherto dominance as the only global superpower will be questioned by other uprising nations. Further, the USA will have to deal with an aging population, diabetes and strong immigration from Mexico.

Argentina's farm belt is larger than the territory of France. This implies that the country is and will remain a key exporter of agricultural products in general, and of soy in particular. Neither its policy uncertainty, nor its chronic labor disruptions will change this status significantly in the long term.

In summary, Austria should strengthen its relationship with Brazil as soy customer, bearing in mind that its other two main soy suppliers, Argentina and the US, may have problems in meeting Austria's demands in the long term.

6. Self-sufficiency in Austria in 2030 and 2050: simulation results

Authors: AWI: Christoph Tribl, Josef Hambrusch, Karl Ortner

6.1. Introduction and research question

The impact of climate change on agriculture has been addressed in various studies. Research results show the associated impacts of climate change (e.g., increase in temperature, changes in the distribution of precipitation, frequency of extreme weather events) on agricultural prodution and food supply (see, e.g., Nelson et al., 2010; OECD, 2013a; Turall et al., 2011). In addition, agricultural production in Austria crucially relies on imports of inputs like energy, protein feed or fertilizers.

Based on the concept of supply balances, we set up two simple simulation models in order to assess the impact of different scenarios on the self-sufficiency rates for agricultural products in Austria. In line with international studies (e.g., Alexandratos and Bruinsma, 2012), the time frame of the simulations is comprised of the years 2030 and 2050. Particularly, several scenarios incorporate different assumptions regarding the impact of climate change, regarding supplies of important agricultural inputs like phosphorus fertilizer or protein feed and regarding bioenergy use.

To briefly describe our approach in addressing self-sufficiency in Austria in 2030 and 2050: the data used for the simulations for 2030 and 2050 include certain positions (or "variables") of supply balances for Austria (2000 to 2020, see chapter 6.2.1). Due to data limitations and in order to simplify the simulation models, we use only specific positions of the supply balances according to Statistics Austria and calculate data for the remaining ones. This database is used as data input, either as a basis for assumptions on specific numerical levels of certain exogenous variables (e.g., crop yields) or as a basis for Monte-Carlo simulations which generate a range of possible numerical levels for 2030 and 2050 of other (exogenous) variables. We establish two different simulation models which differ in the choice regarding the exogeneity or endogeneity of variables. In addition, we consider four different scenarios (for 2030 and 2050 each).

This section is organised as follows: chapter 6.2 qualitatively describes the supply balance database (2000-2020), respective simplifcations of supply balances and calculations regarding feed balances. Chapter 6.3 shows the structure of the simulation models for 2030 and 2050, defines the scenarios, summarises the quantitative scenario assumptions and briefly describes the Monte-Carlo simulations. The results of model 1 and model 2 are illustrated in chapter 6.4. Finally, chapter 6.5 summarises the results and indicates limitations of the results.

6.2. Description of the Database

The simulation models for 2030 and 2050 rely on qualitative and quantitative assumptions, experts' opinions, calculations and estimations, and on time-series data. Regarding the latter, we predominantly use data of supply balances for Austria. Historical supply-balance data is available from 2000 to 2010, and based on OECD forecasts for the EU-27, forecasts up to 2020 were made for certain positions of the Austrian supply balances (see chapter 4.) The following sub-chapters qualitatively describe the database from 2000 to 2020.

6.2.1. Supply balances (2000 – 2020)

Supply balance sheets are used to represent the sources and uses of agricultural products in Austria. The main database for the simulations comprises the years 2000 to 2020 (including data forecasts from 2011 to 2020, see chapter 4.). The "commodity structure" corresponds to that of the OECD outlook database (OECD, 2013b), covering 16 crop products and 12 animal products as shown in Table 33. Some commodities are aggregated into commodity groups, some represent processed products of primary commodities.

Table 33: Commodities covered in the simulations

Crop products	Animal products
wheat	beef & veal
coarse grains[1]	sheep meat
soybeans	pork
other oilseeds[1]	poultry meat
oilseed meals[2]	eggs
protein crops	fish
vegetable oils[2]	raw milk
sugar[2]	butter[2]
starch crops	cheese[2]
fruits	
vegetables	

[1] aggregates, [2] processed products

Referring to the database 2000-2020 we chose certain positions of the supply balances, aggregated several positions into one position and calculated the values for the remaining positions for each year. This procedure is due to fact that, first, all positions of the supply balances were forecasted (2011-2020) separately (see chapter 4.). Choosing data from only specific positions and calculating the remaining ones allows us to establish coherent balances. Second, in some cases data on certain positions of domestic uses are missing and, thus, makes calculations necessary in order to fill the gaps.

Table 34 highlights the original positions of the supply balances according to Statistics Austria and shows our simplifications for the database 2000-2020 and the simulation model (2030, 2050). Imports, exports and changes in stocks are aggregated into the single position "trade balance". On the demand side ("domestic use") we only differentiate between "feed use" and "non-feed use" (as a residual position).

Table 34: simplification of the supply balances

Statistics Austria			**database, simulation model**	
Sources			**Sources**	
+	Production		+	Production
+	Beginning stocks		+/-	Trade balance
-	Ending stocks			
+	Import			
-	Export			
=	Domestic use		=	Domestic use
Uses			**Uses**	
+	Feed use		+	Feed use
+	Seed use		+	Non-feed use
+	Processing			
+	Losses, other			
+	Human consumption			
=	Domestic use		=	Domestic use

For the database 2000-2020, Table 35 shows which positions were used from the Statistics Austria database and the forecasts, respectively, and which positions were calculated. For most commodities we used data on production, consumption and area harvested. These variables provide the basis for the calculation of other variables.

Table 35: calculation scheme of the supply-balance data (2000-2020)

No.	Variable	Calculation
1	Production	Statistics Austria/AGES
2	Trade balance	*= 3 - 1*
3	Domestic use	Statistics Austria/AGES
4	Feed use	calculated from livestock (*8b*)
5	Non-feed use	*= 3 - 4*
6	Per head non-feed use	*= 5 / 10*
7	Self-sufficiency rate	*= 1 / 3*
8a	Area harvested	Statistics Austria/AGES
8b	Livestock*	BMLFUW (2000-2011), *1 / 9b* (2012-2020)
9a	Crop yield	*= 1 / 8a*
9b	Animal yield	*= 1 / 8b* (2000-2011)
10	Population	Statistics Austria

* Note: For the period 2000 to 2011, livestock data is taken from BMLFUW (2012). For the period 2012 to 2020, livestock was calculated based on production and animal yields (using the average yield 2000-2011).

6.2.2. Feed balances

The position “feed use” represents the link between animal and crop production. The calculation of the total feed use per crop product (position 4 in Table 35) necessitates crop-specific feed-use coefficients per animal category (e.g., kg of wheat per milk cow). The feed balance data of Statistics Austria of three years (2007/2008, 2008/2009 and 2009/2010) allows to derive reasonable feed-use coefficients. Based on feed balances on a dry-matter basis, feed-use coefficients were calculated for six animal categories (milk cows, cattle without milk cows, sheep, pigs, poultry, other animals) for each of the three years and for the commodities considered in the feed balance. Employing the respective livestock data for 2009 to 2010 (BMLFUW, 2012)[189] and factors to convert feedingstuffs from dry to fresh matter (LfL, 2012) results in a crop-specific feed use per animal category (in kg per head). Finally, the mean of the three years was used to approximate a crop-

[189] It is important to note that the applied livestock data is the number of livestock at a certain point in time (e.g., each December). Assume that the turnover rate per year of an animal is higher than 1 (e.g., in the case of fattening pigs). In this case, the actual number of livestock over the year is actually higher (in terms of animal production). Thus, our calculated feed-use coefficient per animal is higher than a respective coefficient from the literature. However, this “higher” level is corrected by the “lower” number of animals considered in the calculations (i.e., aggregation of the total feed demand yields figures according to feed balances of Statistics Austria).

specific feed use per animal product.[190] Applying the resulting feed-use coefficients in the calculations yields crop-specific feed uses, which are comparable to the crop-specific feed-use positions in the supply balances of Statistics Austria. It is important to stress that any forage from grassland (e.g., hay, silage) was omitted in the calculations for reasons of simplification.

6.3. Simulation models for 2030 and 2050

To address food security in Austria in 2030 and 2050, we simulated the impact of a set of different assumptions on the respective self-sufficiency rates of several food products. Numerically, these simulations are based on the supply balance data from 2000 to 2020 (see also chapter 4) and on different assumptions regarding the values of certain (exogenous) variables in 2030 and 2050.

We set up two simple simulation models in order to address several assumptions on possible future changes and to analyse respective outcomes. The solution to each model are product-specific self-sufficiency rates for the years 2030 and 2050. These models follow the structure of supply balances and simply simulate the impact of changes in certain supply-balance positions on other positions and, thus, on the self-sufficiency rate. It is important to note that these models do not take any economic considerations of decision makers (farmers, processors, consumers, etc.) into account since the supply balances only contain data on quantities. The main difference between the two models is their structure and, thus, their respective solution variable: model 1 solves for areas and livestock (by taking the trade balance as given), whereas model 2 solves for the trade balance (by taking areas and livestock as given). Thus, additional results include either necessary changes in areas/livestock (model 1) or in trade balances (model 2).

6.3.1. Description of the simulation models

In the following, both simulation models will be briefly described (see Figure 47). Generally, each product category (e.g., “wheat”, “coarse grains”, etc.) is simulated separately. The link between the crop sector and the animal sector is established via the feed use of certain crops per animal. In both models, the following variables are exogenous (i.e., taken as given) for 2030 and 2050:

- population of Austria (forecasts according to Statistics Austria, 2013)
- non-feed use per head (in kg per head)
- crop-specific feed use per animal (in kg per head; see chapter 6.2.2)

[190] The (total) feed use of “other animals” according to Statistics Austria was considered in the model as a constant value. Except for the product categories fruits and vegetables, all crop categories are used as feed in the model (sugar beets were not considered). Referring to animal products, only raw milk is used as feed.

- yields of crops (in tons per hectare; see chapter 6.3.3) and animals (in kg per head; see chapter 6.3.4)

<u>Model 1:</u> *trade balance is exogenous, areas/livestock are endogenous*

In model 1, the animal sector and the crop sector are simulated in two successive steps: the animal sector is modeled first; in a second step, the resulting livestock numbers of the first step enter the crop sector via its respective feed use.

Step 1 (animal sector): Total non-feed use (i.e., human consumption) is the result of the assumed level of non-feed use per head in 2030 and 2050 and population forecasts for 2030 and 2050. In the case of animal products, this non-feed use is equal to the national (i.e., total) use (apart from the case of milk, which is also used as animal feed). Taking the trade balance in 2030 and 2050 as given, the difference between a given national use and a given trade balance is the required animal production to meet the demand for animal products. Assuming certain animal yields (per head) in 2030 and 2050 gives the required level of livestock for animal production.

Step 2 (crop sector): The resulting number of livestock of step 1 determines the feed use of certain crops. Thus, national use of crop products is the sum of feed use and a given non-feed use. Again, taking the trade balance regarding crop products in 2030 and 2050 as given, production of crop products is determined by the national use and the trade balance. Assuming certain levels of crop yields (per hectare) in 2030 and 2050 gives the corresponding acreage of crop products that is required to meet production needs.

According to the structure of model 1, the following research questions can be assessed:

- What is the impact of changes in demand and trade balances on production and, thus, on self-sufficiency?
- Given demand and trade balances for animal products as well as animal yields, how does the number of livestock need to change to guarantee the required animal production? How does the feed use of crop products change?
- Given demand, trade balances and yields of crop products, how does the acreage need to change to guarantee the required production? What is the impact of changes in yields on acreage?

<u>Model 2</u>: areas/livestock are exogenous, trade balance is endogenous

Since livestock and acreage in model 2 are taken as given in 2030 and 2050 (i.e., both variables are “known” in advance), the animal and the crop sector can be simulated simultaneously. On the demand side (feed and non-feed use, i.e., national use), model 2 is similar to model 1. Contrary to model 1, production is determined by yields in 2030 and 2050 and by the exogenously given areas and livestock in 2030 and 2050. The difference between production and national use is the resulting trade balance (i.e., necessary imports or possible exports). The structure of model 2 allows assessing the following research questions:

- What is the impact of changes in crop and animal yields on production?
- What is the impact of changes in demand and production on trade balances? What are the necessary levels of imports or the possible levels of exports? Which self-sufficiency rates can be achieved?

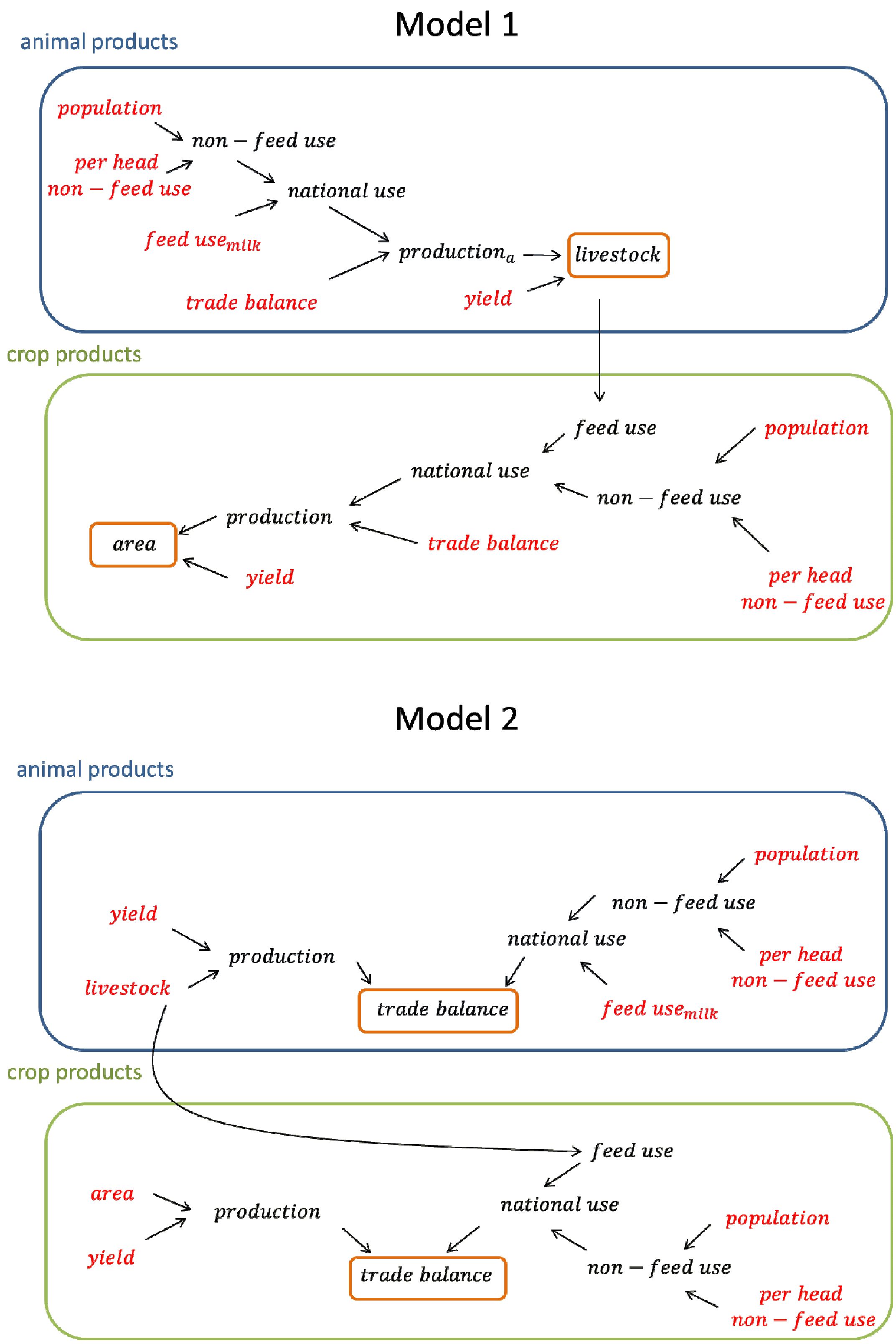


Figure 47: structure of the simulation models for 2030 and 2050

Note: exogenous (i.e., given) variables are indicated in red types.

6.3.2. Definition of scenarios

The aim of the simulation models is to analyse different scenarios by simulating the effect of different assumptions (applied on the exogenous variables) on self-sufficiency rates and on endogenous variables.

For 2030 and 2050, respectively, we define four different scenarios: a baseline scenario, a “most-probable case” scenario with quite moderate assumptions, an optimistic scenario with rather favourably changing assumptions and likely a more positive outcome (“best case”) and a pessimistic scenario (“worst case”) that represent a set of rather unfavourable assumptions and would result in a more negative outcome. Applying these four scenarios for the years 2030 and 2050 and for two different models result in 16 different outcomes (see Figure 48). It is important to note that these denominations of the scenarios (“best case”, “worst case”, etc.) are made for distinguishing and simplifying purposes only, but they do not aim to judge certain scenario-specific assumptions in a subjective manner.

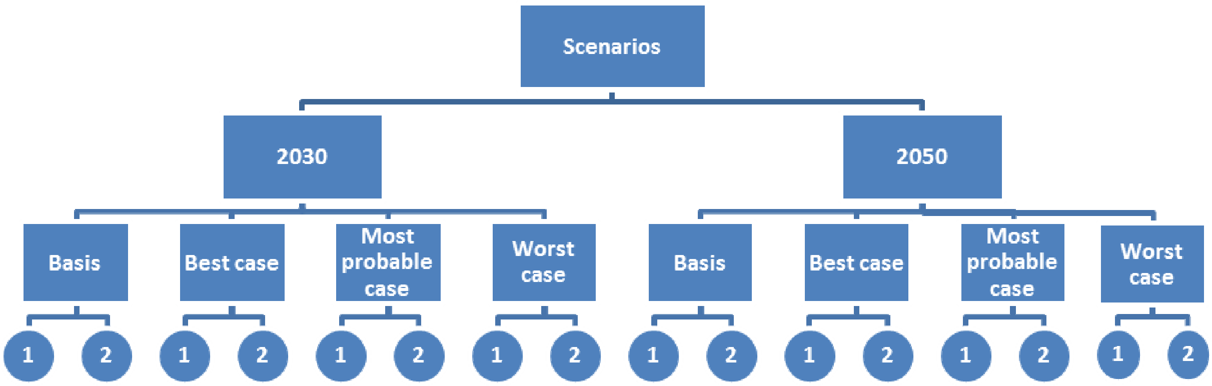


Figure 48: Overview on model-, time- and scenario-specific calculations

Note: 1, 2 … model 1 and model 2

Product-specific self-sufficiency rates in Austria will be addressed by implementing different assumptions on the impact of climate change on crop yields, on the availability of phosphorus fertilizer and of imports of protein feedingstuff, and on the demand for bioenergy. In addition, we consider technical progress in the agricultural sector as well as changes in yields due to different levels (or, intensities) of agricultural inputs. Table 36 qualitatively summarises the scenario-specific assumptions.

Table 36: qualitative definition of scenarios

	baseline scenario	best-case scenario	most-probable case scenario	worst-case scenario
impact of climate change	yes			
technical progress	as before	higher than before	as before	lower than before
input level affecting yields	as before	high input level	medium input level	low input level
phosphorus fertilizer	no shortage		medium impact of shortage	total impact of shortage
bioenergy	as before	low increase in demand	medium increase in demand	high increase in demand
imports of protein feedingstuff	no import restrictions		medium import restrictions	high import restrictions

To account for these scenarios, the exogenous variables of the simulation models are used to employ scenario-specific (baseline, best/most-probable/worst case) and time-specific (2030/2050) assumptions. We make scenario-specific and time-specific assumptions for the following exogenous variables:

- **crop yields**, accounting for the impact of climate change, technical progress, input levels, and the availability of phosphorus fertilizer
- **animal yields**, accounting for technical progress and input levels

For other exogenous variables we only make scenario-specific assumptions (i.e., their numerical levels in 2030 and 2050 are equal):

- **non-feed use per head**, accounting for changes in the demand for bioenergy (wheat, coarse grains, other oilseeds, sugar beet, starch crops)
- **trade balance** (in model 1 only), accounting for the availability of protein feedingstuff (soybeans, other oilseeds, oilseed meals, protein crops)

Assumptions on other exogenous variables like areas/livestock (model 2), feed-use coefficients and population are equal in all scenarios. While there are differences in the **population** between 2030 (about 9 mill. people) and 2050 (about 9.3 mill. people, see Statistics Austria, 2013), **areas/livestock** (model 2 only) and **feed use coefficients** are assumed to be equal in 2030 and 2050. Respective scenario-specific and/or time-specific numerical values of the exogenous variables are based on calculations, on analyses of project partners (e.g., in the case of crop yields per hectare) and/or on discussions within the project team.

6.3.3. Assumptions on changes in crop yields

In the simulation model, crop yields are scenario- and time-specific (i.e., there are eight different yield levels per crop) and account for the impact of climate change and for changes in technical progress, intensity of input levels and fertilisation.

Estimation of yield performance (Mechtler, C., AGES):

Progresses in yield performance of agricultural crops are generally a complex matter based on many components. Improvements to the technical equipment for tillage, sowing, harvesting and plant protection purposes, the availability of adequate fertilizers and crop protection products, successes in plant breeding, restrictions in the application of agrochemicals in certain production programs, as well as the know-how and skills of the farmer himself all make up relevant impact factors for a successful plant production. Based on national yield data of Statistics Austria for more than 20 years (1990–2011), annual changes in yields were estimated by time-series regression of the crops in concern. For categories of crops products such as coarse grains weighted means of the included crops species have been calculated, based on their actual areas. Austria can report relatively high annual growth rates in yields of maize, rape and soybean. As the agrotechnical preconditions have already maintained a well-developed level during the whole period concerned, these yield improvements may be substantially based on progresses in plant breeding. Yield growth rates turn out to be lower for cereal species with certain requirements in quality parameters (bread wheat), which have also to be met by the breeders beside yield performance, and with significant acreage under organic farming (triticale, rye).

The annual rates of change due to technical progress as seen in Table 37 were derived from these regression results. They represent weighted averages of more disaggregated crop products. These annual change rates are less than +1% (of yields in 2015), except for protein crops showing a negative trend.

Differences between crop yields in organic and conventional agriculture serve as a proxy for certain intensities of input levels and were derived from Weigl et al. (s.a). Again, these differences are weighted averages of the respective disaggregated crop products. In the case of protein crops, the difference between the “low-input” yield and the “high-input” yield is highest (-42.3%).

Impact of Phosphorus fertilization (Mechtler, K., Baumgarten, A., AGES):

Phosphorus (P) is important to processes in plant metabolism with energy transfer. It has a positive influence on soil structure and fertility. In assessing the consequences of a mineral lacking P-fertilisation it is relevant whether organic fertilizers are available or not. Therefore yield reduction rates were calculated for regions with and without manure application. The main production areas Northeastern Flats and Hills (mean P-input from organic manure 2 kg P/ha) and the Foothill region of the Alps (mean P-input from organic manure 17 kg P/ha) were selected for cultivation areas with and without livestock husbandry. For each region an average annual P-withdrawal per hectare was calculated based on means of the crops specific withdrawals (20 kg P/ha in the Northeastern region and a higher amount of 25 kg P/ha in the Foothill region due to higher yield potential and higher share of maize in crop rotation). Also included was the different actual plant available P-content in the top soil of the arable land (72 mg P-CAL/kg in Northeastern and 49 mg P-CAL/kg in the Foothill region) in the calculation model. Depending on decreasing P-contents in the soil and on Bavarian results of field experiments, the yield reduction rates were calculated by yield functions created with results of AGES-own field trial series (Dersch, 2005) (StMELF, 2011). The yield functions describe the course of the relative yields for the chosen culture type groups at declining P-contents in the soil.

Crop species with higher nutrient withdrawl rates such as potatoes or sugar beets showed stronger yield falls after 15 (2030) or 35 (2050) years. However, all in all the reduction rates turned out to be rather low: 0.4 to 1.9% after 15 years and 1.1 to 4.6% yield losses after 35 years in case of organic fertilisation and with 0.0 to 3.7% (15 years) and 1.2 to 9.8% (35 years) without manuring, repectively. The variation is given by the the crop species included. It should be stressed that after 15 respectively 35 years of abstinence of mineral P-fertilisation the plant available P-contents will decrease considerably, especially in the Northeastern areas up to 54 (after 15 years) and upt to 32 mg P-CAL/kg (after 35 years). The decrease of P-soil contents in the Foothill region will be less distinct up to 41 and 33 mg P-CAL/kg due the higher organic P-input.

For the scenarios in the study we used the average of the cropspecific yield reduction rates of the two regions, as results need to represent the national level.

Table 37 shows the impact on crop yields in 2030 and 2050 if P-fertilisation is stopped in 2015 and provides an overview of the data input which was used to calculate scenario-specific yields.

Table 37: general assumptions on changes in crop yields

	climate change		**technical progress**	**input level**	**phosphorus fertilizer**	
	decadal rates of change in%		*decadal rates of change in%*	*difference of "low-input" yields, rel. to "high-input" yields*	*rel. change in%*	
	2015-30	*2030-50*			*2030/15*	*2050/15*
wheat	1.03%	1.58%	0.25%	-33.0%	-1.17%	-4.43%
coarse grains	1.48%	1.32%	0.82%	-37.9%	-2.78%	-7.20%
soybeans	2.18%	6.22%	1.00%	-30.0%	-2.78%	-7.20%
other oilseeds	0.50%	0.12%	0.75%	-30.0%	-2.78%	-7.20%
protein crops	-1.59%	-4.94%	-0.13%	-42.3%	-2.78%	-7.20%
sugar	0.56%	0.36%	0.98%	-10.0	-2.78%	-7.20%
starch crops	9.79%	1.48%	0.96%	-33.0%	-2.78%	-7.20%

Relative changes of crop yields due to climate change are calculated within the project (see chapter 2). For the simulation models, data on changes in yields of certain specific crops were aggregated into product categories according to the database of the simulation models.[191] Table 37 shows that all crop yields increase over time (2015/2030/2050) due to climate change, except for the case of protein crops.

Table 38 summarises the scenario-specific assumptions on crop yields, which are based on discussions within the project team.

In the **baseline scenario**, only the impact of climate change and technical progress is accounted for. Annual rates of change due to technical progress are set equal to those presented in Table 37.

The **best-case scenario** accounts for the impact of climate change, a higher annual growth rate of crop yields (1%) than in the baseline scenario due to technical progress[192], a high intensity of input levels (i.e., yields are assumed to be equal to yields of conventional agriculture) and no shortage of phosphorous fertilizers.

The **most-probable case scenario** accounts for the impact of climate change, a technical progress equal to the baseline scenario, an intermediate intensity level of inputs (i.e., 25% of the crops show yields that can be observed in organic agriculture), and 50% less phosphorus fertilizer (i.e., the relative change in yields due to shortage in phosphorus fertilizer as of 2015 – see Table 37 – is weighted by 0.50).

The **worst-case scenario** accounts for the impact of climate change, a relatively low annual growth rate due to technical progress (0.1%; protein crops: -0.13% as in Table 37), a low intensity of inputs (i.e., yields are set equal to those of organic agriculture) and no phosphorus fertilisation as of 2015 (see Table 37).

Scenario- and time-specific crop yields were calculated in four sequential steps (i.e., each assumption was employed on the resulting crop yield of the previous step):

1. impact of climate change
2. technical progress
3. intensity of input level
4. decline in phosphorus fertilizer.

The resulting crop yields in absolute values for each scenario and year are presented in Table 39.

Table 38: scenario-specific assumptions on crop yields

[191] This applies to the product categories „coarse grains“, „other oilseeds“ and “protein crops”. The respective relative changes are weighted averages (with acreage in 2015 due to technical progress used as weights; see next paragraph).

[192] In the case of soybeans, this annual growth rate is set at 1.3%, which is the growth rate as derived from the estimations. In the case of protein crops, the growth rate was set at 0%.

	Baseline scenario	Best-case scenario	Most-probable case scenario	Worst-case scenario
climate change	see Table 37	see Table 37	see Table 37	see Table 37
technical progress	see Table 37	+1% of 2015 per year[1]	see Table 37	+0.1% of 2015 per year[2]
input level *(weight of organic / conventional yields)*	-	0.00 / 1.00	0.25 / 0.75	1.00 / 0.00
phosphorus fertilizer *(weight of differences in yields (with/without P-fertilizer))*	-	-	0.50	1.00

[1] exceptions: soybean (+1.31%, which is the annual rate of change according to regression results), protein crops (+/- 0.00%)

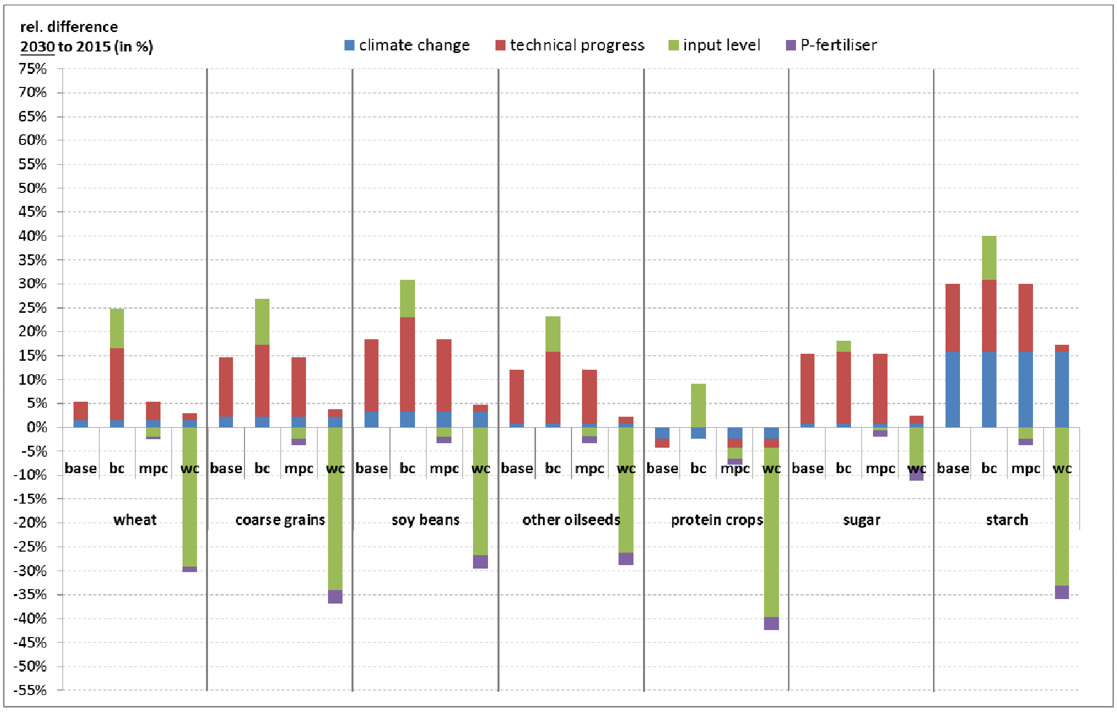
[2] exception: protein crops (-0.13%; see Table 37

Table 39: scenario-specific crop yields (in t/ha and as an index 2015=100)

		Baseline scenario		Best-case scenario		Most-probable case scenario		Worst-case scenario	
	2015	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
t/ha									
wheat	5.3	5.6	6.1	6.7	8.0	5.5	5.8	3.9	3.9
coarse grains	7.9	9.0	10.5	10.0	11.9	8.7	10.0	5.3	5.2
soybeans	2.8	3.4	4.3	3.7	4.9	3.3	4.1	2.1	2.3
other oilseeds	2.4	2.6	3.0	2.9	3.4	2.6	2.9	1.7	1.7
protein crops	2.0	1.9	1.7	2.2	1.9	1.9	1.6	1.2	0.9
sugar*	10.2	11.7	13.8	12.0	14.2	11.5	13.4	9.3	9.1
starch crops	33.1	43.0	50.5	46.3	54.6	41.8	48.4	26.9	26.7
index									
wheat	100	105	114	125	150	103	109	73	73
coarse grains	100	115	134	127	151	111	127	67	66
soybeans	100	118	152	131	173	115	146	75	83
other oilseeds	100	112	127	123	145	109	122	73	71
protein crops	100	96	84	107	97	92	78	58	46
sugar	100	115	136	118	139	114	131	91	89
starch crops	100	130	153	140	165	126	146	81	81

* in raw sugar equivalent

Compared to 2015, crop yields (apart from protein crops) are higher in the baseline scenario, in the best-case scenario and in the most-probable case scenario. In addition, crop yields increase over time (2015/2030/2050). In the worst-case scenario, however, the impact of low intensities of input levels as well as that of no phosphorus fertilisation as of 2015 generally outweigh technical progress and the (generally positive) impact of climate change so that, first, yields are lower compared to 2015 and, second, they are lower in 2050 compared to 2030 in most cases. Figure 49 shows that the largest positive changes in yields are due to technical progress, whereas the largest negative changes in yields are generally due to lower intensity levels of inputs. Both, positive and negative changes increase over time (from 2030 to 2050).



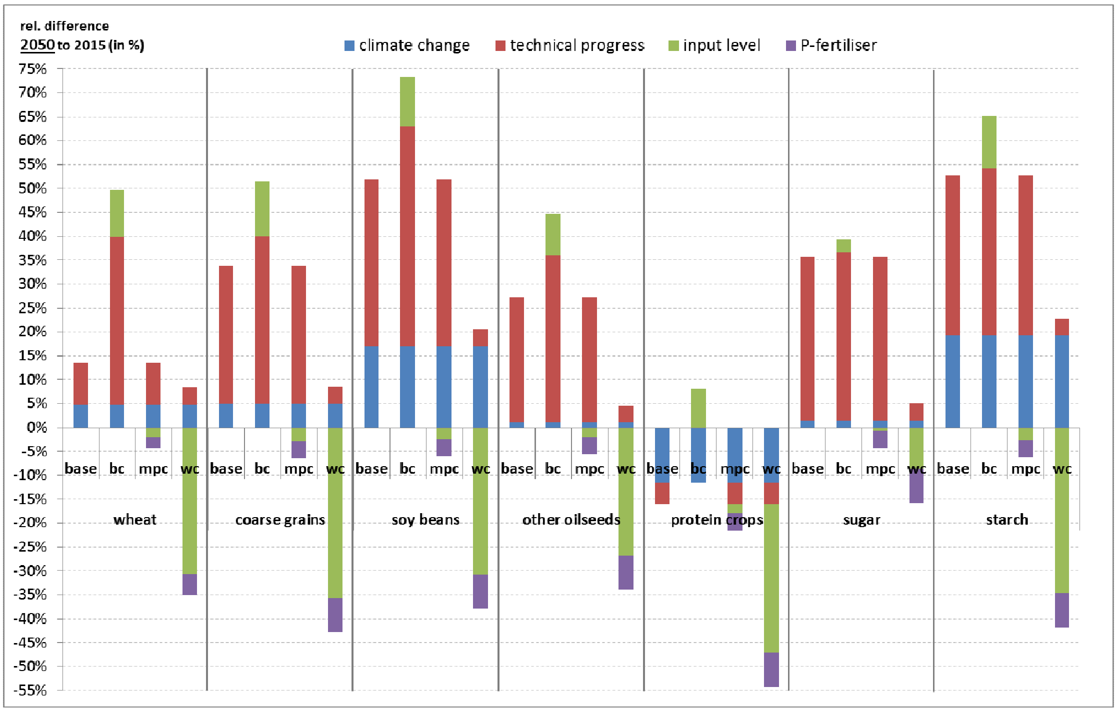


Figure 49: impact of scenario-specific changes on crop yields (in% of 2015)

Note: base = baseline scenario; bc = best-case scenario; mpc = most-probable case scenario; wc = worst-case scenario

6.3.4. Assumptions on other changes

Other assumptions in the simulation model include assumptions of changes in animal yields, changes in imports of protein feedingstuff as well as changes in bioenergy use (see Table 40). In all scenarios, technical progress is assumed to increase animal yields each year by 0.1% of 2015. Based on the resulting yields due to technical progress, different assumptions on the intensity of input levels are assumed to result in an increase (decrease) in animal yields by 10% in the best-case (worst-case) scenario, relative to 2015.

Table 40: other scenario specific assumptions

	Baseline scenario	**Best-case scenario**	**Most-probable case scenario**	**Worst-case scenario**
animal yields				
technical progress	0.1% of 2015 per year	0.1% of 2015 per year	0.1% of 2015 per year	0.1% of 2015 per year
intensity level	-	+10% of 2015	-	-10% of 2015
imports of protein feedingstuff (model 1)	-	-	-10%*	-30%*
per-capita demand for bioenergy	*bioenergy use of 4% of area*	*increase* based on bioenergy use of 10% of area*	*increase* based on bioenergy use of 12% of area*	*increase* based on bioenergy use of 40% of area*
wheat	-	+8.9%	+11.8%	+53.1%
coarse grains	-	+14.1%	+18.8%	+84.8%
other oilseeds	-	+3.0%	+4.0%	+18.1%
sugar	-	+8.5%	+11.4%	+51.1%
starch crops	-	+5.5%	+7.4%	+33.2%

* relative to results of Monte-Carlo simulations (see chapters 6.3.5, 6.4. and Annex 14.1)

Shortages in imports of protein feedingstuff (i.e., soybeans, other oilseeds, oilseed meals, protein crops) are accounted for in the most probable-case scenario and in the worst-case scenario. In the most-probable (worst) case scenario, imports are assumed to decrease by 10% (30%) relative to the levels according to Monte-Carlo simulations (see chapters 6.3.5, 6.4. and Annex 14.1). Since trade balances are taken as given in model 1 only, this scenario assumption is not implemented in model 2.

A possible increase in the demand for bioenergy is accounted for by changes in the non-feed use per head of wheat, coarse grains, other oilseeds, sugar beets and starch crops. These changes are based on expert assessments within the project team on the bioenergy use in terms of certain shares of the mean area from 2008 to 2010 of the respective crop. The respective production for bioenergy use was equated with changes in the non-feed use per head of the respective crops.

6.3.5. Monte-Carlo simulations

As was shown in the previous chapters, we assume either specific levels of exogenous variables (regarding yields and population) or specific relative changes of exogenous variables (i.e., imports of protein feedingstuff, per-head non-feed use of bioenergy crops) for the simulation of scenarios in 2030 and 2050.

For some exogenous variables we account for uncertainties in scenario data for 2030 and 2050 and perform Monte-Carlo simulations (i.e., stochastic simulations). This applies to the following variables:

- **(non-feed) use per head** (model 1 and 2)
- **trade balances** (model 1) and
- **areas/livestock** (model 2).[193]

The numerical values of these variables are treated as random numbers. We assumed a triangle distribution (here: minimum, mean and maximum of the time series according to the database from 2000 to 2020; see chapter 4.1) and made 1,000 independent draws of random values for each variable and respective product. Assuming a triangular distribution, a random variable *x* has the following probability density function (see, e.g., Mayrhofer, 2010, and references therein):

$$f(x) = \begin{cases} \frac{2(x-a)}{(c-a)(b-a)} & for\, a \leq x \leq c \\ \frac{2(x-b)}{(c-b)(b-a)} & for\, c < x \leq b \\ 0 \ otherwise & \end{cases}$$

with *a* = minimum, *b* = maximum; *c* is the most probable value (i.e., in our case, the mean of the time series 2000-2020). Thus, we generated a range of possible data which is based on a probability distribution. This data serves as data input for the simulation models (see Table 41). All data input generated by Monte-Carlo simulations was employed simultaneously in the simulation models and, hence, generated 1,000 different model solutions (i.e., self-sufficiency rates) for each product, scenario and year (2030 and 2050).

Some exogenous variables of the Monte-Carlo simulations are subject to scenario-specific assumptions for certain crops (see also 6.3.3 and 6.3.4.):

In the case of model 1, we assume changes in **trade balances** in the case of protein feedingstuff (soybeans, other oilseeds, oilseed meals, protein crops). Each value drawn by Monte-Carlo simulations (1,000 values for trade balances of each crop) was decreased by 10% (most-probable case scenario) and 30% (worst-case scenario), respectively; the resulting values are the data input for model 1.

[193] Since “yields” (in terms of t/ha or kg/head) are not availablefor the product categories oilseed meals, vegetable oils, fruits, vegetables, and fish, we employ Monte-Carlo simulation on the variable “production” for these categories.

The drawn values of the Monte-Carlo simulations for the **non-feed use per head** were altered in the cases of bioenergy crops according to Table 40. The resulting data serves as input in both model 1 and model 2.

The only exogenous variables of the Monte-Carlo simulations which are not subject to scenario-specific assumption are **areas and livestock**, respectively (i.e., the generated values are used for all scenarios and years). This is only relevant for model 2, where areas and livestock are taken as given.

Table 41: data input for Monte-Carlo simulations (minimum, mean and maximum of the years 2000 to 2020)

commodities	model 1 and 2 per head non-feed use (in kg)+			model 1 trade balance (in tonnes)+			model 2 land use (in ha), livestock (in heads)		
	min	mean	max	min	mean	max	min	mean	max
wheat	66.5	114.8	145.0	-678,238	-186,221	-16,423	261,119	300,939	333,244
coarse grains	115.4	165.2	189.9	-52,856	309,084	773,641	456,608	492,083	527,907
soybeans	1.3	3.8	6.3	-8,479	17,657	65,746	14,000	30,509	47,644
other oilseeds	36.3	60.3	76.7	104,249	291,070	447,953	83,737	100,374	111,687
oilseed meals	-	-	-	365,075	417,926	508,773	101,637	130,883	148,728
protein crops	0.8	3.1	9.9	-8,038	10,500	37,681	14,205	29,415	47,329
vegetable oils	22.4	45.0	55.5	76,440	211,016	283,804	-	-	-
sugar (beets)	37.0	38.1	40.3	-163,724	-118,284	-59,516	39,401	43,838	45,014
starch crops	79.9	90.1	96.4	9,770	59,409	106,211	21,006	21,941	23,737
fruits	134.6	148.9	158.6	376,353	444,196	482,607	-	-	-
vegetables	122.3	127.1	130.2	327,323	437,233	488,151	-	-	-
beef & veal / cattle	15.7	17.5	19.8	-79,154	-70,660	-56,243	1,976,527	2,028,005	2,155,447
sheep (meat)	1.0	1.1	1.3	1,431	2,185	2,834	277,044	310,625	361,183
pork / pigs	54.7	56.9	61.4	-39,067	-18,799	6,646	3,004,907	3,184,691	3,440,405
poultry (meat)	17.4	20.2	22.6	31,210	46,572	57,356	11,786,670	13,998,382	15,860,393
eggs / laying hens	14.2	15.1	16.1	28,128	30,746	32,817	6,525,623	6,979,998	7,845,589
fish	5.4	9.0	13.5	39,898	72,828	114,702	-	-	-
raw milk / milk cows	341.1	348.1	370.9	-	-	-	524,500	553,146	621,002
butter	4.8	5.6	6.6	2,648	13,786	24,344	-	-	-
cheese	17.3	19.9	21.1	5,340	10,348	18,511	-	-	-

+ The data input provided in this table does not include scenario-specific assumption

6.4. Results

6.4.1. Results Model 1

In the following, we present the simulation results of model 1 (see appendix 14.1 for more details). Model 1 asks for the impact of changes in consumption and trade on production. In model 1, the self-sufficiency rate is calculated by assuming that trade balances are exogenously given. Production is endogenous and calculated as the difference between national use (consisting of feed use and non-feed use) and the trade balance. In the first step, we calculated self-sufficiency rates of animal products. In a second step, the endogenously determined number of livestock entered the calculation of self-sufficiency rates of crop products via their feed use. It is important to note that (unlike in model 2) the resulting self-sufficiency rates do *not* account for scenario-specific yields (due to climate change, shortage in phosphorus fertilizers, etc.). Rather, after the determination of production, the solutions are divided by scenario-specific yields to determine respective livestock numbers and acreage.

The resulting self-sufficiency rates are scenario-specific and consider two different time frames (2030, 2050), see an overview of underlying assumptions in Table 42. In the case of animal products, there are no scenario-specific assumptions which affect their self-sufficiency rates (assumptions on animal yields do not affect self-sufficiency rates of animal products in this model). Only time-specific assumptions about the population in Austria affect the self-sufficiency rates of animal products via changes in total consumption. Since animal yields are scenario- and time-specific, the same applies to (endogenously determined) livestock numbers and, thus, feed use and domestic use of respective crop products. In addition, we employ scenario-specific assumptions on the non-feed use per head of crop products and on imports. Monte-Carlo simulations were executed for the exogenous variables

- trade balances
- non-feed use per head.

The respective scenario-specific assumptions were applied to the resulting values of the Monte-Carlo simulations (see chapter 6.3.).

Table 42: assumptions affecting self-sufficiency rates in model 1

	population	animal yields	total feed use	non-feed use per head (crop products)[1]	imports (crop products)[2]
time-specific assumptions:					
2030	9.0 mill.	time-specific assumptions	based on endogenous livestock	no time-specific assumptions	no time-specific assumptions
2050	9.3 mill.	time-specific assumptions	based on endogenous livestock		
scenario-specific assumptions:					
baseline	no scenario-specific assumptions	scenario-specific assumptions	based on endogenous livestock	-	-
best-case		scenario-specific assumptions	based on endogenous livestock	increase based on bioenergy use of 10% of crop-specific area	-
most-probable		scenario-specific assumptions	based on endogenous livestock	increase based on bioenergy use of 12% of crop-specific area	-10%
worst-case		scenario-specific assumptions	based on endogenous livestock	increase based on bioenergy use of 40% of crop-specific area	-30%

[1] wheat, coarse grains, other oilseeds, sugar, starch crops
[2] soybeans, other oilseeds, oilseed meals, protein crops

Since consumption (i.e., non-feed use plus feed use) for crop products is determined in the model by the number of livestock, the results regarding animal products (step 1 of model 1) will be presented first. Table 43 shows the resulting self-sufficiencies. In this model, there are no scenario-specific assumptions regarding animal products affecting the self-sufficiency rates. Differences between 2030 and 2050 are due to an increase in the Austrian population and, thus, an increase in the non-feed use of animal products. However, these differences are of minor importance. The average self-sufficiency rate (i.e., the mean of the 1,000 results for self-sufficiency rates due to Monte-Carlo simulations) decreases for beef & veal, pork and cheese in 2030 and 2050 by -1 to -11%-age points, relative to 2015. All other animal products exhibit increases in self-sufficiencies (+1 to +13%-age points). Assuming scenario- and time-specific animal yields (see chapter 6.3.4), Table 44 shows the required changes in the number of livestock to meet production needs.

Table 43: self-sufficiency rates of animal products (model 1, all scenarios)

	2000-2010	*diff. to 2015*	2015	2030	*diff. to 2015*	2050	*diff. to 2015*
beef & veal	144%	*-9%*	153%	143%	*-10%*	142%	*-11%*
sheep meat	79%	*+5%*	73%	79%	*+6%*	80%	*+6%*
pork	103%	*-3%*	105%	103%	*-2%*	103%	*-2%*
poultry meat	73%	*+1%*	72%	75%	*+3%*	76%	*+4%*
eggs	75%	*-1%*	76%	78%	*+1%*	78%	*+2%*
fish	6%	*+2%*	3%	15%	*+12%*	16%	*+13%*
raw milk	100%	*0%*	100%	100%	*0%*	100%	*0%*
butter	80%	*+16%*	64%	73%	*+9%*	74%	*+10%*
cheese	93%	*-2%*	95%	93%	*-1%*	94%	*-1%*

Note: Table entries are means (mean from 2000 to 2010 and mean for 2030 and 2050 resulting from the Monte-Carlo simulations, respectively). Table entries in *italics* indicate *absolute* differences of mean values (in %age-points) relative to the value for 2015.

Except for the case of sheep, the average number of livestock decreases in the best-case scenario, relative to 2015. In the worst-case scenario with relatively low animal yields, livestock numbers must be highest in order to meet the necessary production. Depending on the scenario, time frame and product, livestock increases by +1% (poultry) to +42% (sheep), relative to 2015.

Table 44: livestock according to scenario-specific yields (model 1)

	2000-2010, *rel. to 2015*	**2015** 1,000 heads		**2030**, *rel. to 2015*	**2050,** *rel. to 2015*
cattle	*+1%*	2,015.9	baseline/most prob.	*+4%*	*+5%*
			best-case	*-5%*	*-5%*
			worst-case	*+15%*	*+16%*
sheep	*+18%*	280.2	baseline/most prob.	*+25%*	*+28%*
			best-case	*+14%*	*+17%*
			worst-case	*+38%*	*+42%*
pigs	*+3%*	3,118.7	baseline/most prob.	*+5%*	*+6%*
			best-case	*-5%*	*-3%*
			worst-case	*+16%*	*+18%*
poultry	*-13%*	14,999.2	baseline/most prob.	*+1%*	*+4%*
			best-case	*-8%*	*-5%*
			worst-case	*+12%*	*+15%*
laying hens	*-11%*	7,390.4	baseline/most prob.	*+2%*	*+5%*
			best-case	*-7%*	*-4%*
			worst-case	*+14%*	*+16%*
milk cows	*0%*	555.5	baseline/most prob.	*+5%*	*+5%*
			best-case	*-5%*	*-4%*
			worst-case	*+16%*	*+17%*

Note: Table entries in *italics* indicate relative changes (in %) of mean values, relative to the value for 2015.

As an example, Figure 50 shows the distributions of the number of milk cows (Monte-Carlo simulated input data are the trade balance and the non-feed use per head). The grey boxes represent the value of the 1st and 3rd quartile, respectively. Thus, the (vertical) range of each box represents possible numbers of milk cows within a probability of 25% and 75%. The median represents the value with a probability of 50%. Figure 50 shows that the mean values and respective median values are quite close to each other. The short black lines below and above the grey boxes indicate the maximum and minimum results of the simulations. Thus, the minimum (maximum) number of milk cows is on average about 59,000 (65,000) heads lower (higher) than the respective mean value.

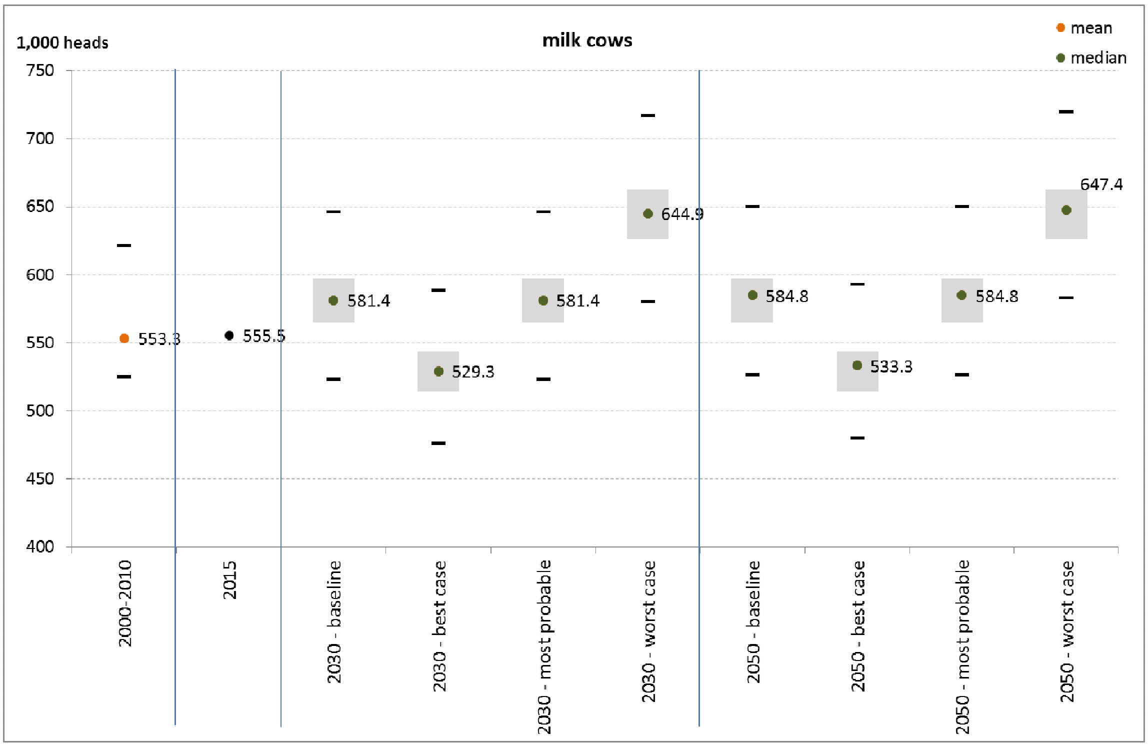


Figure 50: number of milk cows (in 1,000 heads)

Note: The lower and upper black lines indicate minimum and maximum values, respectively. The lower and upper boundaries of the grey boxes indicate the 1st and the 3rd quartile, respectively. Figures indicate the mean value.

For each scenario and time frame, the resulting number of livestock generate changes in the total feed use for certain crop products. Total feed use of crop products is lowest in the best-case scenario and highest in the worst-case scenario. Applying the assumptions on population in 2030 and 2050, on increases in per-head non-feed use for bioenergy crops and on decreases in imports of protein feedingstuff gives the following self-sufficiency rates for crop products (see Table 45).

Table 45: self-sufficiency rates of crop products (model 1)

	2000-2010	*diff. to 2015*	2015		2030	*diff. to 2015*	2050	*diff. to 2015*
wheat	125%	*+21%*	105%	baseline	121%	*+16%*	120%	*+16%*
				best-case	120%	*+16%*	120%	*+15%*
				most-probable	119%	*+15%*	119%	*+14%*
				worst-case	115%	*+10%*	115%	*+10%*
coarse grains	90%	*-4%*	94%	baseline	91%	*-3%*	91%	*-3%*
				best-case	91%	*-3%*	91%	*-3%*
				most-probable	92%	*-2%*	92%	*-2%*
				worst-case	94%	*-1%*	94%	*0%*
soybeans	86%	-1%	88%	baseline	80%	*-7%*	81%	*-7%*
				best-case	79%	*-9%*	79%	*-8%*
				most-probable	82%	*-5%*	83%	*-5%*
				worst-case	87%	*0%*	87%	*0%*
other oilseeds	54%	*+16%*	38%	baseline	46%	*+7%*	47%	*+9%*
				best-case	47%	*+9%*	49%	*+11%*
				most-probable	53%	*+15%*	54%	*+16%*
				worst-case	68%	*+30%*	69%	*+31%*
oilseed meals	30%	*-11%*	41%	baseline	36%	*-5%*	37%	*-4%*
				best-case	30%	*-11%*	31%	*-10%*
				most-probable	43%	*+1%*	43%	*+2%*
				worst-case	60%	*+18%*	60%	*+19%*
protein crops	99%	*+33%*	66%	baseline	86%	*+21%*	87%	*+21%*
				best-case	86%	*+20%*	86%	*+20%*
				most-probable	88%	*+22%*	88%	*+22%*
				worst-case	91%	*+25%*	91%	*+25%*
vegetable oils	52%	*+8%*	44%	baseline	49%	*+5%*	51%	*+7%*
				best-case	49%	*+5%*	50%	*+7%*
				most-probable	49%	*+5%*	51%	*+7%*
				worst-case	49%	*+5%*	51%	*+7%*
sugar	135%	*-3%*	138%	baseline	133%	*-6%*	132%	*-7%*
				best-case	130%	*-8%*	129%	*-9%*
				most-probable	129%	*-9%*	128%	*-10%*
				worst-case	122%	*-17%*	121%	*-17%*
starch crops	90%	*-3%*	94%	baseline	93%	*-1%*	93%	*0%*
				best-case	93%	*0%*	93%	*0%*
				most-probable	93%	*0%*	94%	*0%*
				worst-case	95%	*+1%*	*95%*	*+1%*
fruits	65%	*-2%*	64%	all scenarios	67%	*+3%*	68%	*+4%*
vegetables	61%	*+2%*	57%	all scenarios	63%	*+6%*	65%	*+7%*

Note: Table entries are means (mean from 2000 to 2010 and mean for 2030 and 2050 resulting from the Monte-Carlo simulations, respectively). Table entries in *italics* indicate *absolute* differences of mean values (in %age-points) relative to the value for 2015.

For most crop products, average self-sufficiency rates are higher in the worst-case scenario than they are in the best-case scenario, indicating higher production needs in the worst-case scenario.[194] In addition, average self-sufficiency rates for 2030 and 2050 are higher relative to 2015 for most crop products. However, they are lower in the cases of coarse grains, sugar, soybeans, oilseed meals and starch crops in some scenarios.

Assuming the time- and scenario specific crop yields (see chapter 6.3.3), Table 46 summarises the resulting changes in acreage needed to meet production needs (see also Figure 51 to Figure 55 for specific crop products). Relative to 2015, acreage needs are higher in the worst-case scenario for all crops. For example, while acreage needs for coarse grains are lower in the baseline, the best-case and the worst-case scenario, acreage must be up to 110% higher than in 2015. Considering the acreage of all crop products in the model, the changes in the total acreage differ between -29% or -297,000 hectares (best-case scenario, 2050) and +109% or +1,128,000 hectares (worst-case scenario, 2050).

[194] In the cases of fruits and vegetables there are no scenario-specific differences due to the absence of scenario-specific assumptions and since these products are not used as animal feed.

Table 46: areas according to scenario-specific yields (model 1)

	2000-2010, *rel. to 2015*	**2015** 1,000 ha		**2030,** *rel. to 2015*	**2050,** *rel. to 2015*
wheat	*-9%*	315.6	baseline	*-3%*	*-8%*
		(31% of total)	best-case	*-16%*	*-28%*
			most-probable	*+6%*	*+2%*
			worst-case	*+86%*	*+90%*
coarse grains	*+2%*	486.8	baseline	*-16%*	*-26%*
		(47% of total)	best-case	*-25%*	*-35%*
			most-probable	*-7%*	*-17%*
			worst-case	*+101%*	*+110%*
soybeans	*-50%*	40.6	baseline	*-25%*	*-40%*
		(4% of total)	best-case	*-38%*	*-51%*
			most-probable	*-21%*	*-36%*
			worst-case	*+38%*	*+29%*
other oilseeds	*-6%*	103.8	baseline	*-10%*	*-14%*
		(10% of total)	best-case	*-13%*	*-20%*
			most-probable	*+11%*	*+6%*
			worst-case	*+138%*	*+161%*
protein crops	*+89%*	20.2	baseline	*+116%*	*+153%*
		(2% of total)	best-case	*+83%*	*+108%*
			most-probable	*+128%*	*+175%*
			worst-case	*+301%*	*+418%*
sugar	*-2%*	44.2	baseline	*-10%*	*-22%*
		(4% of total)	best-case	*-7%*	*-19%*
			most-probable	*-1%*	*-12%*
			worst-case	*+57%*	*+65%*
starch crops	*+4%*	21.5	baseline	*-19%*	*-29%*
		(2% of total)	best-case	*-21%*	*-30%*
			most-probable	*-11%*	*-20%*
			worst-case	*+75%*	*+83%*
total area considered	*-3%*	1,032.7	baseline	*-9%*	*-17%*
			best-case	*-19%*	*-29%*
			most-probable	*+1%*	*-6%*
			worst-case	*+99%*	*+109%*

Note: Table entries in *italics* indicate relative changes (in %) of mean values, relative to the value for 2015.

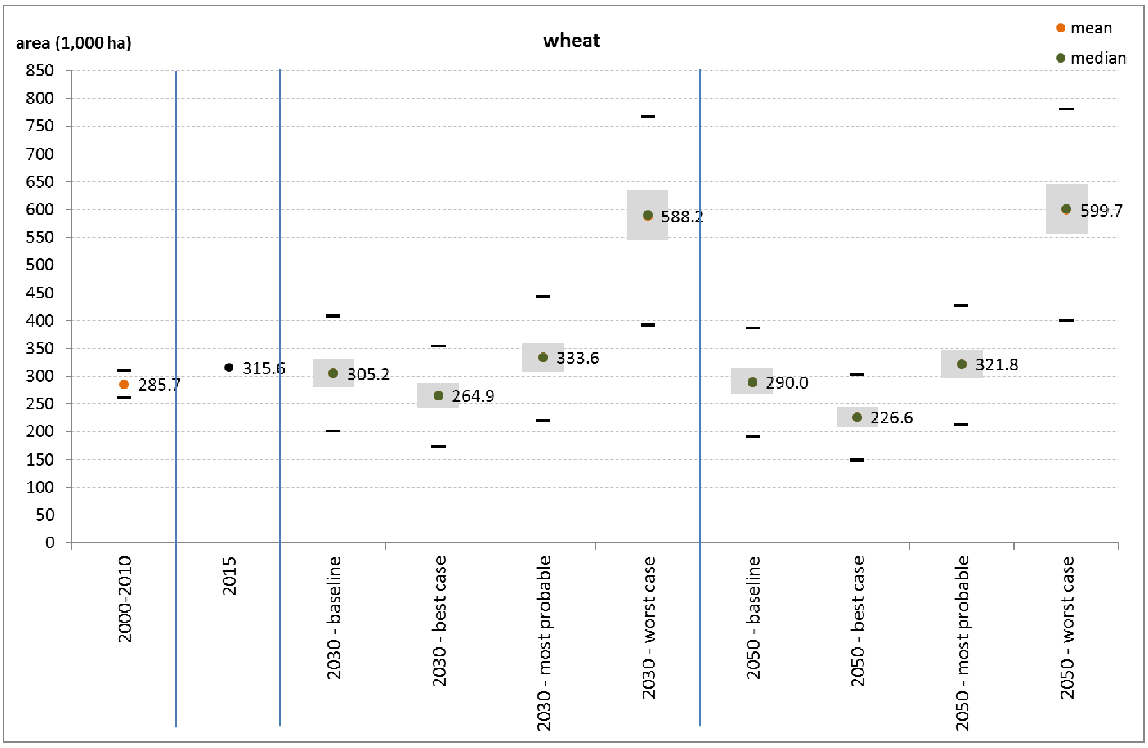


Figure 51: acreage of wheat

Note: The lower and upper black lines indicate minimum and maximum values, respectively. The lower and upper boundaries of the grey boxes indicate the 1st and the 3rd quartile, respectively. Figures indicate the mean value.

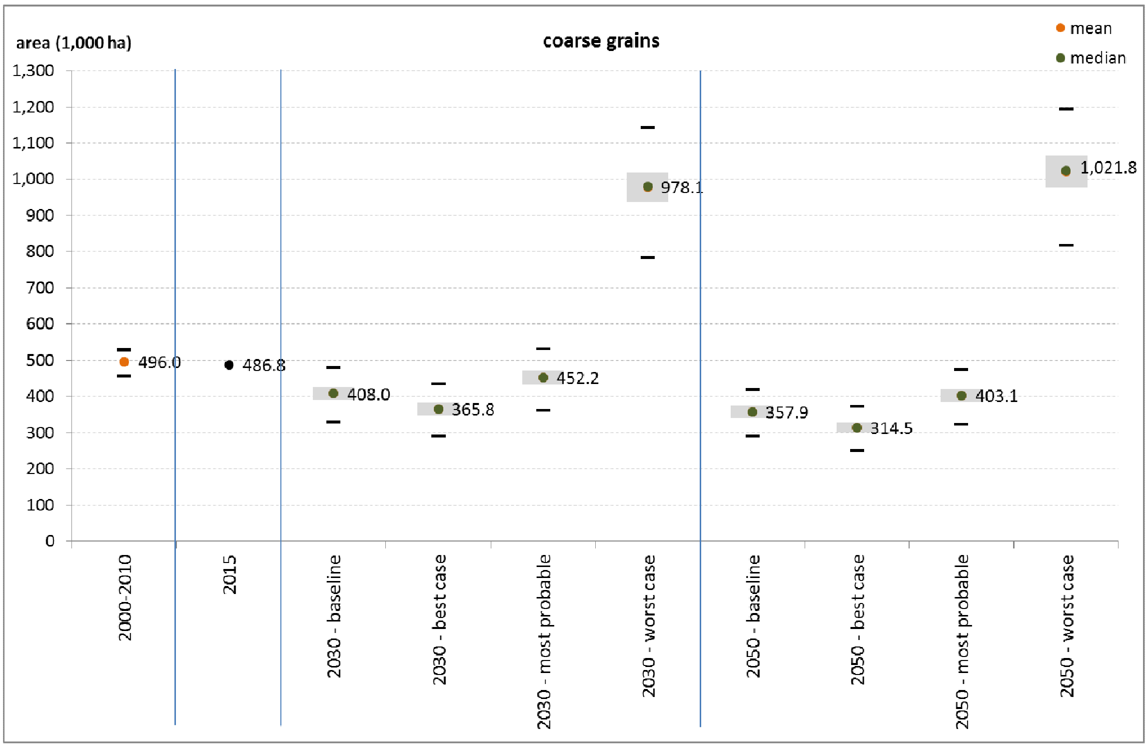


Figure 52: acreage of coarse grains

Note: The lower and upper black lines indicate minimum and maximum values, respectively. The lower and upper boundaries of the grey boxes indicate the 1st and the 3rd quartile, respectively. Figures indicate the mean value.

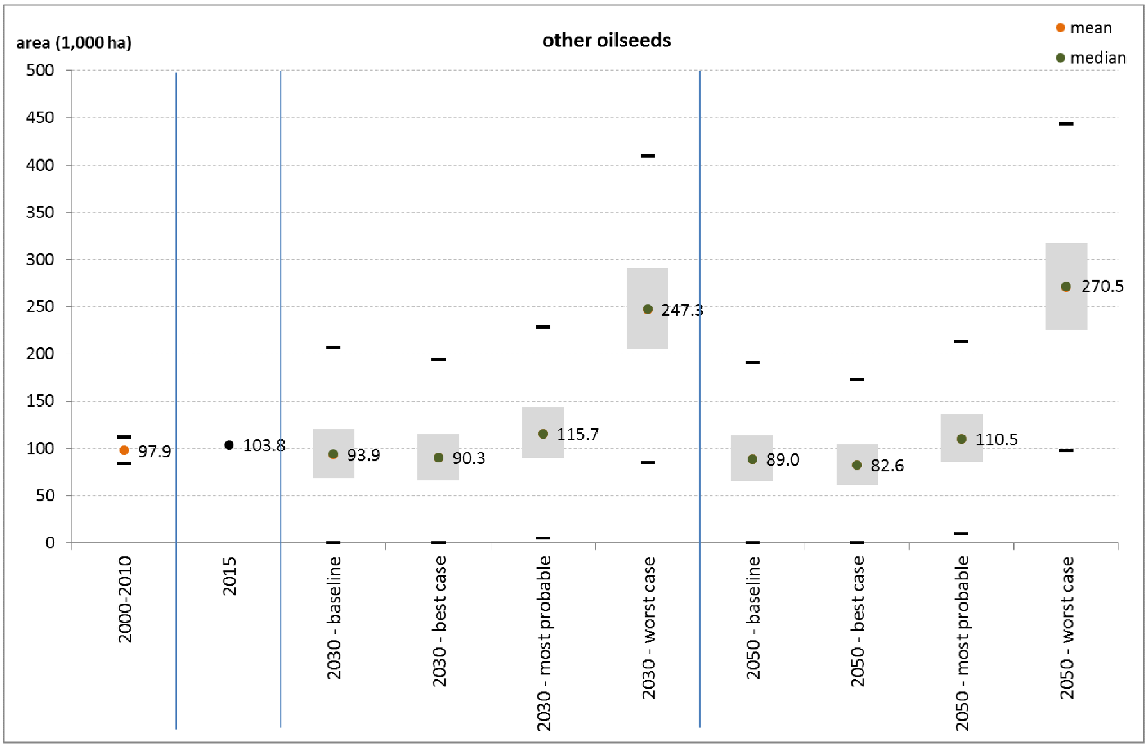


Figure 53: acreage of "other oilseeds"

Note: The lower and upper black lines indicate minimum and maximum values, respectively. The lower and upper boundaries of the grey boxes indicate the 1st and the 3rd quartile, respectively. Figures indicate the mean value.

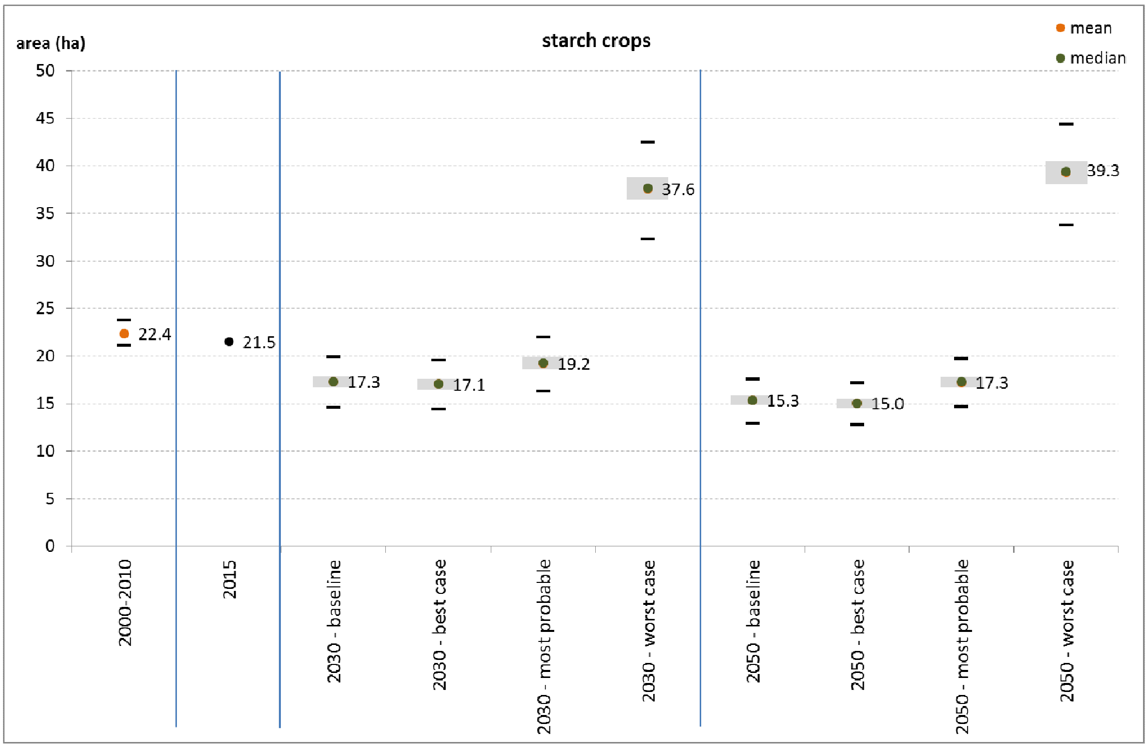


Figure 54: acreage of starch crops

Note: The lower and upper black lines indicate minimum and maximum values, respectively. The lower and upper boundaries of the grey boxes indicate the 1st and the 3rd quartile, respectively. Figures indicate the mean value.

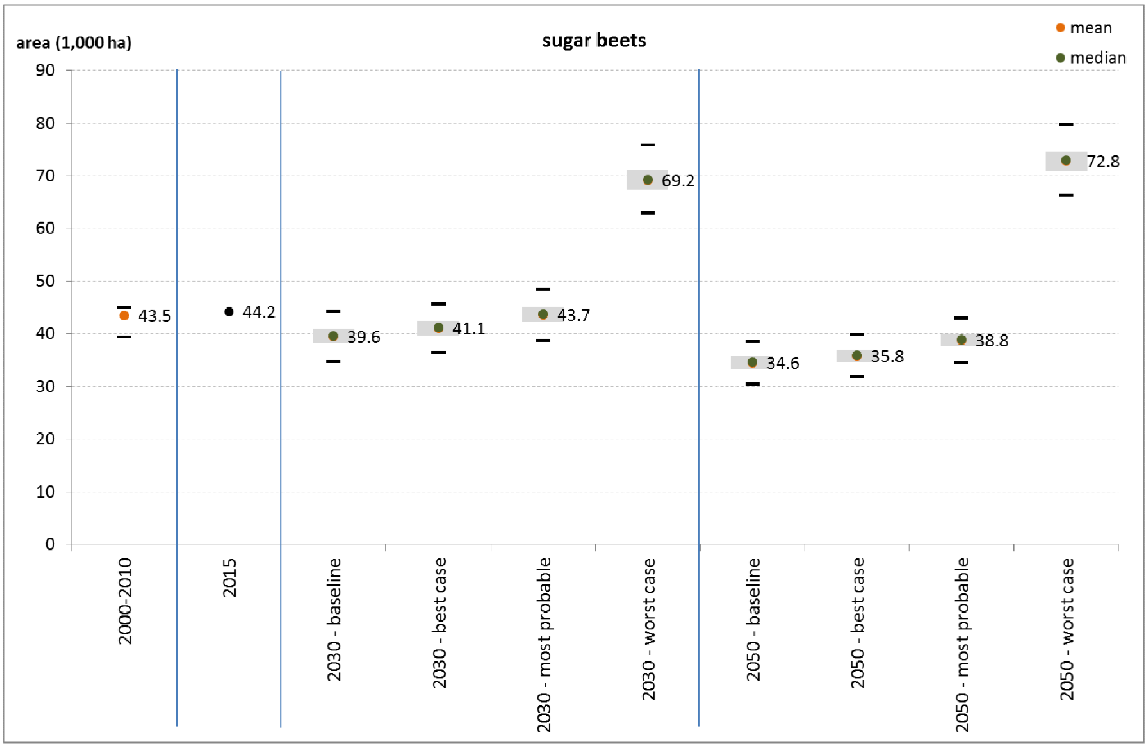


Figure 55: acreage of sugar beets

Note: The lower and upper black lines indicate minimum and maximum values, respectively. The lower and upper boundaries of the grey boxes indicate the 1st and the 3rd quartile, respectively. Figures indicate the mean value.

For the interpretation of the results of model 1 it is essential to recall the principle structure of the model where production is defined as the difference between consumption and trade balance. Accordingly, consumption determines production as trade balances are given by Monte-Carlo simulations. Consumption is derived from both non-feed use and feed use. Assuming a constant per-capita consumption, a growing population results in an increasing demand for commodities. In model 1 the number of animals is determined endogenously (from endogenous production and exogenous animal yields). Depending on yield levels, an increasing animal production generally implies increasing livestock numbers and raises demand for feed, which has to be met by increasing crop production (e.g., feedstuff like cereals, protein crops, etc.) since trade balances are taken as given. Changes in yields (e.g., due to the impact of climate change) do not affect production directly but the required area cultivated or number of livestock. A raise in the self-sufficiency rates of an individual commodity in model 1 must always be viewed in the context of an increasing area or livestock. For instance, the worst-case scenarios show higher self-sufficiency rates than in the best-case scenario because of considerably higher production, i.e. implicitly requiring a higher acreage and livestock. Put differently, model 1 determines the acreage and livestock numbers that are required to meet a given consumption level, given a pre-defined level of trade. In most cases, the worst-case scenarios show the maximum self-sufficiency rate, the minimum self-sufficiency rates are mostly the result of the best-case or the baseline scenario.

Figure 56 summarises the results of model 1. In this figure, product categories are ordered according to the mean self-sufficiency rate from 2000 to 2010 (see the black line). For each product, there are eight different simulation results of average self-sufficiency rates (two years, four scenarios). Only the respective minimum and maximum average result of self-sufficiencies is illustrated in this figure. In addition, this figure shows the corresponding changes in acreage and livestock numbers relative to 2015 (indicated by bars and the secondary y-axis on the right hand side) that are required to meet these self-sufficiency rates. Most scenarios suggest an extension of areas and livestock numbers. The maximum self-sufficiency rates of protein crops and "other oilseeds" imply the highest increases in respective acreages. The scenarios with minimum self-sufficiency rates of, e.g., starch crops, soybeans, coarse grains or "other oilseeds" imply a reduction of respective areas.

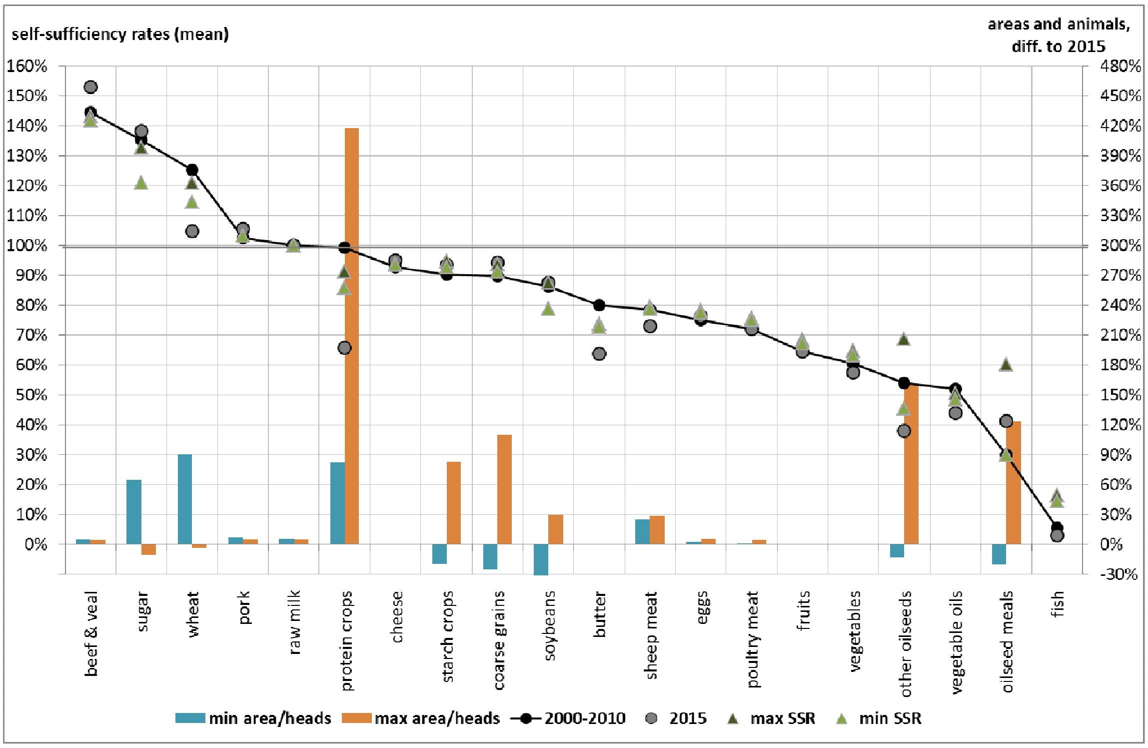


Figure 56: Minimum and maximum average self-sufficiency rates of model 1 and related changes in acreage and livestock numbers (relative to 2015).

Note: bars indicate relative changes of acreage or livestock numbers (relative to 2015; see the secondary y-axis on the right hand side) that correspond to the minimum (min) or maximum (max) self-sufficiency rates according to scenario results. There are no areas for fruits and vegetables in the database.

Figure 57 explains the reasons for changes in self-sufficiency rates (relative to 2015) via changes in production and consumption. In case of increasing self-sufficiency rates, all results are located below the 45° (dashed) line implying that changes in production exceed that of consumption, that production increases and consumption decreases, or that consumption decreases more than does production. For instance, regarding protein crops, all scenarions show increasing self-sufficiency rates because of an increase in production that exceeds that of consumption. The production of vegetable oils decreases in all scenarios but consumption shows an even sharper fall, again resulting in an increasing self-sufficiency rate.

Most products follow a clear pattern displaying either increasing or decreasing self-sufficiency rates (relative to 2015) in all scenarios. Exceptions are oilseed meals and starch crops showing both, rising and falling self-sufficiency rates. Unlike in case of increasing self-sufficiency rates, the scenario results of decreasing self-sufficiency rates are above the 45° (dashed) line (see Figure 56).

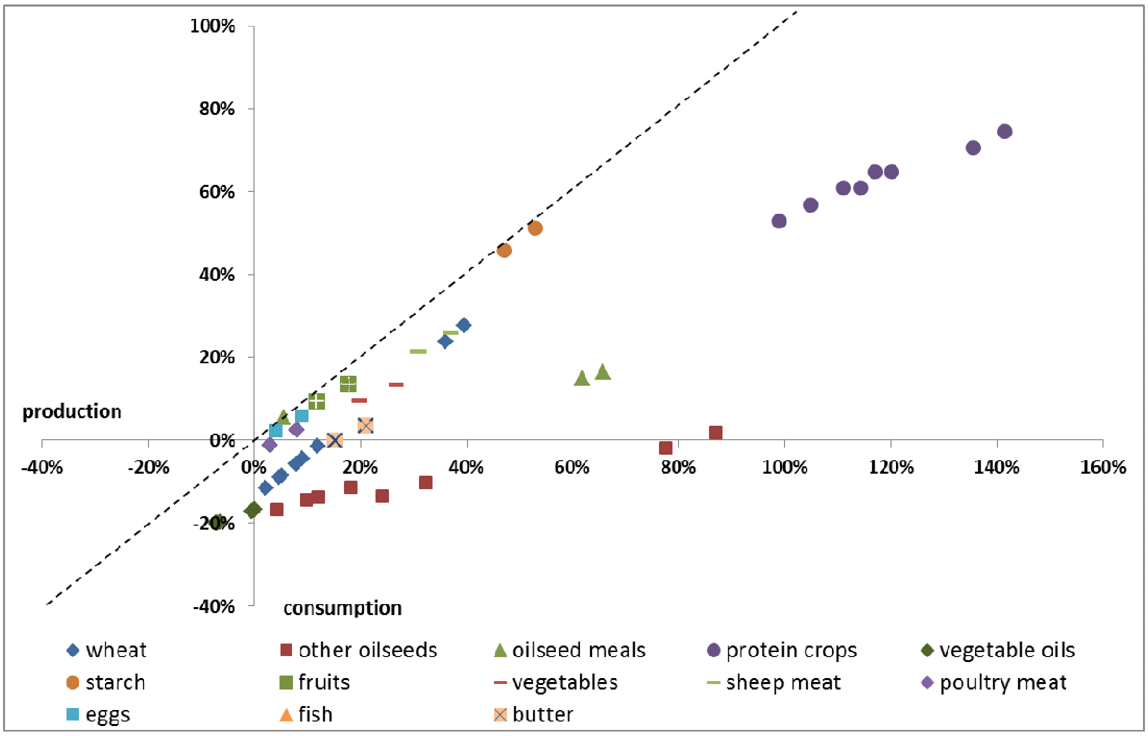


Figure 57: Determinants of increasing self-sufficiency rates (changes of production and consumption in %, relative to 2015)

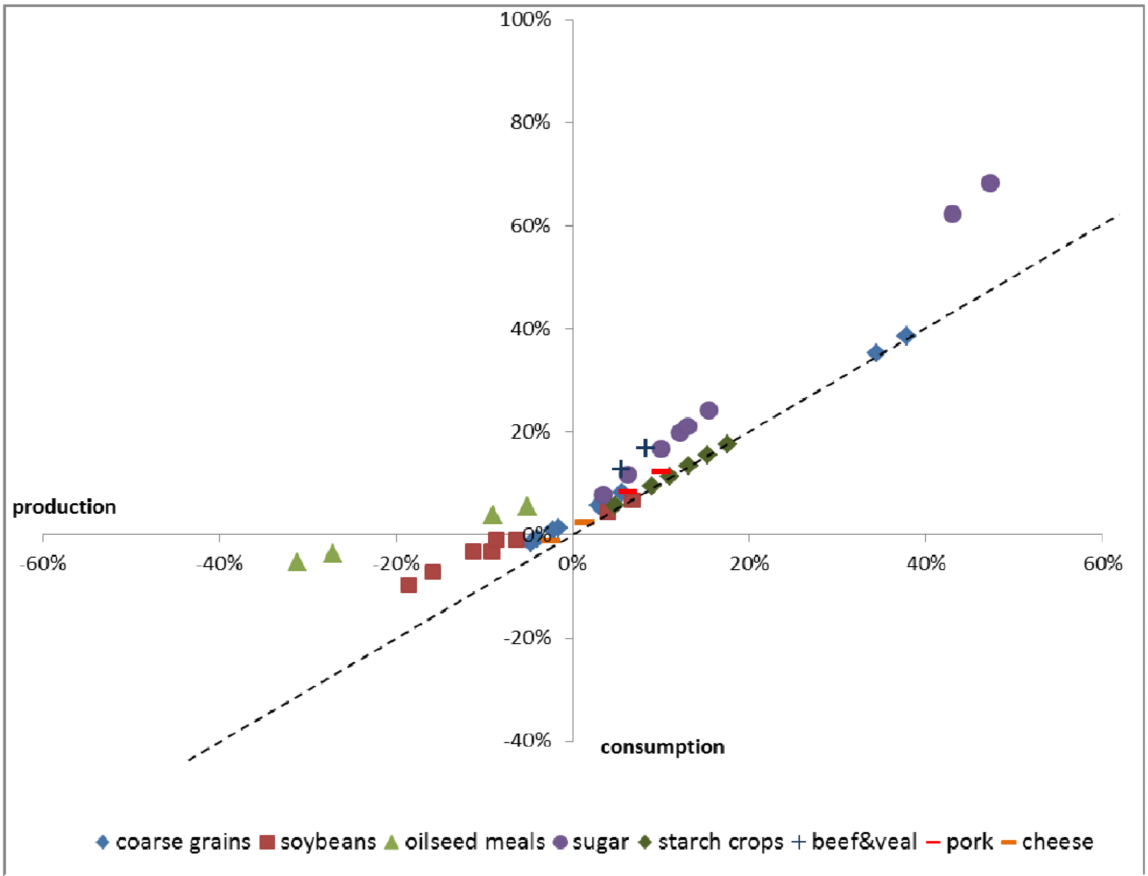


Figure 58: Determinants of decreasing self-sufficiency rates (changes of production and consumption in%, relative to 2015)

Note: figures for fish cannot be displayed on this scale (production: +376% - +454%, consumption: -6% - -9%)

6.4.2. Results Model 2

Contrary to model 1, model 2 assumes that areas and livestock are given. Model 2 asks for the impact of changes in consumption and production on trade balances. Since crop and animal yields are given as well, production is exogenous. Assumptions on climate change, technical progress, shortage of phosphorus fertilizer and intensity of input levels directly affect the self-sufficiency rates. In this model, the endogenous variable is the trade balance. This, however, implies that model 2 does not consider changes in imports of protein feedingstuff as is the case in model 1.

Again, the resulting self-sufficiency rates are scenario-specific and consider two different time frames (2030, 2050), see an overview of underlying assumptions in Table 47.

Monte-Carlo simulations were executed for the exogenous variables

- areas
- livestock
- non-feed use per head

In the case of non-feed use per head, the respective scenario-specific assumptions were applied on the resulting values of the Monte-Carlo simulations (see chapter 6.3.5).

Table 47: assumptions affecting self-sufficiency rates in model 2

	population	**crop and animal yields**	**non-feed use per head** (crop products)[1]
time-specific assumptions:			
2030	9.0 mill.	time-specific assumptions	no time-specific assumption
2050	9.3 mill.	time-specific assumptions	
scenario-specific assumptions:			
baseline	no scenario-specific assumption	scenario-specific assumptions	-
best-case		scenario-specific assumptions	increase based on bioenergy use of 10% of crop-specific area
most-probable		scenario-specific assumptions	increase based on bioenergy use of 12% of crop-specific area
worst-case		scenario-specific assumptions	increase based on bioenergy use of 40% of crop-specific area

[1] wheat, coarse grains, other oilseeds, sugar, starch crops

Table 48 and Table 49 show the resulting self-sufficiencies of crop and animal products (see the appendix for more details). In general, self-sufficiency rates are highest in the best-case scenario and lowest in the worst-case scenario. For all products (except beef & veal), self-sufficiency rates are less than 100% in the worst-case scenario, implying the necessity of imports. Reductions in average self-sufficiencies (relative to 2015) are especially high in the cases of sugar (up to -67%-age points), cereals (wheat and coarse grains; up to -46%-age points) and starch crops (up to -40%-age points). In the case of animal products, the same applies to beef & veal (up to -28%-age points) or pork (up to -15%-age points). Figure 59 to Figure 64 illustrate the range of self-sufficiency results based on Monte-Carlo simulations for certain crop and animal products.

Table 48: self-sufficiency rates of crop products (model 2)

	2000-2010	*diff. to 2015*	2015		2030	*diff. to 2015*	2050	*diff. to 2015*
wheat	125%	*+21%*	105%	baseline	120%	*+16%*	127%	*+22%*
				best-case	134%	*+30%*	157%	*+52%*
				most-probable	109%	*+4%*	113%	*+8%*
				worst-case	61%	*-44%*	60%	*-45%*
coarse grains	90%	*-4%*	94%	baseline	112%	*+18%*	129%	*+35%*
				best-case	118%	*+24%*	139%	*+45%*
				most-probable	102%	*+8%*	115%	*+21%*
				worst-case	50%	*-44%*	49%	*-46%*
soybeans	86%	*+1%*	88%	baseline	84%	*-3%*	107%	*+20%*
				best-case	93%	*+6%*	122%	*+35%*
				most-probable	82%	*-6%*	103%	*+15%*
				worst-case	54%	*-34%*	58%	*-29%*
other oilseeds	54%	*+16%*	38%	baseline	50%	*+12%*	55%	*+17%*
				best-case	54%	*+15%*	61%	*+23%*
				most-probable	47%	*+9%*	51%	*+12%*
				worst-case	28%	*-10%*	26%	*-12%*
oilseed meals	30%	*-11%*	41%	all scenarios	35%	*-6%*	35%	*-6%*
protein crops	99%	*+33%*	66%	baseline	64%	*-2%*	55%	*-11%*
				best-case	71%	*+5%*	63%	*-3%*
				most-probable	61%	*-5%*	51%	*-15%*
				worst-case	38%	*-28%*	30%	*-36%*
vegetable oils	52%	*+8%*	44%	all scenarios	45%	*+2%*	44%	*0%*
sugar	135%	*-3%*	138%	baseline	144%	*+5%*	163%	*+25%*
				best-case	135%	*-3%*	154%	*+16%*
				most-probable	127%	*-11%*	142%	*+3%*
				worst-case	75%	*-63%*	71%	*-67%*
starch crops	90%	*-3%*	94%	baseline	119%	*+26%*	135%	*+41%*
				best-case	121%	*+28%*	138%	*+45%*
				most-probable	108%	*+14%*	120%	*+27%*
				worst-case	56%	*-38%*	54%	*-40%*
fruits	65%	*-2%*	64%	all scenarios	59%	*-6%*	57%	*-8%*
vegetables	61%	*+2%*	57%	all scenarios	55%	*-2%*	53%	*-4%*

Note: Table entries are means (mean from 2000 to 2010 and mean for 2030 and 2050 resulting from the Monte-Carlo simulations, respectively). Table entries in *italics* indicate *absolute* differences of mean values (in %age-points) relative to the value for 2015.

Table 49: self-sufficiency rates of animal products (model 2)

	2000-2010	*diff. to 2015*	2015		2030	*diff. to 2015*	2050	*diff. to 2015*
beef & veal	144%	*-9%*	153%	baseline/most prob.	141%	*-12%*	138%	*-15%*
				best-case	154%	*+1%*	152%	*-1%*
				worst-case	127%	*-26%*	125%	*-28%*
sheep meat	79%	*+5%*	73%	baseline/most prob.	71%	*-2%*	70%	*-3%*
				best-case	78%	*+5%*	77%	*+4%*
				worst-case	64%	*-9%*	63%	*-10%*
pork	103%	*-3%*	105%	baseline/most prob.	102%	*-4%*	100%	*-5%*
				best-case	112%	*+6%*	110%	*+4%*
				worst-case	92%	*-14%*	90%	*-15%*
poultry meat	73%	*+1%*	72%	baseline/most prob.	69%	*-3%*	68%	*-4%*
				best-case	76%	*+3%*	74%	*+2%*
				worst-case	62%	*-10%*	61%	*-11%*
eggs	75%	*-1%*	76%	baseline/most prob.	73%	*-3%*	72%	*-4%*
				best-case	80%	*+4%*	79%	*+3%*
				worst-case	66%	*-10%*	65%	*-11%*
fish	6%	*+2%*	3%	all scenarios	4%	*+1%*	4%	*+1%*
raw milk	100%	*0%*	100%	baseline/most prob.	97%	*-3%*	95%	*-5%*
				best-case	106%	*+6%*	105%	*+5%*
				worst-case	87%	*-13%*	86%	*-14%*
butter	80%	*+16%*	64%	baseline/most prob.	67%	*+3%*	66%	*+2%*
				best-case	73%	*+10%*	72%	*+8%*
				worst-case	60%	*-4%*	59%	*-4%*
cheese	93%	*-2%*	95%	baseline/most prob.	100%	*+5%*	98%	*+3%*
				best-case	110%	*+15%*	108%	*+13%*
				worst-case	90%	*-5%*	89%	*-6%*

Note: Table entries are means (mean from 2000 to 2010 and mean for 2030 and 2050 resulting from the Monte-Carlo simulations, respectively). Table entries in *italics* indicate *absolute* differences of mean values (in %age-points) relative to the value for 2015.

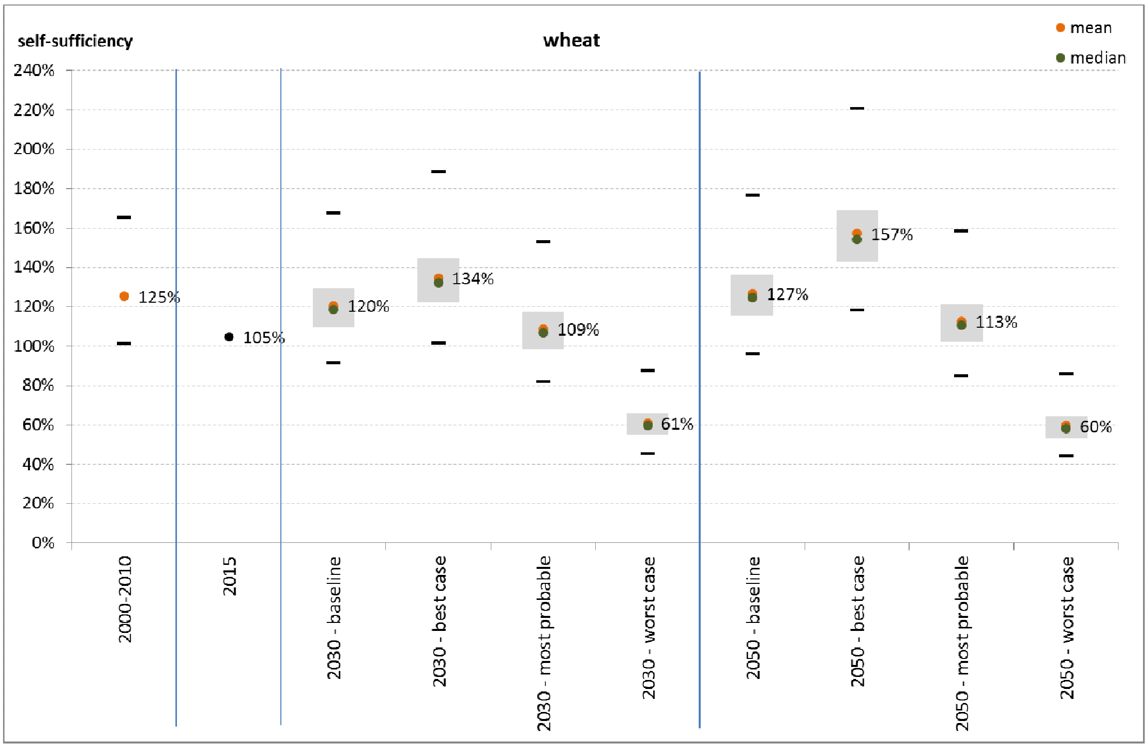


Figure 59: Self-sufficiency rates for wheat

Note: The lower and upper black lines indicate minimum and maximum values, respectively. The lower and upper boundaries of the grey boxes indicate the 1st and the 3rd quartile, respectively. Figures indicate the mean value.

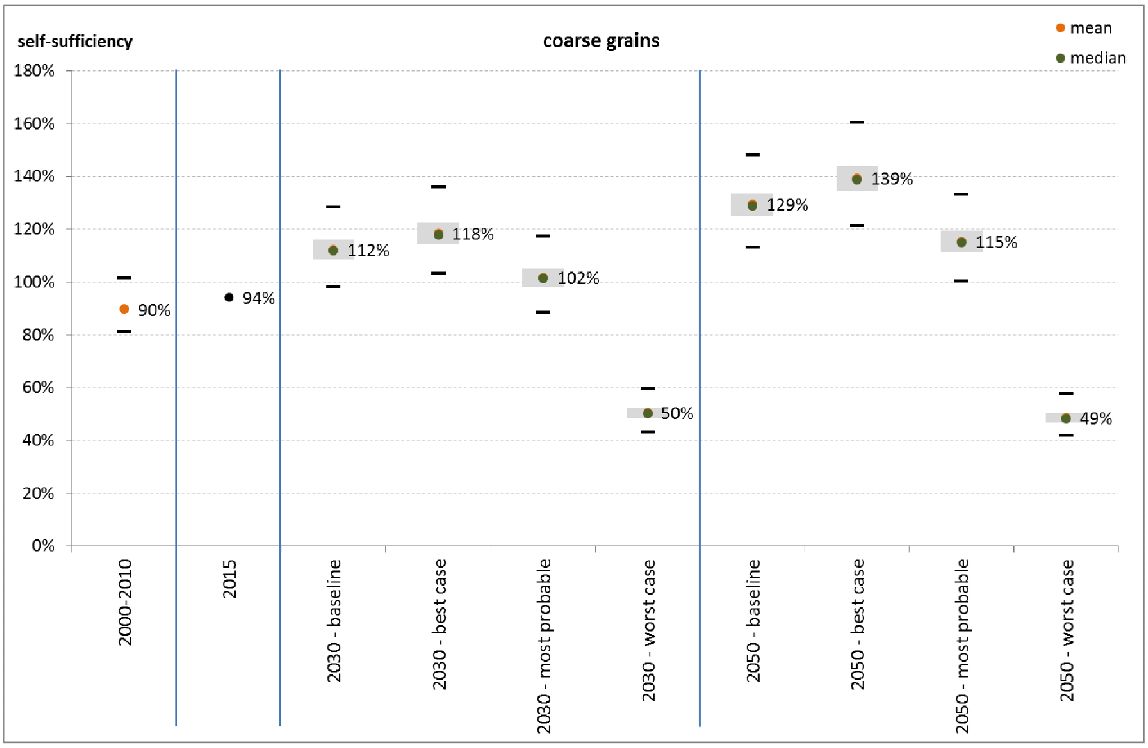


Figure 60: Self-sufficiency rates for coarse grains

Note: The lower and upper black lines indicate minimum and maximum values, respectively. The lower and upper boundaries of the grey boxes indicate the 1st and the 3rd quartile, respectively. Figures indicate the mean value

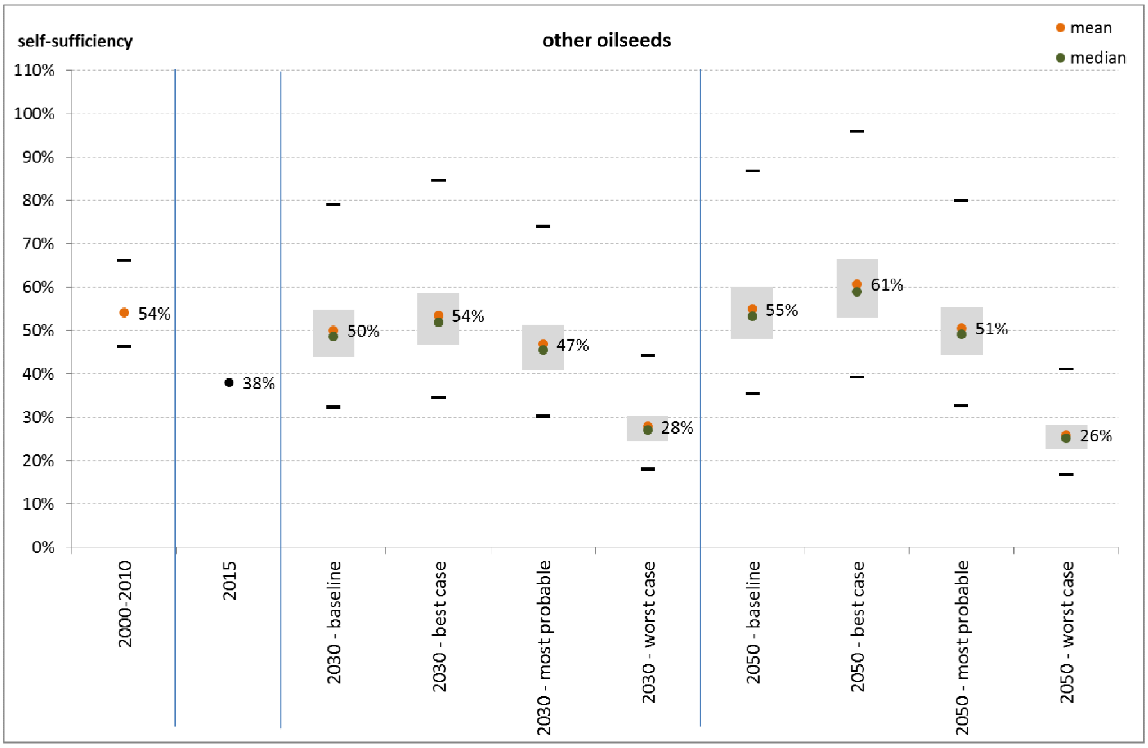


Figure 61: Self-sufficiency rates for other oilseeds

Note: The lower and upper black lines indicate minimum and maximum values, respectively. The lower and upper boundaries of the grey boxes indicate the 1st and the 3rd quartile, respectively. Figures indicate the mean value.

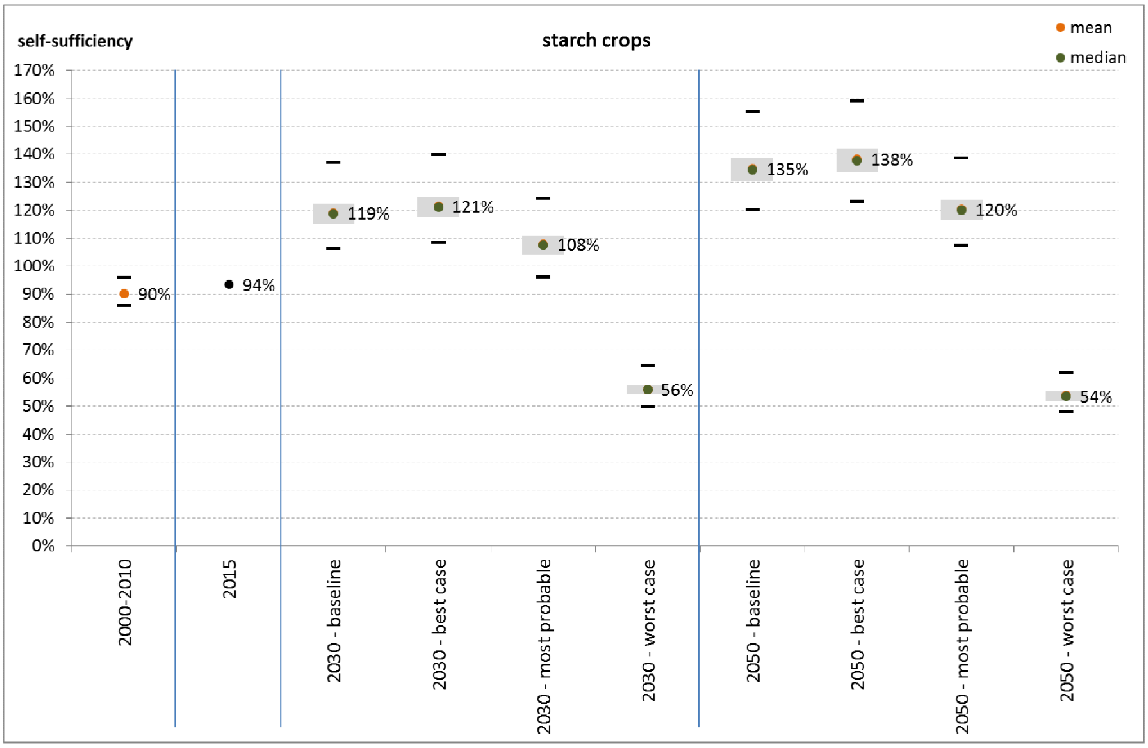


Figure 62: Self-sufficiency rates for starch crops

Note: The lower and upper black lines indicate minimum and maximum values, respectively. The lower and upper boundaries of the grey boxes indicate the 1st and the 3rd quartile, respectively. Figures indicate the mean value.

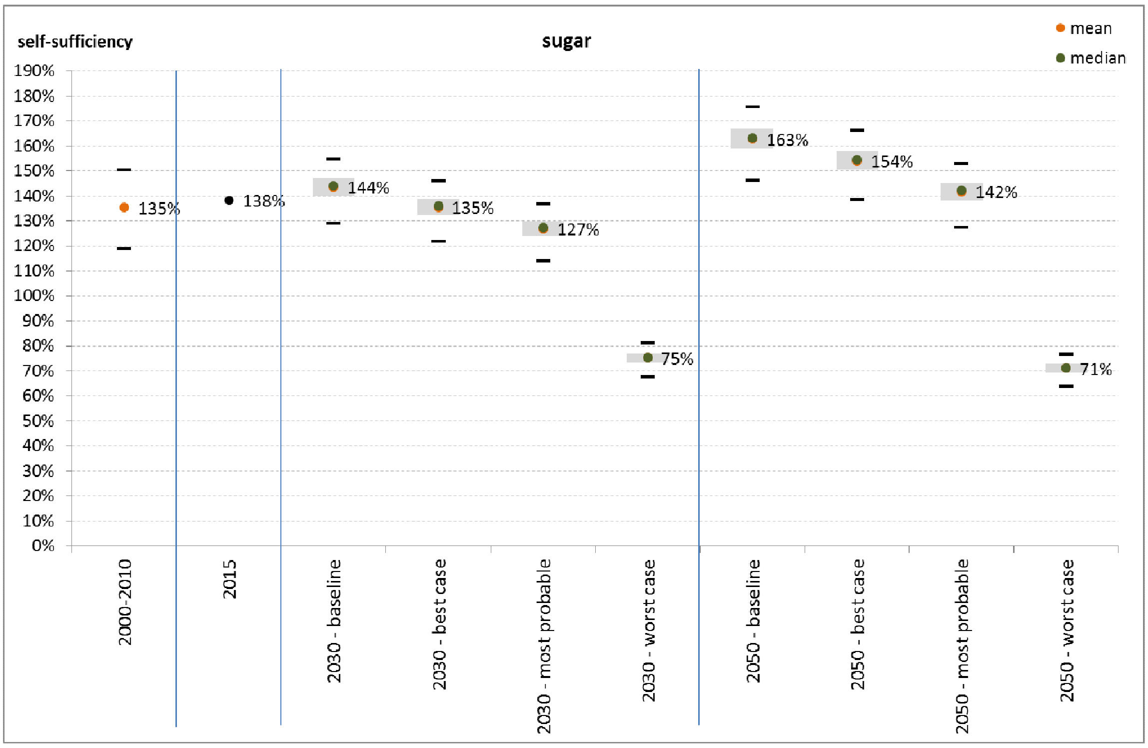


Figure 63: Self-sufficiency rates for sugar

Note: The lower and upper black lines indicate minimum and maximum values, respectively. The lower and upper boundaries of the grey boxes indicate the 1st and the 3rd quartile, respectively. Figures indicate the mean value.

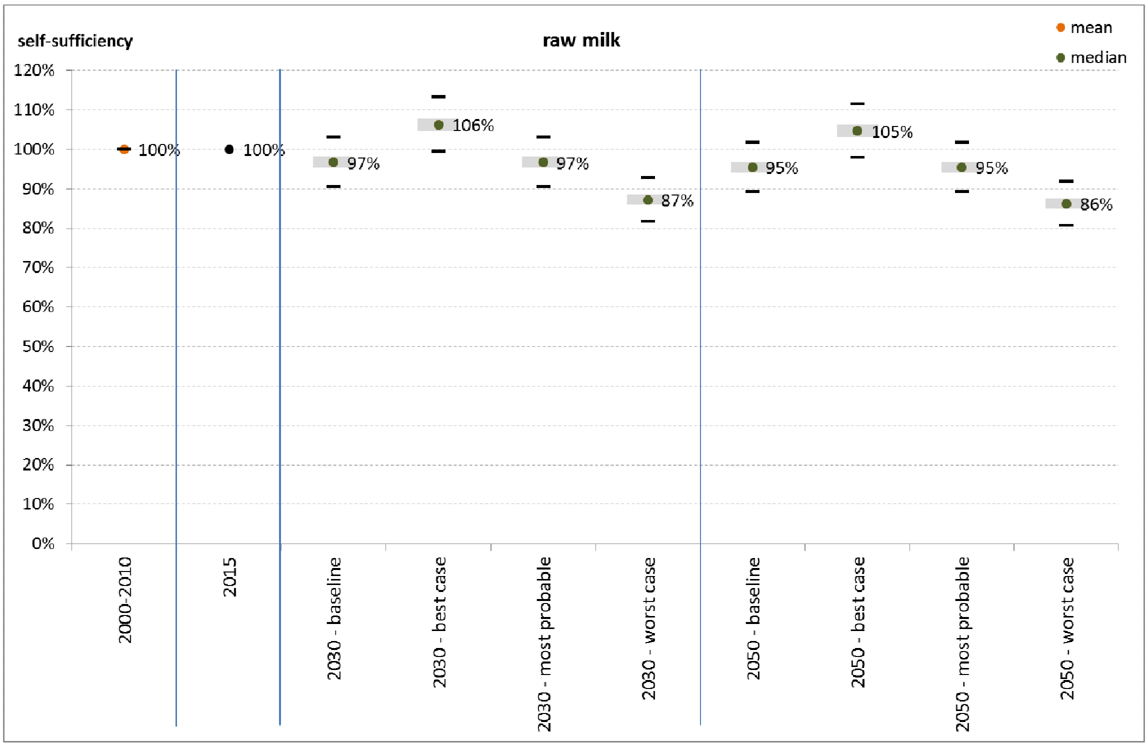


Figure 64: Self-sufficiency rates for raw milk

Note: The lower and upper black lines indicate minimum and maximum values, respectively. The lower and upper boundaries of the grey boxes indicate the 1st and the 3rd quartile, respectively. Figures indicate the mean value.

Referring to imports/exports (which are endogenous in model 2), Table 50 and Table 51 show that for most products average trade figures over time (2000 to 2010) and for 2015 are positive (i.e., net imports) indicating dependencies from other countries. Exceptions are net exports in the cases of sugar and wheat, beef & veal, and pork; see also Figure 63 to Figure 68. In 2030 and 2050, there is an import dependency in all four scenarios for soybeans (only 2030), other oilseeds, oilseed meals, protein crops, vegetable oils, and fruit & vegetables. The same is true for sheep meat, poultry meat, eggs, fish and butter. In the worst-case scenario, net exports are only possible in the case of beef & veal; in the best-case scenario, net exports are possible in the cases of wheat, coarse grains, soybeans (2050), sugar, starch crops, beef & veal, pork, (raw) milk and cheese.

Table 50: Trade balances of crop products in 1,000 tons (model 2)

	2000-2010	*diff. to 2015*	**2015**		**2030**	*diff. to 2015*	**2050**	*diff. to 2015*
wheat	-276.4	*-200.2*	-76.1	baseline	-267.8	*-191.7*	-363.2	*-287.1*
				best-case	-490.7	*-414.5*	-847.4	*-771.3*
				most-probable	-113.0	*-36.9*	-175.9	*-99.8*
				worst-case	771.7	***+847.8***	818.9	***+895.0***
coarse grains	387.6	*+152.3*	235.3	baseline	-478.9	***-714.3***	-1,171.3	***-1,406.6***
				best-case	-755.3	***-990.6***	-1,649.1	***-1,884.4***
				most-probable	-68.7	***-304.0***	-650.5	***-885.8***
				worst-case	2,563.0	*+2,327.7*	2,706.8	*+2,471.4*
soybeans	21.0	*+4.6*	16.3	baseline	19.9	*+3.6*	-8.1	***-24.4***
				best-case	9.0	*-7.3*	-26.6	***-42.9***
				most-probable	22.8	*+6.5*	-2.8	*-19.2*
				worst-case	57.4	*+41.1*	52.4	*+36.0*
other oilseeds	194.6	*-203.0*	397.7	baseline	270.4	*-127.2*	254.0	*-143.7*
				best-case	260.1	*-137.5*	229.6	*-168.0*
				most-probable	298.6	*-99.1*	288.6	*-109.0*
				worst-case	453.7	*+56.1*	482.5	*+84.9*
oilseed meals	451.2	*+69.1*	382.1	all scenarios	425.0	*+42.9*	425.0	*+42.9*
protein crops	-0.01	*-21.1*	21.1	baseline	36.6	*+15.5*	45.4	*+24.2*
				best-case	29.9	*+8.8*	37.6	*+16.5*
				most-probable	38.9	*+17.7*	48.8	*+27.6*
				worst-case	60.1	*+38.9*	68.8	*+47.7*
vegetable oils	160.2	*-105.1*	266.6	all scenarios	212.8	*-53.7*	226.5	*-40.1*
sugar	-112.7	*+11.4*	-124.1	baseline	-151.9	*-27.8*	-227.1	*-103.0*
				best-case	-134.2	*-10.1*	-212.2	*-88.1*
				most-probable	-104.0	*+20.1*	-167.7	*-43.6*
				worst-case	130.6	***+254.7***	158.1	***+282.2***
starch crops	74.0	*+24.8*	49.2	baseline	-152.0	***-201.2***	-288.8	***-337.9***
				best-case	-180.5	***-229.6***	-334.0	***-383.2***
				most-probable	-66.1	***-115.3***	-181.5	***-230.7***
				worst-case	471.1	*+421.9*	513.8	*+464.6*
fruits	431.0	*+24.8*	456.7	all scenarios	546.8	*+90.1*	595.6	*+138.9*
vegetables	407.5	*-60.7*	468.2	all scenarios	512.4	*+44.2*	554.2	*+86.0*

Note: Table entries are means (mean from 2000 to 2010 and mean for 2030 and 2050 resulting from the Monte-Carlo simulations, respectively). Net imports (exports) are given by positive (negative) values. Table entries in *italics* indicate *absolute* differences of mean values (in 1,000 tons) relative to the value for 2015 (+ … more imports/less exports; - … more exports/less imports). ***Bold*** figures indicate a switch from a net-exported product (in 2015) to a net-imported product (and vice versa).

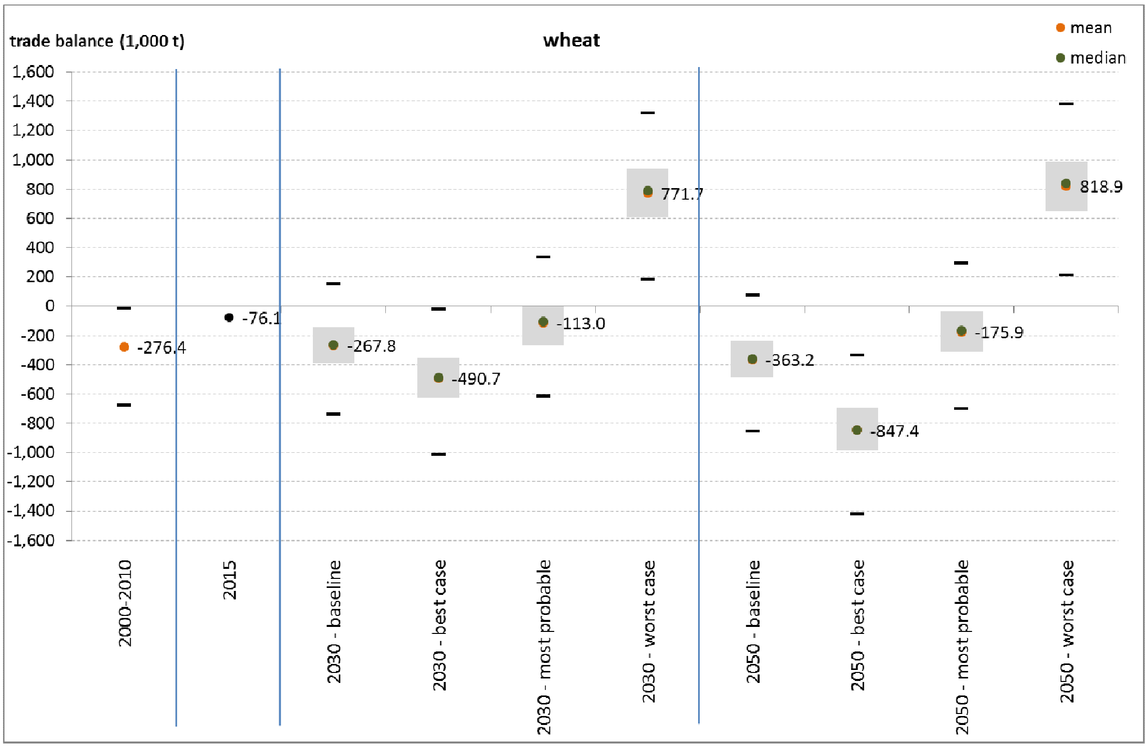


Figure 65: Trade balances for wheat

Note: The lower and upper black lines indicate minimum and maximum values, respectively. The lower and upper boundaries of the grey boxes indicate the 1st and the 3rd quartile, respectively. Figures indicate the mean value.

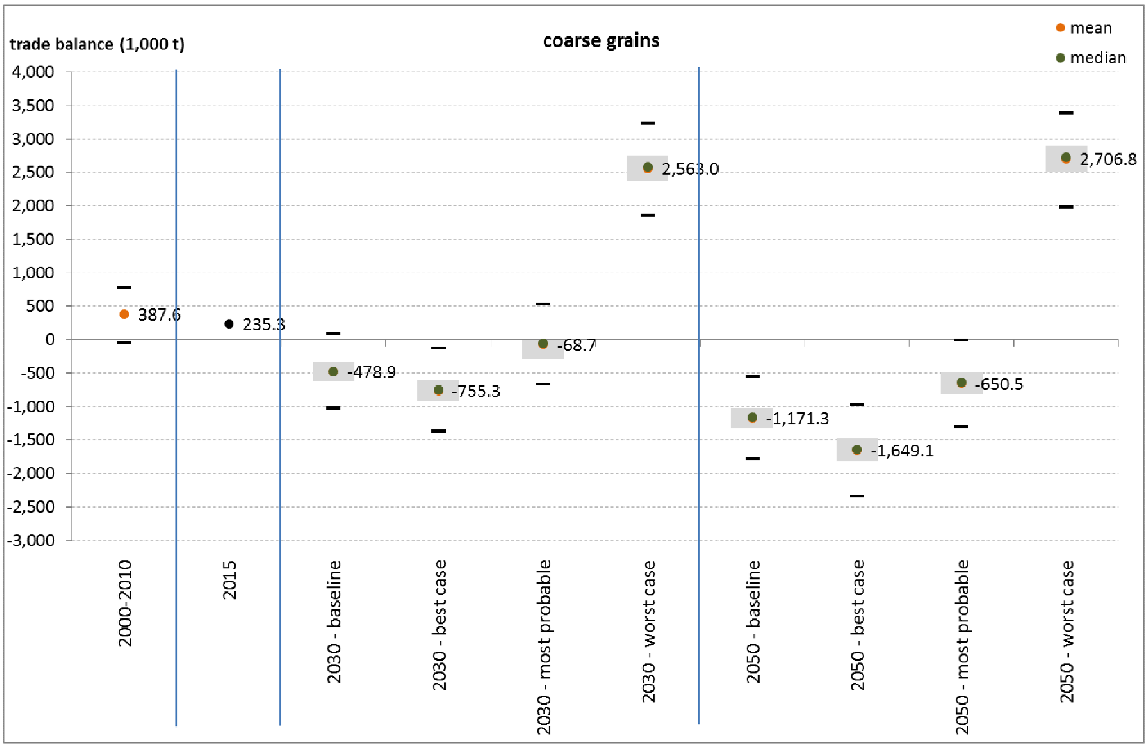


Figure 66: Trade balances for coarse grains

Note: The lower and upper black lines indicate minimum and maximum values, respectively. The lower and upper boundaries of the grey boxes indicate the 1st and the 3rd quartile, respectively. Figures indicate the mean value.

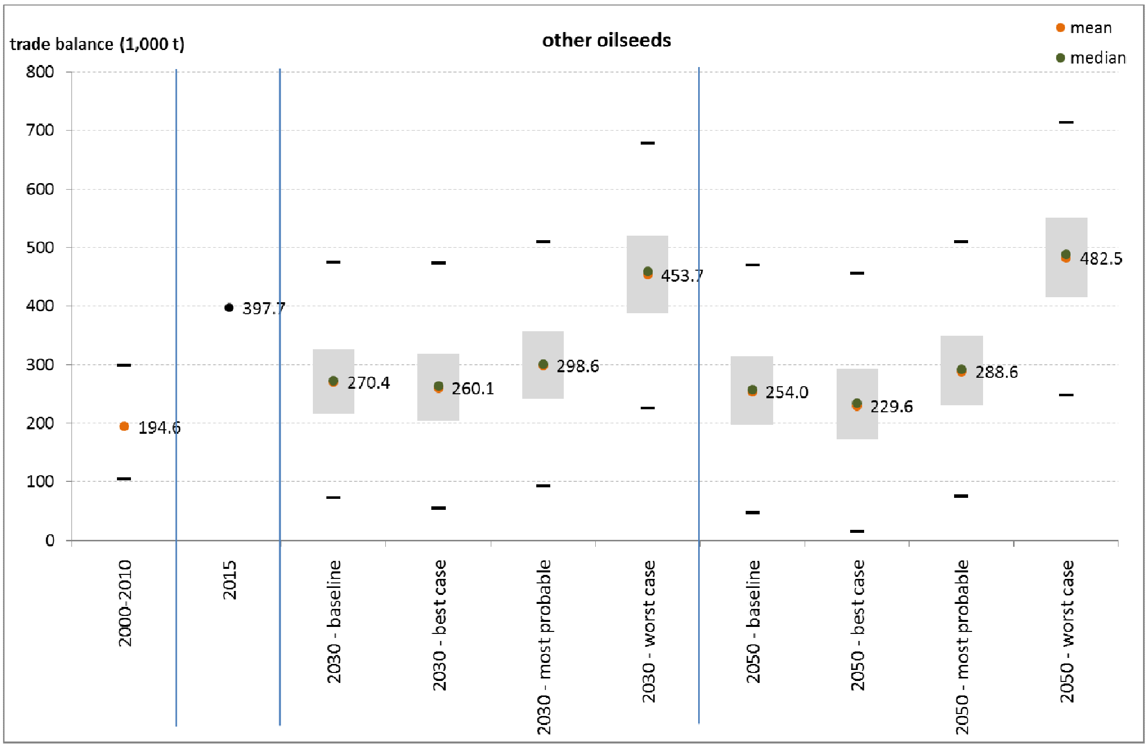


Figure 67: Trade balances for "other oilseeds"

Note: The lower and upper black lines indicate minimum and maximum values, respectively. The lower and upper boundaries of the grey boxes indicate the 1st and the 3rd quartile, respectively. Figures indicate the mean value.

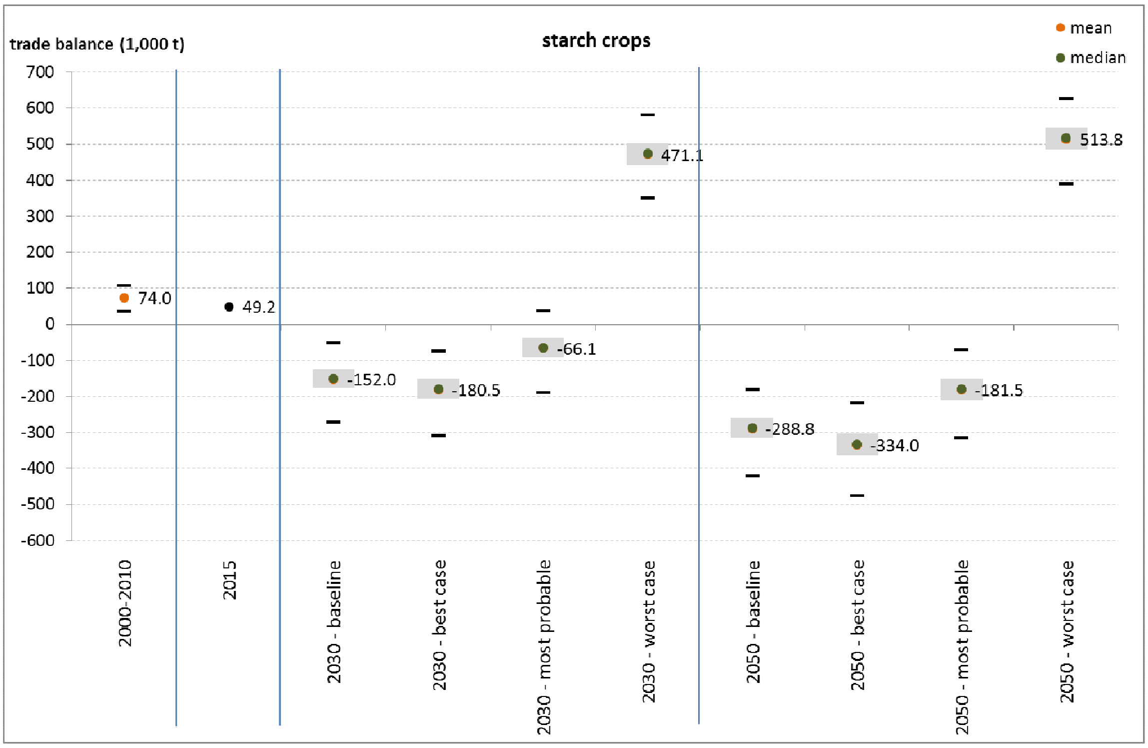


Figure 68: Trade balances for starch crops

Note: The lower and upper black lines indicate minimum and maximum values, respectively. The lower and upper boundaries of the grey boxes indicate the 1st and the 3rd quartile, respectively. Figures indicate the mean value.

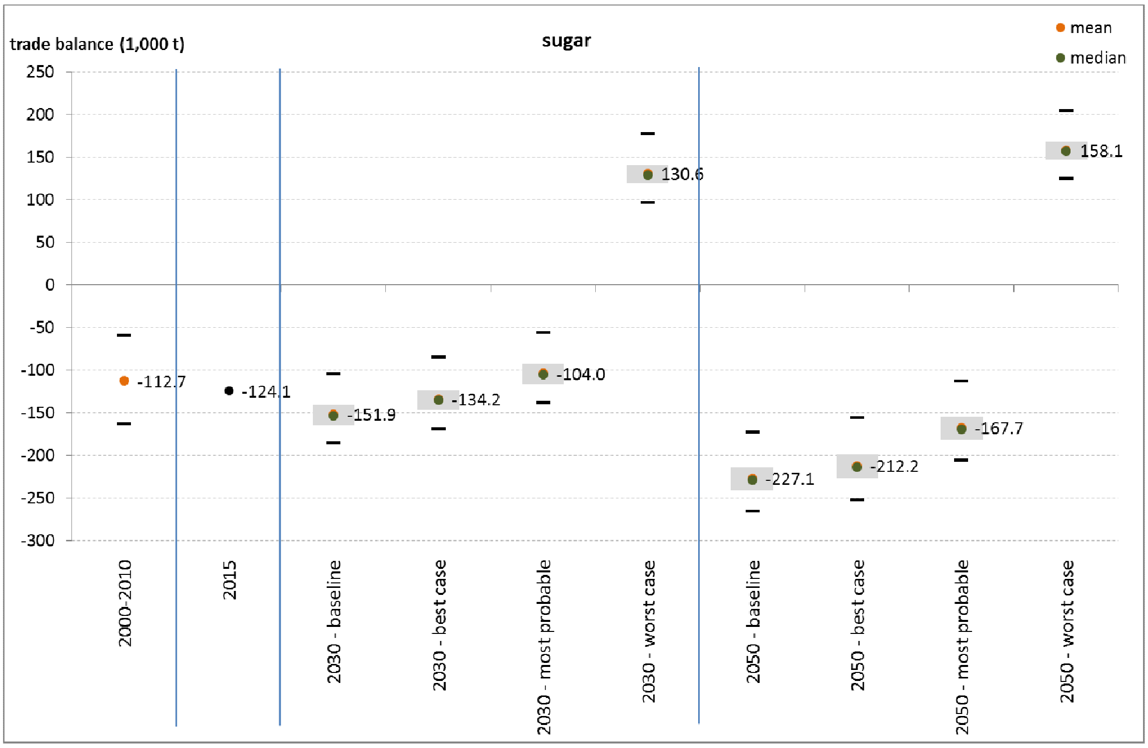


Figure 69: Trade balances for sugar

Note: The lower and upper black lines indicate minimum and maximum values, respectively. The lower and upper boundaries of the grey boxes indicate the 1st and the 3rd quartile, respectively. Figures indicate the mean value.

Table 51: Trade balances of animal products in 1,000 tons (model 2)

	2000-2010	*diff. to 2015*	**2015**		**2030**	*diff. to 2015*	**2050**	*diff. to 2015*
beef & veal	-67.0	*+7.7*	-74.7	baseline/most prob.	-64.0	*+10.7*	-62.6	*+12.1*
				best-case	-86.0	*-11.3*	-84.5	*-9.8*
				worst-case	-42.0	*+32.7*	-40.6	*+34.1*
sheep meat	2.1	*-0.3*	2.3	baseline/most prob	2.9	*+0.6*	3.2	*+0.8*
				best-case	2.2	*-0.1*	2.4	*+0.1*
				worst-case	3.6	*+1.3*	3.9	*+1.5*
pork	-11.9	*+13.9*	-25.8	baseline/most prob	-8.8	*+17.0*	-0.1	*+25.7*
				best-case	-60.8	*-35.0*	-52.1	*-26.3*
				worst-case	43.2	***+69.0***	51.9	***+77.7***
poultry meat	41.8	*-9.2*	51.0	baseline/most prob	56.7	*+5.6*	60.9	*+9.8*
				best-case	44.5	*-6.5*	48.7	*-2.3*
				worst-case	68.8	*+17.8*	73.0	*+22.0*
eggs	29.9	*-1.7*	31.6	baseline/most prob	36.7	*+5.1*	39.8	*+8.2*
				best-case	26.9	*-4.7*	30.0	*-1.6*
				worst-case	46.5	*+14.9*	49.5	*+17.9*
fish	54.4	*-35.6*	90.0	all scenarios	81.2	*-8.8*	84.3	*-5.7*
raw milk	0.00	*0.0*	0.0	baseline/most prob	116.2	***+116.2***	166.2	***+166.2***
				best-case	-218.6	***-218.6***	-168.5	***-168.5***
				worst-case	451.0	***+451.0***	501.0	***+501.0***
butter	8.7	*-9.9*	18.5	baseline/most prob	17.1	*-1.4*	18.3	*-0.2*
				best-case	13.8	*-4.8*	15.0	*-3.5*
				worst-case	20.5	*+1.9*	21.7	*+3.1*
cheese	11.5	*+2.5*	9.0	baseline/most prob	0.4	*-8.6*	3.4	*-5.6*
				best-case	-16.8	***-25.8***	-13.8	***-22.8***
				worst-case	17.6	*+8.6*	20.5	*+11.5*

Note: Table entries are means (mean from 2000 to 2010 and mean for 2030 and 2050 resulting from the Monte-Carlo simulations, respectively). Net imports (exports) are given by positive (negative) values. Table entries in *italics* indicate *absolute* differences of mean values (in 1,000 tons) relative to the value for 2015 (+ … more imports/less exports; - … more exports/less imports). ***Bold*** figures indicate a switch from a net-exported product (in 2015) to a net-imported product (and vice versa).

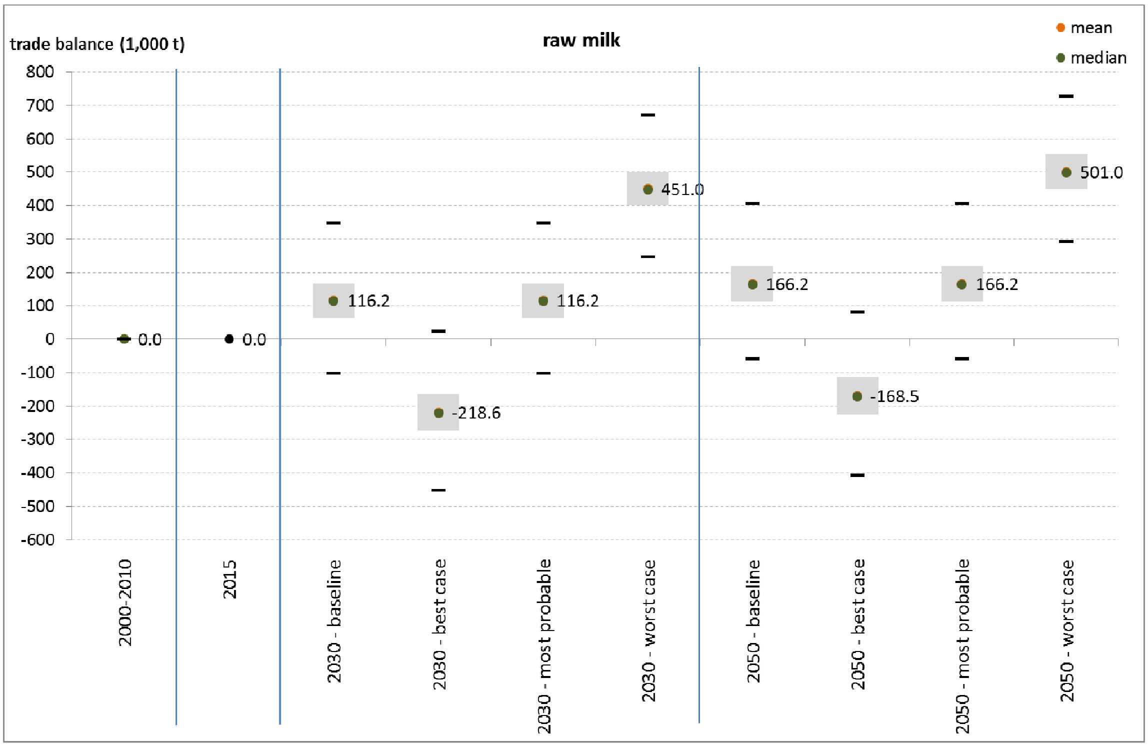


Figure 70: Trade balances for raw milk

Note: The lower and upper black lines indicate minimum and maximum values, respectively. The lower and upper boundaries of the grey boxes indicate the 1st and the 3rd quartile, respectively. Figures indicate the mean value.

In model 2 the endogenous trade variable solves the supply balance. Figure 71 shows the minimum and maximum average self-sufficiency rates of the simulation results. Products to the left of the vertical blue line have been net exported (2000-2010; 2015) so far (beef & veal, sugar, wheat, pork, milk); products to the right have been net imported so far. Figure 70 shows the associated changes in trade (absolute difference to 2015) that correspond to the respective average minimum and maximum self-sufficiency rates of model 2. Positive changes in trade indicate either more imports (coarse grains, soybeans, other oilseeds, oilseed meals, protein crops, starch crops, fruits, vegetables, sheep meat, poultry meat, eggs, butter, cheese), less exports (beef and veal) or a switch from net exports to net imports (wheat, sugar, pork, milk). Negative changes indicate either more exports (wheat, sugar, beef & veal, pork, milk), less imports (other oilseeds, vegetable oils, sheep meat, poultry meat, eggs, fish, butter) or a switch from net imports to net exports (coarse grains, soybeans, starch crops, cheese). Coarse grains show the highest absolute changes in average imports/exports, relative to 2015.

It is important to note that an increase in the self-sufficiency rate does not necessarily imply more imports or less exports: For example, in the case of protein crops, the maximum average self-sufficiency rate (71%) is higher than the one in 2015 (66%). However, to fulfill the supply balance according to the simulations, requires more imports in absolute terms (+8,803 t). In the case of vegetable oils, the minimum/maximum average self-sufficiency rate is either almost equal or slightly lower to that in 2015 but requires less imports.

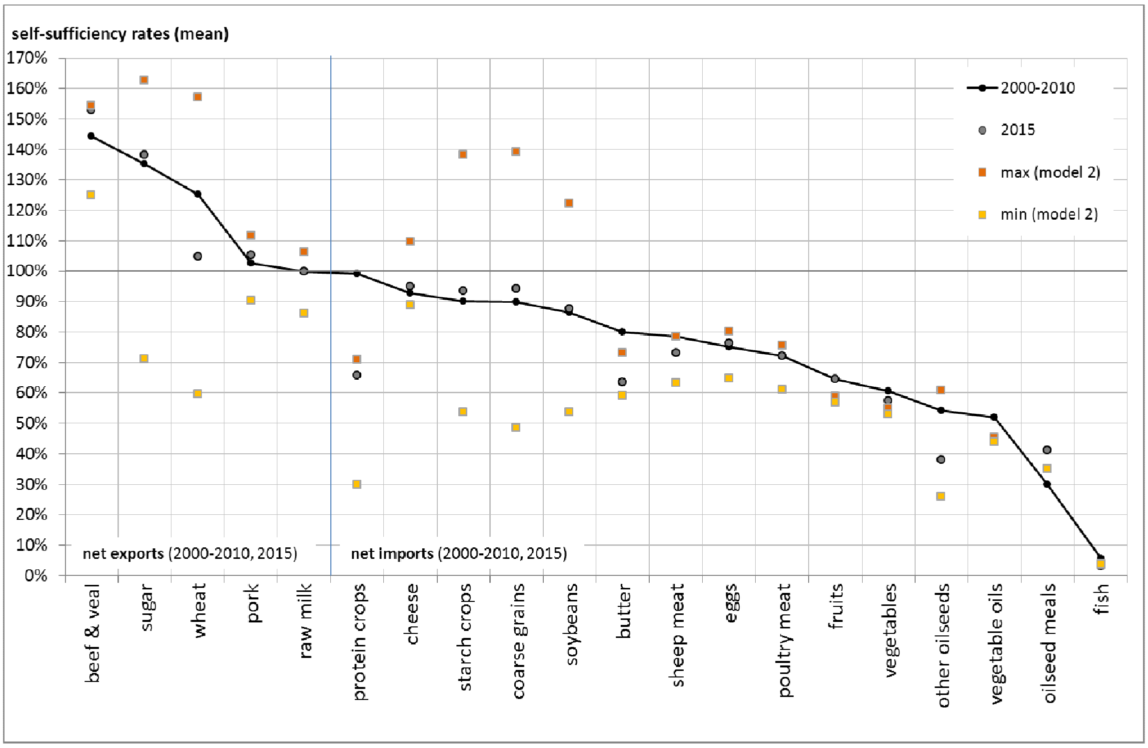


Figure 71: Minimum and maximum average self-sufficiency rates of model 2

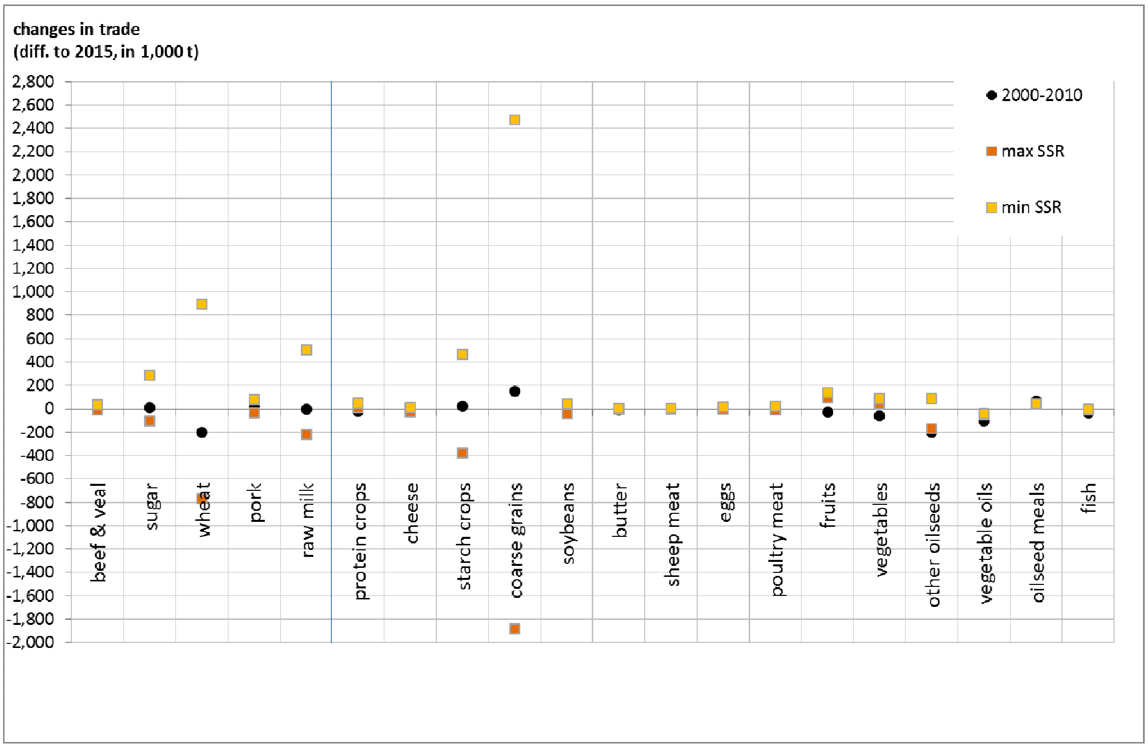


Figure 72: Absolute changes in trade (difference to 2015) corresponding to minimum and maximum self-sufficiency rates of model 2

6.5. Summary of simulation results

Based on various assumptions, we assess the impact of threats like climate change, shortages in Phosphorus fertilizer and in imports of protein feedingstuff, lower intensities of input use in agricultural production and a higher demand for bioenergy influencing self-sufficiency rates of important agricultural commodities in Austria. Incorporating two different time frames (2030, 2050), four scenarios and two different model specifications, we obtained 16 scenario results (i.e., eight for each model). The specification of two different models allows us to address different research questions:

Model 1: What is the impact of a given consumption level (population growth, per-capita consumption) and trade balance on production and, thus, on the self-sufficiency rate of selected agricultural commodities? Considering scenario- and time-specific yields of crops and animals (tonnes per ha or kg per head), what are the required areas and livestock numbers to meet production needs?

Model 2: Which level of self-sufficiency can be obtained, given the specific assumptions on consumption (population growth, per-capita consumption) and production (areas and yield per ha; livestock and yield per head)? What is the impact of the assumptions on trade balances?

Figure 71 summarizes the simulation results by illustrating the minimum and maximum average self-sufficiency rates out of eight results for each model and product.

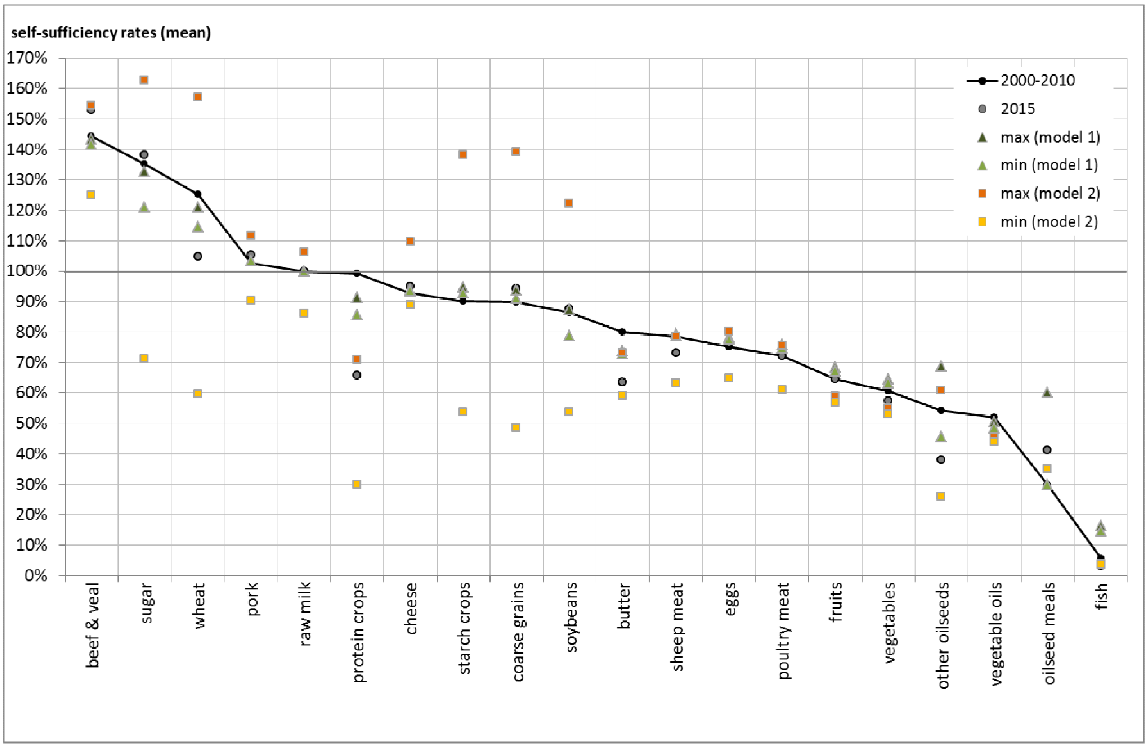


Figure 73: Summary of simulation results (average self-sufficiency rates)

Because of the structure of **model 1**, the self-sufficiency rates between 2030 and 2050 within a specific scenario differ only slightly and depend on different population figures only in the case of animal products. Differences between scenario results in the case of crop products can be traced back, first, to changes in the per-capita consumption of non-feed use (i.e., demand for bio-energy crops). Compared to the baseline scenario, it is assumed that the demand for bioenergy crops increases in all the other scenarios with the worst case scenario showing the highest demand. Second, another source of impact on crop consumption is the feed demand of animals. Since animal production of the scenarios results in different livestock, feed demand varies between the scenarios. Third, trade balances of protein feed were altered in order to consider import restrictions and their impact on self-sufficiency rates of the scenarios. Consequently, in order to fulfill the supply balance, crop production needs to be highest particularly in the worst-case scenario, thereby raising self-sufficiency rates. Keeping in mind the explanations above, most crop products display the highest self-sufficiency rates in the worst-case scenario due to a bulk of "negative" assumptions. It is essential that the self-sufficiency rates according to model 1 are interpreted with the figures for the required acreage or livestock numbers. Acreage and livestock are derived by implementing scenario-specific changes in yields (e.g., due to climate change) on the endogenously determined required production. In the reference year 2015, the acreage of the crops considered in the model is some 1 million hectares. In the baseline and best-case scenario of the year 2050, this area drops by 17% and 29%, respectively; the results for the worst-case scenario suggest an increase in the required acreage by 109% in 2050.

The interpretation of **model 2** is rather easy as it describes self-sufficiency rates for pre-defined production and consumption levels. Contrary to model 1, the solution to the model is necessary imports or possible exports. This allows conclusions concerning the impacts of changing yields (e.g., due to climate change) on self-sufficiency rates directly. As in model 1, the population grows between 2030 and 2050 by some 300,000 people and affects the (non-feed) consumption level. The influence of animal husbandry on feed demand is the same in all scenarios as livestock figures are equal in all scenarios. Compared to model 1, differences in self-sufficiency rates between 2030 and 2050 are higher. Furthermore, the simulations indicate that self-sufficiency decreases from the best-case scenario to the worst-case scenario, reflecting the sum of "negative" assumptions in the latter. Given the assumptions considered, the scenarios imply quite different self-sufficiency rates. Contrary to model 1, changes in average self-sufficiency rates (relative to 2015) are quite substantial so that net-export or net-import positions change for some products.

Considering the impact of climate change on crop yields only, this impact (which is positive for most crop products in Austria) may be regarded as uncritical for Austrian agricultural production. However, since climate change is a global, long-term issue and involves complex interaction between various processes (Fischer et al., 2005), necessary imports to Austria may be affected. In interpreting the simulation results, it is important to note some limitations:

The forecasts of most supply balance positions for Austria were derived from historical data (2000 to 2010) and OECD forecasts up to 2020. Generally, such a short timespan (eleven years only) is a rather weak basis for reliable forecasts. However, accounting for shares of Austria on EU-27 forecasts of the OECD as well as implementing Monte-Carlo simulations may help to overcome this limitation to some extent.

In addition, the results presented in this study are based on a series of assumptions. Simplifications concerning the calculated feed-use coefficients, crop and animal yields, scenario-specific assumptions, etc. have an impact on the quality of the results. In the simulation models, possible effects of climate change on weeds and pests and on animals are indirectly handled by assuming different yield levels in the respective scenarios. To simplify the simulation models, any considerations on the supply and use of grassland were omitted. Animal husbandry of ruminants in Austria significantly depends on forage from grassland (e.g., hay, silage). Especially in the scenarios based on an increase in livestock (particularly, the worst-case scenario in model 1), this simplification needs to be considered. To some extent, grassland can be regarded a reserve of arable land, particularly considering its shifting production due to climate change. In addition, changes in yields due to warmer temperatures and changed precipitation may also influence the competiveness between crops.

It is most important to keep in mind that, since these simple simulation models are based on positions of supply balances (i.e., data on quantities) only, no economic considerations by decision makers (farmers, consumers) and, hence, no adoption paths (e.g., shifts in crop rotation, changes in livestock based on economic considerations, etc.) are taken into account.

For all these reasons, the interpretation of the results should be treated in a conservative “if … else” manner. The simulation models do not aim to forecast self-sufficiencies in 2030 and 2050. Rather, the models indicate the possible impact of certain assumed changes. In addition, the year 2015 was chosen as a reference period for relative changes of self-sufficiency rates. Some input data for 2030 and 2050 were generated via Monte-Carlo simulations which are based on values of the time series 2000 to 2020. Thus, a respective average value (e.g., number of cattle in 2030 and 2050) of a given variable can be higher or lower than the respective value in the reference period 2015, depending on the trend in the relevant time series. Consequently, while general conclusions derived from scenario results relative to each other are quite plausible, the specific magnitudes of scenario results (e.g., self-sufficiency of a certain crop in 2050) should be treated with caution.

Some aspects were not directly addressed in the scenarios. One widely discussed topic nowadays is concerned with food waste relating to losses in production, storage and transportation, as well as consumer waste. In the industrialised world, food is predominantly wasted on the consumer side, amounting to 11-13% of production (OECD, 2013a). Hence, strategies to increase self-sufficiency should also include efforts to reduce the waste of food. Another aspect deals with food preferences and diets. Pursuant to the Austrian nutrition report (Elmadfa, 2012), total meat consumption peaked in 1990 with some 103 kg per head. According to the OECD (2013a) it takes two tonnes of grain to produce one tonne of poultry, four tonnes of grain to produce one tonne of pork, and between seven and ten tonnes of grain to produce a tonne of beef. Hence, a shift in the diet towards a lower meat consumption would enable more of the grain production to be allocated directly to food use. Similarly, lower consumption of energy crops would allow a shift in production resources to other food crops.

7. Risk Management Options

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7.1. Risk management in this project

Steinwider, H. (AGES)

According to **ISO/DIS 31000**, risk management is defined as a series of coordinated activities carried out to manage and control risks. Organizations should enable themselves to have an appropriate response to the risks affecting them. Risk management should help to avoid ineffective and inefficient responses to risk.

Risk management is also a process of weighing policy alternatives in consultation with interested parties, considering risk assessment and other legitimate factors and selecting appropriate prevention and control options.

In WP 4 of this project, risk management options concerning food security risks and political strategies for ensuring food security are developed.

The results of the project may supot politics o select and implement appropriate options for the adaption and mitigation of the effects of climate change and supply risks. The responsible governments must be able to act proactively rather than reactively to establish a reliable basis for decision making and planning as well as to improve the resilience of food security according to climate change and supply risks.

To select the most appropriate risk management option, costs and efforts of the implementation are balanced against the benefits. When selecting them, the organization should consider the values and perceptions of stakeholders and the most appropriate ways to communicate with them. Though equally effective, some risk treatments can be more acceptable to stakeholders than others.

If the resources are limited, the risk management plan should clearly identify the priority order in which individual options should be implemented.

Risk management can introduce risks like the failure or ineffectiveness of the chosen measures and can even cause secondary risks that need to be assessed. The regular monitoring of the measures should be an integral part of risk management.

Decision makers and stakeholders should be aware of the nature and extent of the residual risk after risk treatment.

7.2. Risk Management Options

Project Team

Following the findings of the project, climate change caused by human activity is a fact. Climate change will influence the specific Austrian supply situation, particularly after 2030. Food resilience is not only affected by the effects of climate change on global agricultural production, but also by socio-economic impacts and security policy risks.

Austrian agricultural production and food supply resilience is dependent on imports of food, feed, energy and some other inputs relevant for agricultural production.

Major risks identified in this project that will affect agricultural production and food supply in Austria:

1) Climate change: Changing climatic and extreme weather conditions affecting agricultural production in Austria/Europe. Effects on yields are limted in general until 2050.
2) Import of energy: Dependency on imports of crude oil, diesel, natural gas; dependency on nitrogen fertilizer produced by natural gas (Haber-Bosch-process)
3) Import of inputs (phosphate fertilizer): Dependency on imports of phosphates
4) Import of high-protein feedingstuffs: Dependency on imports of soy bean meal and vegetable oils
5) Technical progress: Public suspicion about technical progress (e.g. biotechnology)
6) Biofuels and biofibres: Uncontrolled expansion of areas farmed for biofuels and biofibres
7) Agricultural policy: Political targets towards a low input agricultural policy (e.g. 100% organic farming)

The three scenarios “best case, most probable case and worst case scenario” (chapter 6) demonstrate different risk and results.

The risk management options listed below are not recommendations, but possible political answers from an experts’ point of view.

This study recommends general measures as to how to adapt to climate change. These questions have been already addresses by the Austrian Strategy for the Adaption to Climate Change („Österreichische Strategie zur Anpassung an den Klimawandel“[195]).

7.2.1. Risk management options regarding climate change and agricultural production in Austria

All specific scientific research on climate change indicates that agriculture has to adapt to it. Following the 5th report of the IPCC on climate change, Austria will have to face more and more extreme weather situations, which will especially influence agricultural production. Yields, sale volumes of farms, prices of agricultural products and farmers' income may fluctuate strongly year by year. Feed and food markets will become more volatile.

1. Management Option:

State financed storage of key agricultural products to stabilize markets and guarantee supply in years with low domestic production.

2. Management Option:

Subsidized insurances, either with respect to production or based on the average yearly farm income, to sustain the economic viability of farms (investing power) and farmers' incomes.

3. Management Option:

Enhance research and plant breeding particularly regarding drought and heat tolerant varieties.

4. Management Option:

Market support policy that stabilizing prices and farming systems that increase yields.

7.2.2. Risk management options regarding the dependency on imports of fossil energy

Worldwide reserves of petrol as well as natural gas are already extremely limited and prices are relatively high when compared to output prices of agricultural production. Different economic sectors in Austria are in competition with respect to petrol and natural gas based energy use. Most of the competitors have higher added values than

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195 http://www.lebensministerium.at/umwelt/klimaschutz/klimapolitik_national/anpassungsstrategie/strategie-kontext.html

agriculture, which could finally result in the situation that agriculture will not have access to affordable and economically justifiable energy.

5. Management Option:

Raising the Austrian self-sufficiency rate in the energy sector.

6. Management Option:

Limit the use of petrol and natural gas based energy to those sectors, where no other energy use is technically or economically possible (e.g. energy for mobility).

Replace fossil energy (natural gas) with alternative energy sources (wind power, solar energy) for the production of nitrogen fertilizers.

7. Management Option:

Enhance fertilization efficiency and foster research to develop methods and/or plants to fix nitrogen by plants (due to the dependency on imports of fossil energy for the production of nitrogen fertilizer).

8. Management Option:

Increase the production of biofuels as well as of biogas. Agriculture should be able to produce the energy needed for agricultural production and food logistics. Using the bio-waste, which accumulates year by year in Austria and originates from households, gastronomy and the food industry, it should be possible to reduce the demand for area. Foster investments and research to enhance the energy efficiency and development of new generations of biofuels.

9. Management Option:

Diversify suppliers of crude oil and by doing so, minimize the risk of getting cut off from supply in the short and medium term.

10. Management Option:

Assist in building of stable political institutions and peace-keeping activities in exporting countries.

7.2.3. Risk management options regarding the dependency on imports of inputs, particularly of phosphates and pesticides

The main phosphor suppliers are Morocco, Jordan and Syria, of which Morocco at the moment is the most important because of its reserve quantities.

11. Management Option:

Limit the use of phosphor to the minimum demand of soil-based crop production.

12. Management Option:

Enhance recycling of phosphor from any available source, e.g. sewage treatment plants (laundry detergents) or extracts from bones in abattoirs.

13. Management Option:

Enhance scientific research on the mobilization of phosphate in agricultural soils.

14. Management Option:

Assist in building of stable political institutions and peace keeping actions in exporting countries of phosphates.

15. Management Option:

Ensure technical and legal facilities to produce vitamins, essential amino acids and pesticides in Europe. Problems according to lacking supply of pesticides may be crucial as crop pests and invasive pathogens have already a high impact on yields. Climate change may intensify the risks.

7.2.4. Risk management options regarding dependency on imports of high-protein feedingstuffs

16. Management Option:

Enhance the cultivation of soy beans for feed production in Central Europe (Austrian protein strategy, “Danube soya”).

17. Management Option:

Enhance research and debate possible methods and technologies to solve weed control problems in soy cropping

18. Management Option:

Raise protein feed production by using more low quality wheat for protein production.

19. Management Option:

Enhance the protein feed production in biofuel production process

20. Management Option:

Consider the use of animal offal and meat and bone meal for feeding of non-ruminants.

21. Management Option:

Re-evaluate hygiene provisions to facilitate feeding of food waste for animals.

22. Management Option:

Reduce meat consumption in human diets.

23. Management Option:

Enhance the consumption of meat which is less dependent on high quality protein feedingstuffs and requires the use of grassland and meadows (ruminants)

7.2.5. Risk management options regarding technical progress

24. Management Option:

Intensify scientific and applied research programs in plant and animal breeding. The final objective should not only be to raise yields in crop production but also to increase the transformation rate in animal production.

25. Management Option:

Inform the public on food security issues and present-day agricultural production methods and enable an unbiased dispute on technologies and measures to enhance productivity

7.2.6. Risk management options regarding biofuels und biofibres

The increased use of biofuels and bio-fibres is an important pillar of the bioeconomy. Fossil energy resources will decrease within the next decade and may end anytime. Prices will rise. Political risks may disturb markets even earlier.

26. Management Option:

Enhance the use of biofuels and biofibres as a political instrument to moderate prices for fossil energy and to steer demand and supply (in addition to other alternative energy sources).

27. Management Option:

Prevent an uncontrolled expansion of land farmed for biofuels and biofibres, by steering the demand for food, feed, fibers and fuel.

7.2.7. Risk management options regarding political presuppositions

28. Management Option:

Balance reasons between political presupposition towards a low input agriculture (e.g. organic farming) and a high input agriculture. Sustainable agricultural intensification (more intense production taking into account environmental aspects) may be a solution.

29. Management Option:

Limit the consumption of agricultural area by construction of e.g. building, roads, or reforestation and other use.

8. Conclusions

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On a global scale, climate change will have a positive impact on agricultural production by 2030 in most of regions. Most of the crops will benefit by 2030 under the selected climate scenario, by 2050 there are some regions where negative impacts can be seen.

In Austria, climate change will generally have a positive influence on per-hectare yields for most of the crops. If technical progress and a high input level are assumed, yields will increase up to 2050. The exceptions to this are protein crops.

Climate change will cause more extreme weather events (especially heat and drought and heavy rain) affecting agricultural production and yields within a growth period. Regional markets may be disturbed. Volatile prices and import needs for manageable periods will be a consequense.

Self sufficiency rates (SSR) and acreage needed for food and feed production are strongly influenced by other parameters in the medium term.

- Dependency on imports of crude oil, diesel, natural gas; dependency on nitrogen fertilizer produced by natural gas (Haber-Bosch-process)
- Dependency on imports of inputs, particularly phosphates and active components of pesticides
- Dependency on imports of high-protein feedingstuffs, particularly soy bean meal and vegetable oils
- Accepting technical progress (e.g. biotechnology) by politics and the population
- Uncontrolled expansion of areas farmed for biofuels and biofibres
- Political presupposition towards a low input agriculture (e.g. 100% organic farming)

Currently, Austria is a net exporter of sugar, beef and veal; regarding wheat and pork, production is slightly higher than domestic demand. There are deficiencies in the cases of “other” oil seeds (i.e. non-soybeans), oil seed meals, vegetable oils, fruits, vegetables, poultry meat, eggs, butter and, most extremely, fish. Based on supply balance data (historical data and forecasts up to 2020) and data derived via Monte-Carlo simulations, self-sufficiency rates for Austria in 2030 and 2050 are addressed by means of two simple simulation models. The scenarios employed in the simulation models for 2030 and 2050 can be described as follows:

1. The best case scenario assumes relatively high level of agricultural productivity. All possibilities offered by technical progress (including biotechnology) are used. The intensity level of inputs increases relative to 2015. There are no shortages in energy, inputs and imports of feedingstuffs. Demand for biofuel and biofibres increases up to 10% of the acreage of the respective crops.

2. The most probable case scenario assumes a medium input level and expanded areas farmed extensively (25%). Technical progress and breeding efforts stay at the same extent as today. Shortages in phosphate and high-protein feedingstuffs supply are taken into account. Demand for biofuel and biofibres increases up to 12% of the acreage of the respective crops. The scenario assumes that the share of extensive agriculture is higher. The most probable case scenario more or less mirrors current political focus.

3. The worst case scenario assumes a relatively low input level (100% organic agriculture). Shortages in fossil energy, phosphate fertilizers and high-protein feedingstuffs are also taken into account. In this scenario, demand for biofuel and biofibres increases up to 40% of the acreage of the respective crops.

Given a set of different assumptions, the largest positive changes in crop yields per hectare (relative to 2015) are due to technical progress. However, the largest negative changes in yields are generally due to lower intensity levels of inputs. Lower intensity levels may be the result of shortages in input supply or due to political presuppositions.

Model 1: Virtual acreage needed

In the **best-case scenario** the required total acreage to meet present-day food security demands of Austria decreases by -19% (-191,000 ha) in 2030 and by -29% (–297,000 ha) in 2050, relative to 2015.

In the **most-probable case scenario** the required acreage to meet present-day food security demands of Austria increases in 2030 by +1% (+10,000 ha) in 2030 and decreases 2050 by -6% (-60,000 ha) in 2050, relative to 2015.

The most-probable case scenario indicates that more extensive agriculture and more area used for biofuel and fiber production is possible if technical progress is not prohibited.

In the **worst-case scenario** the acreage needed to meet present-day food security demands of Austria increases by +99% (+1,025,000 ha) in 2030 and by +109% (+1,128,000 ha) in 2050, relative to 2015.

Model 2: Self Sufficiency rates (acreage is taken as given)

If the acreage is taken as given in the **best-case scenario**, the SSRs change is as follows (in%age points relative to 2015):

SSR Best-case scenario	**2030**	**2050**
Wheat	+30%	+52%
Coarse Grains	+24%	+45%
Protein Crops	+5%	-3%
Sugar	-3%	+16%
Beef & Veal	+1%	-1%
Sheep Meat	+5%	+4%
Pork	+6%	+4%
Poultry	+3%	+2%
Raw Milk	+6%	+5%

In the **most-probable case scenario**, absolute changes in SSRs (in%age points) relative to 2015 are as follows:

SSR: Most-probable case scenario	**2030**	**2050**
Wheat	+4%	+8%
Coarse Grains	+8%	+21%
Protein Crops	-5%	-15%
Sugar	-11%	+3%
Beef & Veal	-12%	-15%
Sheep Meat	-2%	-3%
Pork	-4%	-5%
Poultry	-3%	-4%
Raw Milk	-3%	-5%

In the **worst-case scenario** the product-specific SSRs change in the following way (in %age points relative to 2015):

SSR Worst-case scenario	**2030**	**2050**
Wheat	-44%	-45%
Coarse Grains	-44%	-46%
Protein Crops	-28%	-36%
Sugar	-63%	-67%
Beef & Veal	-26%	-28%
Sheep Meat	-9%	-10%
Pork	-14%	-15%
Poultry	-10%	-11%
Raw Milk	-13%	-14%

The project team defined risk management options, recommendations and a communication strategy:

The simulation models show that the assumption of a given production (model 2, assuming given areas, livestock and yields) implies higher changes in SSRs relative to 2015 than the assumption of a given trade balance (model 1). The results of model 1 show that SSRs in 2030 and 2050 are close to historical (2000-2010) SSRs. However, this does not imply that food security is not a future issue: a constant SSR (+/- 0%) is the result of equal relative changes (in %) in, both, production and consumption. According to the structure of model 1, a high and positive relative change in production (with production being the solution of the model) must be guaranteed by an increase in acreage or livestock. In this sense, model 1 derives a "required" SSR. The assumptions on changes in imports of protein feed, population and changes in per-capita demand for bioenergy in model 1 result in relatively moderate changes in SSRs. Relative to 2015, changes in crop yields in 2030 and 2050 are positive for all crops (except for protein crops). However, in the worst case scenario, crop yields are lower than in 2015, thereby implying relatively large increases in acreage that are necessary to guarantee the required production. Theoretically and given the model assumptions, the acreage of arable crops considered in model 1 must more than double according to simulation results.

Model 2 (taking production and consumption as given) likewise implies that a constant SSR is the result of equal relative changes in production and consumption. In addition, such a situation also requires relative changes in trade (which is the solution variable of model 2) of an equal size. However, the result of a decreasing SSR for a product with import needs (i.e., SSR below 100%) does not necessarily imply more imports in absolute terms (i.e., in tonnes): for example, if the negative relative change in production is higher than the negative relative change in consumption, the SSR decreases, but import needs may decrease in absolute terms. The assumptions on changes in crop and animal yields, population and changes in bioenergy use in model 2 imply relatively large changes in and ranges of possible SSRs. Products like cheese, starch crops, coarse grains or soybeans may become net-exported products in the best case; products like sugar, wheat, pork and milk may become net-imported products in the worst case, thereby indicating possible future import dependencies that previously (2000-2010) did not exist.

It is important to emphasise that these simple simulation models employed in this project do not "forecast" SSRs for 2030 and 2050. Rather, the simulation models show the possible range of results for SSRs due to Monte-Carlo simulations, given a set of assumptions, by leaving economic decisions of agents aside and by taking certain variables as given. Therefore, the results show the impact of assumed changes on certain supply-balance positions in an "if … then"-manner only.

8.1. Recommendations

Based on the findings and results of this project, the following recommendations may assist decision makers in meeting Austria's future food security:

8.1.1. Climate change and agricultural production in Austria

All specific scientific research on climate change indicates that agriculture has to adapt to it. Following the 5th report of the IPCC on climate change, Austria will have to face more and more extreme weather situations, which will especially influence agricultural production. Yields, sale volumes of farms, prices of agricultural products and farmers' income may fluctuate strongly year by year. Feed and food markets will be more volatile.

Therefore we recommend

- State financed storage of key agricultural products to stabilize markets and guarantee supply in years with low yields.
- Subsidized assurances, either with respect to production or based on the average yearly farm income, to sustain the economic viability of farms (investing power) and farmers' incomes.
- Enhancing research and plant breeding particularly regarding drought and heat tolerant varieties.
- Market support policy that stabilize prices and farming systems that increase yields.

8.1.2. Dependency on imports of crude oil, diesel, natural gas; dependency on nitrogen fertilizer produced by natural gas.

Austria is heavily dependent on imports of high strategic importance originating from non-EU countries. These imports include energy (crude oil, natural gas), phosphate fertilizer and protein feedstuffs, especially soy.

The main **crude oil** suppliers to Austria are (in descending order with respect to amount) Kazakhstan, Libya and Nigeria. **Natural gas** is mainly imported from Russia and Norway. Kazakhstan can be expected to be a stable trading partner for oil- and gas exports to Austria in the short-term and in the subsequent period leading up to 2050. Libya's future development is highly uncertain due to the physical and political devastation caused by the regime change in 2011. Nigeria will remain a highly potent, but also an uncertain exporter of hydrocarbons to Austria until 2015 and most likely beyond that. Russia has no imminent internal or external risk factors in the near-term and can continue to be viewed as a stable exporter of crude oil and gas for Austria until 2015; in the mid-term Austria will have to be prepared to face increasing foreign competition for Russian oil and gas. Norway will be able to supply hydrocarbons to Austria with high reliability until 2050.

Worldwide reserves of petrol as well as natural gas are already limited and prices are relatively high, when compared to output prices of agricultural production. Different economic sectors in Austria are heavily competing with respect to petrol and natural gas based energy use. Most of the competitors have higher values added than agriculture, which finally could result in the situation that agriculture will not have access to affordable and economically justifiable energy.

We recommend

- raising Austria's self-sufficiency rate in the energy sector
- limiting the use of petrol and natural gas based energy to those sectors, where no other energy use is technically or economically possible (e.g. energy for mobility)
- replacing fossil energy (natural gas) by alternative energy sources (wind power, solar energy) for the production of nitrogen fertilizers
- enhancing fertilization efficiency and fostering research to develop methods and/or plants to fix nitrogen by plants (due to the dependency on imports of fossil energy for the production of nitrogen fertilizer)
- increasing the production of biofuels as well as of biogas. Agriculture should be able to produce the energy needed for agricultural production and food logistics. Using bio-waste, which accumulates year by year in Austria and originates from households, gastronomy and the food industry, it should be possible to reduce the demand for area. Austria should foster investments and research to enhance energy efficiency and eventual development of new generations of biofuels
- diversifying suppliers of crude oil and doing so, minimizing the risk of getting cut off from supply in the short and medium term.
- assisting in building up stable political institutions in exporting countries Austria is depending on.

8.1.3. Dependency on imports of phosphates and other inputs

Concerning **phosphate,** Morocco (by far the largest phosphate supplier worldwide, accounting for more than 90% of all imports to Austria) will be in a monopolistic position in the 21st century. Austria will have to prepare how to ensure an uninterrupted export for its agriculture sector from only one dominant exporter who is threatened by internal and external security threats as well as by demographic, societal and environmental pressure.

We recommend

- limiting the use of phosphor to the minimum demand of soil based crop production
- enhancing recycling of phosphor from any source available, e.g. sewage treatment plants (laundry detergents) or extracts from bones in abattoirs
- enhancing scientific research on the mobilization of phosphates in agricultural soils, even that only postpones the problem
- assisting in the building of stable political institutions and peace-keeping actions in phosphate exporting countries
- ensuring technical and legal facilities to produce vitamins, essential amino acids and pesticides in Europe. Problems according to lacking supply of pesticides may

be crucial as crop pests and invasive pathogens already have a high impact on yields. Climate change may intensify the risks.

8.1.4. Dependency on imports of high-protein feedingstuffs

Austria depends on feed imports, especially vegetable oils and soy bean meals. The protein component in oil seed meals is essential for Austrian pig and poultry production. In spite of successfully raising the supply rate for oil seed meals by reinforcing domestic oil plant cultivation, the protein supply situation remains crucial. Soy products are particularly important to ensure high quality protein feeding components for pigs and poultry. Throughout the last decades, there have been strong efforts to increase soy bean production, but it seems difficult to achieve the necessary level of production. Planting in more areas is restricted by a lack of varieties adapted to Austrian climate conditions (yield) and difficulties in weed.

Consequently, the good or at least relevant self-sufficiency levels for pork and poultry meat are more or less superficial and very sensible to shortages of the protein supply from abroad.

Actual per capita consumption of meats in EU and Austria is double the world level. Enforcement of oil crops cultivation within the last decade and industrial use of cereals in Austria have been lowering protein imports, but only gradually.

With SSRs of 9% for soybean, 49% for oil seed meals and 46% for vegetable oils EU-27 exhibits similar shortages in the home production of relevant agricultural products as Austria.

We recommend

- enhancing the cultivation of soy beans for feed production in central Europe (Austrian protein strategy, “Danube soya”)
- enhancing research and debate possible methods and technologies to solve weed control problems in soy cropping
- raising protein feed production by using more low quality wheat for protein production
- considering the use of animal offal and meat and bone meal for feeding of non ruminants
- re-evaluating hygiene provisions to facilitate feeding of food waste to animals

- promoting responsible use of meat in human diets. For Austria effects of reducing meat consumption in diets on food security may be limited as around 70% of Austrian farm land can only be used by meat production due to geography (alpine grassland) or climatic or natural limitations (crops grow only in feeding quality crop rotation).

- promoting the consumption of meat less dependent on high quality protein feedingstuffs and using feed from grassland and meadows (ruminants)
- assisting in building up stable political institutions in exporting countries Austria is depending on.
- With regard to soy, Austria should strengthen its relationship with Brazil as soy supplier bearing in mind that its other two main soy suppliers, Argentina and the US, may have problems in meeting Austria's demands in the long term.

8.1.5. Technical progress

We recommend

- intensifying scientific and applied research programs in plant and animal breeding. The final objectives should be to raise yields in crop production as well as to increase the transformation rate in animal production
- informing the public on food security issues and present-day agricultural production methods and enable an unbiased dispute on technologies and measures to enhance productivity.

8.1.6. Biofuels und biofibres

The increased use of biofuels and biofibres is an important pillar of the bioeconomy. Fossil energy resources will decrease within the next decade and may end anytime. Prices will rise. Political risks may disturb markets even earlier.

We recommend

- enhancing the use of biofuels and biofibres as a political instrument to moderate prices for fossil energy and to steer demand and supply (in addition to other alternative energy sources)
- preventing an unlimited expansion of areas farmed for biofuels and biofibres, by steering the demand for food, feed, fibers and fuel.

We have to keep in mind that higher farm prices in developing countries increase incomes in agriculture, lead to rising investments, and at the same time favor productivity in the sector. There are still about 1.4 billion people living on less than US$1.25 a day. At least 70% of the world's very poor people are rural. 80% of rural households farm to some extent, and typically it is the poorest households that rely most on farming and agricultural labor.[196] 90% of the world's extremely poor are small-scale farmers.[197] Higher agricultural

[196] IFAD, Rural Poverty Report 2011, 5, http://www.ifad.org/rpr2011/index.htm

[197] FAO (2012): Livestock sector development for poverty reduction, Rome; XIII

prices, even if they are results of biofuel production, may reduce poverty and boost investments in a long term.[198]

8.1.7. Policy presuppositions

A low input agriculture may be more environmental friendly. Extensive low input agricultural production needs more area to produce the same amount of food. Extensive low input agricultural production in Austria is factually an export of virtual area to developing countries. Dependencies grow strongly.

A high input agriculture may harm the environment and interfere with animal welfare believes. SSR may be increased significantly.

We recommend

- balancing reasons between political presupposition towards a low input agriculture (e.g. organic farming) and a high input agriculture. Sustainable agricultural intensification (more intense production taking into account envirnomentalö aspects) may be a solution
- limiting the consumption of agricultural area by construction of e.g. building, roads or reforestation and other use.

8.2. Development of a communication strategy

The project is useful for policy makers, agriculture, food industry and retailers in long term economic planning. Agriculture is highly dependent on weather conditions and vulnerable to climate change impacts. The results are very useful to farmers, so they are able to adapt their production and take measures to mitigate the impacts. For farmers it is very important to know about future developments in order to make careful decisions on long term investments. For the food industry and retailers, it is important to know if they can rely on traditional suppliers, if they will get food all the time and from where they can get it risk-free in future. The assessment will also be important regarding land use priorities (food, feed and biomass production in Austria) and supporting long term policy decisions in agricultural and energy policy.

Project results will be published and presented in scientific fora, political circles and stakeholder meetings. As some of the recommendations do not comply with the published opinion, it makes sense to present results selective and gentle. Results will be used for recommendations in routine work of the project partners.

[198] See pages 6, 14 regearding prices John Dixon and Aidan Gulliver with David Gibbon Principal Editor: Malcolm Hall, http://www.fao.org/docrep/003/y1860e/y1860e00.htm, last visited Dec 2013

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12. Abbreviations

SSR	self-sufficiency rate
min	minimum
1st q	1st quartile
mn	mean
med	median
3rd q	3rd quartile
max	maximum
bl	baseline scenario
bc	best-case scenario
mpc	most-probable case scenario
wc	worst-case scenario

13. Glossary

Agriculture: The managed production of crops and livestock for food, fibre, forage and fuel.

Biodiversity: The amount of biological variation within and between species of living organisms and whole ecosystems in terrestrial and aquatic environments.

Climate Change: The change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (United Nations Convention on Climate Change definition).

Consumption: Consumption is an activity in which institutional units use up goods or services; consumption can be either intermediate or final. It is the use of goods and services for the satisfaction of individual or collective human needs or wants. Alternatively, a consumption of a good or service is one that is used (without further transformation in production) by households, non-profit institutions serving households (NPISHs) or government units for the direct satisfaction of individual needs or wants or the collective needs of members of the community.

Global trade: The exchange of capital, goods and services across international borders.

Governance: The exercise of political, economic and administrative authority in the management of a country's affairs at all levels. Governance comprises the complex mechanisms, process, relationships and institutions through which citizens and groups articulate their interests, exercise their rights and obligations and mediate their differences.

Infrastructure: The physical and organisational structure needed for the operation of a society or enterprise, or the services and facilities necessary for an economy to function. The term usually refers to the technical structures that support a society, such as roads, water supply, sewerage, power grids, telecommunications.

Supply chain: A system of organisations, people, technology, activieties, information and resources that begins with the sourcing of raw material and extends through the delivery of end items to the final customer.

Sustainable production: A method of production using processes and systems that are non-polluting, conserve non-renewable energy and natural resources, are economically efficient, are safe for workers, communities and consumers, and do not compromise the needs of future generations.

Trade balance: The trade balance is the difference between exports and imports of goods and services.

Volatility (price volatility): The wide and frequent variation in average price over a period of measurement.

14. Annex

14.1. Results of the simulation models

Authors: AWI: Christoph Tribl, Josef Hambrusch

Table 1/1: Model 1 – self-sufficiency rates (SSR) of crops (in %)

model 1 SSR (%)	2000 - 2010				2015	Sce-nario	2030						2050					
	min	mn	med	max			min	1st q	mn	med	3rd q	max	min	1st q	mn	med	3rd q	max
wheat	101	125	124	165	105	bl	101	112	121	119	128	154	101	112	120	119	127	153
						bc	101	112	120	118	127	154	101	112	120	118	126	152
						mpc	101	112	119	118	126	151	101	111	119	117	125	150
						wc	101	109	115	114	120	140	101	109	115	113	120	139
coarse grains	81	90	88	101	94	bl	80	88	91	91	94	101	81	88	91	92	94	101
						bc	80	88	91	91	94	101	81	88	91	92	94	101
						mpc	82	89	92	92	95	101	82	89	92	92	95	101
						wc	86	91	94	94	96	101	86	91	94	94	96	101
soy-beans	45	86	89	135	88	bl	45	71	80	81	90	105	46	72	81	82	90	105
						bc	40	69	79	80	89	106	42	70	79	81	89	106
						mpc	50	74	82	83	91	105	51	75	83	84	91	105
						wc	65	81	87	88	93	104	65	82	87	88	94	103
other oilseeds	46	54	53	66	38	bl	0	36	46	46	56	81	0	38	47	48	58	81
						bc	0	38	47	48	57	81	0	40	49	50	59	82
						mpc	3	45	53	53	62	83	7	47	54	55	63	84
						wc	34	62	68	68	74	89	36	63	69	69	75	89

Table 1/2: Model 1 – self-sufficiency rates (SSR) of crops (in %)

model 1 SSR (%)	2000 - 2010				2015	Sce-nario	2030						2050					
	min	mn	med	max			min	1st q	mn	med	3rd q	max	min	1st q	mn	med	3rd q	max
oilseed meals	22	30	30	39	41	bl	23	33	36	37	40	47	24	34	37	38	41	48
						bc	16	26	30	30	34	42	17	28	31	32	35	43
						mpc	31	40	43	43	46	53	32	41	43	44	47	53
						wc	51	58	60	60	62	67	52	58	60	60	62	67
protein crops	92	99	99	108	66	bl	56	80	86	87	94	109	57	81	87	88	94	109
						bc	53	79	86	87	94	110	54	79	86	87	94	110
						mpc	60	82	88	89	94	108	61	82	88	89	95	108
						wc	71	87	91	92	96	106	72	87	91	92	96	106
vegetable oils	34	52	57	62	44	bl	0	40	49	50	59	82	0	42	51	51	61	83
						bc	0	40	49	49	59	82	0	42	50	51	61	83
						mpc	0	40	49	50	59	82	0	42	51	51	61	83
						wc	0	40	49	50	59	82	0	42	51	51	61	83
sugar	119	135	136	150	138	bl	117	128	133	133	137	146	117	127	132	132	136	145
						bc	116	126	130	131	135	143	115	125	129	129	133	141
						mpc	116	125	129	130	134	142	115	124	128	129	132	140
						wc	112	119	122	122	125	131	111	118	121	121	124	130
starch crops	86	90	90	96	94	bl	86	91	93	93	95	99	87	91	93	93	95	99
						bc	87	92	93	93	95	99	87	92	93	93	95	99
						mpc	87	92	93	93	95	99	87	92	94	94	95	99
						wc	90	93	95	95	96	99	90	94	95	95	96	99

Table 1/3: Model 1 – self-sufficiency rates (SSR) of crops (in %)

model 1 SSR (%)	2000 - 2010				2015	Sce-nario	2030						2050					
	min	mn	med	max			min	1st q	mn	med	3rd q	max	min	1st q	mn	med	3rd q	max
fruits	61	64	64	69	64	bl	61	66	67	67	66	73	63	67	68	68	67	74
						bc	61	66	67	67	66	73	63	67	68	68	67	74
						mpc	61	66	67	67	66	73	63	67	68	68	67	74
						wc	61	66	67	67	66	73	63	67	68	68	67	74
vege-tables	57	61	60	67	57	bl	57	61	63	63	66	71	59	62	65	64	67	72
						bc	57	61	63	63	66	71	59	62	65	64	67	72
						mpc	57	61	63	63	66	71	59	62	65	64	67	72
						wc	57	61	63	63	66	71	59	62	65	64	67	72

Table 1/4: Model 1 – self-sufficiency rates (SSR) of animal products (in %)

model 1 SSR (%)	2000 - 2010				2015	Scenario	2030						2050					
	min	mn	med	max			min	1st q	mn	med	3rd q	max	min	1st q	mn	med	3rd q	max
beef & veal	135	144	146	152	153	bl	134	141	143	143	146	154	132	139	142	142	144	152
						bc	134	141	143	143	146	154	132	139	142	142	144	152
						mpc	134	141	143	143	146	154	132	139	142	142	144	152
						wc	134	141	143	143	146	154	132	139	142	142	144	152
sheep meat	72	79	78	85	73	bl	70	77	79	79	81	87	71	77	80	80	81	87
						bc	70	77	79	79	81	87	71	77	80	80	81	87
						mpc	70	77	79	79	81	87	71	77	80	80	81	87
						wc	70	77	79	79	81	87	71	77	80	80	81	87
pork	99	103	102	108	105	bl	99	102	103	103	105	107	99	102	103	103	105	107
						bc	99	102	103	103	105	107	99	102	103	103	105	107
						mpc	99	102	103	103	105	107	99	102	103	103	105	107
						wc	99	102	103	103	105	107	99	102	103	103	105	107
poultry meat	68	73	73	78	72	bl	65	73	75	75	77	83	67	74	76	76	78	84
						bc	65	73	75	75	77	83	67	74	76	76	78	84
						mpc	65	73	75	75	77	83	67	74	76	76	78	84
						wc	65	73	75	75	77	83	67	74	76	76	78	84
eggs	74	75	75	77	76	bl	75	77	78	78	78	80	76	78	78	78	79	81
						bc	75	77	78	78	78	80	76	78	78	78	79	81
						mpc	75	77	78	78	78	80	76	78	78	78	79	81
						wc	75	77	78	78	78	80	76	78	78	78	79	81

Table 1/5: Model 1 – self-sufficiency rates (SSR) of animal products (in %)

model 1 SSR (%)	2000 - 2010				2015	Sce-nario	2030						2050					
	min	mn	med	max			min	1st q	mn	med	3rd q	max	min	1st q	mn	med	3rd q	max
fish	4	6	5	8	3	bl	0	0	15	9	26	62	0	0	16	12	29	63
						bc	0	0	15	9	26	62	0	0	16	12	29	63
						mpc	0	0	15	9	26	62	0	0	16	12	29	63
						wc	0	0	15	9	26	62	0	0	16	12	29	63
milk (raw)	100	100	100	100	100	bl	100	100	100	100	100	100	100	100	100	100	100	100
						bc	100	100	100	100	100	100	100	100	100	100	100	100
						mpc	100	100	100	100	100	100	100	100	100	100	100	100
						wc	100	100	100	100	100	0	100	100	100	100	100	100
butter	71	80	77	93	64	bl	48	67	73	73	79	94	50	68	74	74	79	94
						bc	48	67	73	73	79	94	50	68	74	74	79	94
						mpc	48	67	73	73	79	94	50	68	74	74	79	94
						wc	48	67	73	73	79	94	50	68	74	74	79	94
cheese	89	93	93	97	95	bl	89	92	93	94	95	97	90	93	94	94	95	97
						bc	89	92	93	94	95	97	90	93	94	94	95	97
						mpc	89	92	93	94	95	97	90	93	94	94	95	97
						wc	89	92	93	94	95	97	90	93	94	94	95	97

Table 1/6: Model 1 – areas in 1,000 ha

model 1	2000 - 2010				2015	Sce-nario	2030						2050					
	min	mn	med	max			min	1st q	mn	med	3rd q	max	min	1st q	mn	med	3rd q	max
wheat	261	286	281	309	316	bl	201	281	305	305	330	407	191	267	290	290	314	386
						bc	172	243	265	265	287	354	148	208	227	226	245	302
						mpc	220	307	334	333	361	443	212	297	322	322	347	426
						wc	392	545	588	591	634	767	400	555	600	602	647	781
coarse grains	457	496	505	528	487	bl	328	390	408	408	426	478	288	343	358	358	374	419
						bc	290	349	366	366	383	433	249	300	315	315	329	372
						mpc	362	432	452	452	473	531	323	386	403	403	421	472
						wc	782	936	978	980	1,020	1,142	817	978	1,022	1,023	1,065	1,192
soy-beans	14	20	18	34	41	bl	14	27	30	31	35	44	12	21	24	25	28	35
						bc	11	22	25	26	29	38	9	17	20	20	23	29
						mpc	17	28	32	32	36	45	14	23	26	26	29	37
						wc	35	51	56	56	61	74	33	48	52	53	57	69
other oilseeds	84	98	96	112	104	bl	0	68	94	94	121	206	0	66	89	89	113	190
						bc	0	66	90	90	115	194	0	62	83	82	104	173
						mpc	5	90	116	116	143	228	9	86	111	110	136	213
						wc	85	206	247	248	291	409	97	226	271	271	317	443

Table 1/7: Model 1 – areas in 1,000 ha

model 1	2000 - 2010				2015	Sce-nario	2030						2050					
	min	mn	med	max			min	1st q	mn	med	3rd q	max	min	1st q	mn	med	3rd q	max
oilseed meals	102	118	112	146	144	bl	19	98	124	124	150	238	16	90	113	114	137	214
						bc	15	91	116	116	139	220	16	82	102	103	124	192
						mpc	39	122	148	148	175	261	39	113	137	137	162	239
						wc	146	263	303	305	345	466	155	280	323	325	368	496
protein crops	19	36	39	47	15	bl	20	36	44	43	51	72	24	43	51	50	59	85
						bc	16	30	37	36	43	63	18	34	42	41	49	71
						mpc	23	39	46	45	53	75	28	47	56	55	64	91
						wc	47	69	81	80	92	125	60	89	104	103	118	162
vegetable oils						bl												
						bc												
						mpc												
						wc												
sugar	39	43	44	45	44	bl	35	38	40	40	41	44	30	33	35	35	36	39
						bc	36	40	41	41	42	46	32	35	36	36	37	40
						mpc	39	42	44	44	45	48	34	38	39	39	40	43
						wc	63	67	69	69	71	76	66	71	73	73	75	80
starch crops	21	22	22	24	22	bl	15	17	17	17	18	20	13	15	15	15	16	18
						bc	14	16	17	17	18	20	13	15	15	15	16	17
						mpc	16	19	19	19	20	22	15	17	17	17	18	20
						wc	32	36	38	38	39	42	34	38	39	39	41	44

Table 1/8: Model 1 – areas in 1,000 ha

model 1	2000 - 2010				2015	Scenario	2030						2050					
	min	mn	med	max			min	1st q	mn	med	3rd q	max	min	1st q	mn	med	3rd q	max
fruits						bl												
						bc												
						mpc												
						wc												
vegetables						bl												
						bc												
						mpc												
						wc												
area	957	1,004	1,009	1,049	1,033	bl	750	898	938	939	979	1,138	687	825	862	863	899	1,046
						bc	666	804	841	842	878	1,023	583	704	736	737	768	893
						mpc	840	1,000	1,042	1,043	1,085	1,254	783	933	973	973	1,012	1,170
						wc	1,711	1,981	2,057	2,059	2,132	2,417	1,797	2,080	2,161	2,163	2,240	2,533

Table 1/9: Model 1 – livestock in 1,000 heads

model 1	2000 - 2010				2015	Sce-nario	2030						2050					
	min	mn	med	max			min	1st q	mn	med	3rd q	max	min	1st q	mn	med	3rd q	max
cattle	1,997	2,045	2,026	2,155	2,016	bl	1,885	2,036	2,096	2,096	2,153	2,328	1,897	2,036	2,108	2,109	2,153	2,342
						bc	1,716	1,853	1,908	1,908	1,960	2,120	1,730	1,853	1,922	1,923	1,960	2,136
						mpc	1,885	2,036	2,096	2,096	2,153	2,328	1,897	2,036	2,108	2,109	2,153	2,342
						wc	2,091	2,259	2,325	2,325	2,388	2,583	2,100	2,259	2,333	2,334	2,388	2,593
sheep	304	331	327	358	280	bl	279	329	350	349	368	426	288	329	359	358	368	436
						bc	254	300	318	318	335	388	263	300	327	327	335	398
						mpc	279	329	350	349	368	426	288	329	359	358	368	436
						wc	310	365	388	387	408	473	319	365	397	397	408	483
pigs	3,064	3,218	3,170	3,440	3,119	bl	2,997	3,195	3,264	3,258	3,330	3,558	3,048	3,195	3,315	3,309	3,330	3,611
						bc	2,728	2,908	2,972	2,966	3,031	3,239	2,780	2,908	3,023	3,017	3,031	3,293
						mpc	2,997	3,195	3,264	3,258	3,330	3,558	3,048	3,195	3,315	3,309	3,330	3,611
						wc	3,325	3,544	3,621	3,615	3,694	3,947	3,374	3,544	3,670	3,663	3,694	3,997
poultry	11,787	12,979	13,027	14,644	14,999	bl	11,929	14,301	15,156	15,193	16,034	18,206	12,358	14,301	15,592	15,615	16,034	18,671
						bc	10,859	13,018	13,797	13,830	14,596	16,573	11,269	13,018	14,218	14,240	14,596	17,026
						mpc	11,929	14,301	15,156	15,193	16,034	18,206	12,358	14,301	15,592	15,615	16,034	18,671
						wc	13,233	15,864	16,812	16,853	17,786	20,196	13,679	15,864	17,259	17,286	17,786	20,667

Table 1/10: Model 1 – livestock in 1,000 heads

model 1	2000 - 2010				2015	Sce-nario	2030						2050					
	min	mn	med	max			min	1st q	mn	med	3rd q	max	min	1st q	mn	med	3rd q	max
laying hens	6,526	6,610	6,526	6,974	7,390	bl	6,863	7,381	7,563	7,560	7,753	8,184	7,061	7,381	7,769	7,766	7,753	8,399
						bc	6,248	6,719	6,885	6,882	7,057	7,450	6,439	6,719	7,085	7,081	7,057	7,659
						mpc	6,863	7,381	7,563	7,560	7,753	8,184	7,061	7,381	7,769	7,766	7,753	8,399
						wc	7,613	8,188	8,390	8,386	8,600	9,079	7,816	8,188	8,600	8,596	8,600	9,297
fish						bl												
						bc												
						mpc												
						wc												
milk cows	525	553	534	621	556	bl	523	565	581	581	597	646	526	565	585	585	597	650
						bc	476	514	529	529	544	588	480	514	533	534	544	593
						mpc	523	565	581	581	597	646	526	565	585	585	597	650
						wc	580	627	645	645	663	717	583	627	647	648	663	719
butter						bl												
						bc												
						mpc												
						wc												
cheese						bl												
						bc												
						mpc												
						wc												

Table 2/1: Model 2 – self-sufficiency rates (SSR) of crops (in %)

model 2 SSR (%)	2000 - 2010				2015	Sce-nario	2030						2050					
	min	mn	med	max			min	1st q	mn	med	3rd q	max	min	1st q	mn	med	3rd q	max
wheat	101	125	124	165	105	bl	91	110	120	118	130	168	96	115	127	125	136	177
						bc	101	122	134	132	145	188	118	143	157	154	169	221
						mpc	82	99	109	107	117	153	85	102	113	111	121	159
						wc	45	55	61	60	66	87	44	54	60	58	65	86
coarse grains	81	90	88	101	94	bl	98	109	112	112	116	128	113	125	129	129	134	148
						bc	103	114	118	118	122	136	121	134	139	139	144	160
						mpc	88	98	102	101	105	117	100	111	115	115	119	133
						wc	43	48	50	50	52	60	42	47	49	48	50	58
soy-beans	45	86	89	135	88	bl	40	69	84	84	99	149	51	88	107	107	126	189
						bc	44	77	93	93	109	164	58	100	122	122	143	216
						mpc	39	67	82	82	96	144	49	84	103	103	121	182
						wc	25	44	54	54	63	94	28	48	58	58	68	103
other oilseeds	46	54	53	66	38	bl	32	44	50	49	55	79	35	48	55	53	60	87
						bc	35	47	54	52	59	84	39	53	61	59	67	96
						mpc	30	41	47	46	51	74	33	44	51	49	55	80
						wc	18	24	28	27	31	44	17	23	26	25	28	41

Table 2/2: Model 2 – self-sufficiency rates (SSR) of crops (in %)

model 2 SSR (%)	2000 - 2010				2015	Sce-nario	2030						2050					
	min	mn	med	max			min	1st q	mn	med	3rd q	max	min	1st q	mn	med	3rd q	max
oilseed meals	22	30	30	39	41	bl	23	31	35	35	39	47	23	31	35	35	39	47
						bc	23	31	35	35	39	47	23	31	35	35	39	47
						mpc	23	31	35	35	39	47	23	31	35	35	39	47
						wc	23	31	35	35	39	47	23	31	35	35	39	47
protein crops	92	99	99	108	66	bl	25	50	64	62	75	134	21	43	55	53	65	117
						bc	28	56	71	69	83	149	25	49	63	61	75	134
						mpc	24	48	61	59	72	129	20	40	51	50	60	109
						wc	15	30	38	37	45	81	12	23	30	29	35	64
vegetable oils	34	52	57	62	44	bl	24	38	45	44	51	92	23	37	44	42	49	89
						bc	24	38	45	44	51	92	23	37	44	42	49	89
						mpc	24	38	45	44	51	92	23	37	44	42	49	89
						wc	24	38	45	44	51	92	23	37	44	42	49	89
sugar	119	135	136	150	138	bl	129	140	144	144	147	155	146	159	163	163	167	175
						bc	122	132	135	136	139	146	138	150	154	155	158	166
						mpc	114	124	127	127	130	137	127	138	142	142	145	153
						wc	68	73	75	75	77	81	64	69	71	71	73	77
starch crops	86	90	90	96	94	bl	106	115	119	119	122	137	120	130	135	134	139	155
						bc	108	117	121	121	125	140	123	134	138	138	142	159
						mpc	96	104	108	108	111	124	107	117	120	120	124	139
						wc	50	54	56	56	58	64	48	52	54	54	55	62
fruits	61	65	64	69	64	bl	51	57	59	59	61	68	49	55	57	57	59	65
						bc	51	57	59	59	61	68	49	55	57	57	59	65
						mpc	51	57	59	59	61	68	49	55	57	57	59	65
						wc	51	57	59	59	61	68	49	55	57	57	59	65

Table 2/3: Model 2 – self-sufficiency rates (SSR) of crops (in %)

model 2 SSR (%)	2000 - 2010				2015	Sce-nario	2030						2050					
	min	mn	med	max			min	1st q	mn	med	3rd q	max	min	1st q	mn	med	3rd q	max
vege-tables	57	61	60	67	57	bl	50	54	55	55	56	60	49	52	53	53	54	57
						bc	50	54	55	55	56	60	49	52	53	53	54	57
						mpc	50	54	55	55	56	60	49	52	53	53	54	57
						wc	50	54	55	55	56	60	49	52	53	53	54	57

Table 2/4: Model 2 – self-sufficiency rates (SSR) of animal products (in %)

model 2 SSR (%)	2000 - 2010				2015	Sce-nario	2030						2050					
	min	mn	med	max			min	1st q	mn	med	3rd q	max	min	1st q	mn	med	3rd q	max
beef & veal	135	144	146	152	153	bl	122	135	141	141	145	159	120	133	138	138	143	157
						bc	134	149	154	154	160	175	132	146	152	152	157	172
						mpc	122	135	141	141	145	159	120	133	138	138	143	157
						wc	110	122	127	127	131	144	109	120	125	125	129	142
sheep meat	72	79	78	85	73	bl	59	68	71	71	75	87	58	66	70	70	74	86
						bc	64	74	78	78	82	96	63	73	77	77	81	94
						mpc	59	68	71	71	75	87	58	66	70	70	74	86
						wc	53	61	64	64	68	79	52	60	63	63	67	78
pork	99	103	102	108	105	bl	91	99	102	102	104	112	90	97	100	100	102	111
						bc	100	109	112	112	114	123	98	107	110	110	112	121
						mpc	91	99	102	102	104	112	90	97	100	100	102	111
						wc	82	89	92	92	94	101	81	88	90	90	93	100
poultry meat	68	73	73	78	72	bl	55	65	69	68	72	86	54	64	68	67	71	85
						bc	60	71	76	75	80	95	59	70	74	74	78	93
						mpc	55	65	69	68	72	86	54	64	68	67	71	85
						wc	50	58	62	62	65	78	49	57	61	61	64	77
eggs	74	75	75	77	76	bl	65	71	73	73	75	84	64	69	72	72	74	83
						bc	71	78	80	80	83	92	70	76	79	79	81	91
						mpc	65	71	73	73	75	84	64	69	72	72	74	83
						wc	58	64	66	66	68	76	57	63	65	65	67	75

Table 2/5: Model 2 – self-sufficiency rates (SSR) of animal products (in %)

model 2 SSR (%)	2000 - 2010				2015	Sce-nario	2030						2050					
	min	mn	med	max			min	1st q	mn	med	3rd q	max	min	1st q	mn	med	3rd q	max
fish	4	6	5	8	3	bl	2	3	4	4	4	6	2	3	4	4	4	6
						bc	2	3	4	4	4	6	2	3	4	4	4	6
						mpc	2	3	4	4	4	6	2	3	4	4	4	6
						wc	2	3	4	4	4	6	2	3	4	4	4	6
milk (raw)	100	100	100	100	100	bl	90	95	97	97	98	103	89	94	95	95	97	102
						bc	99	105	106	106	108	113	98	103	105	105	106	111
						mpc	90	95	97	97	98	103	89	94	95	95	97	102
						wc	82	86	87	87	88	93	81	85	86	86	88	92
butter	71	80	77	93	64	bl	57	63	67	67	70	79	56	62	66	65	69	77
						bc	62	70	73	73	77	86	61	68	72	72	75	85
						mpc	57	63	67	67	70	79	56	62	66	65	69	77
						wc	51	57	60	60	63	71	50	56	59	59	62	70
cheese	89	93	93	97	95	bl	90	96	100	99	103	115	88	95	98	98	101	113
						bc	99	106	110	109	113	126	97	104	108	107	111	124
						mpc	90	96	100	99	103	115	88	95	98	98	101	113
						wc	81	87	90	90	93	104	80	86	89	88	91	102

Table 2/6: Model 2 – trade balances of crops (in 1,000 tonnes)

Model2 trade balance (1,000 t)	2000 - 2010				2015	Sce-nario	2030						2050					
	min	mn	med	max			min	1st q	mn	med	3rd q	max	min	1st q	mn	med	3rd q	max
wheat	-678	-276	-231	-16	-76	bl	-737	-386	-268	-263	-146	148	-856	-486	-363	-359	-235	74
						bc	-1,016	-621	-491	-486	-355	-24	-1,421	-987	-847	-843	-696	-336
						mpc	-615	-244	-113	-106	21	335	-701	-311	-176	-167	-36	291
						wc	183	608	772	790	937	1,317	211	650	819	839	990	1,382
coarse grains	-53	388	453	774	235	bl	-1,030	-619	-479	-473	-344	85	-1,780	-1,324	-1,171	-1,164	-1,022	-561
						bc	-1,376	-911	-755	-748	-603	-134	-2,340	-1,822	-1,649	-1,643	-1,480	-969
						mpc	-666	-220	-69	-58	75	532	-1,300	-812	-651	-640	-493	-7
						wc	1,859	2,374	2,563	2,583	2,755	3,232	1,984	2,509	2,707	2,725	2,904	3,389
soybeans	-8	21	4	66	16	bl	-51	1	20	20	39	83	-95	-31	-8	-9	16	69
						bc	-68	-12	9	8	30	77	-124	-53	-27	-27	0	58
						mpc	-47	5	23	22	41	85	-87	-25	-3	-3	20	71
						wc	6	45	57	57	70	104	-3	38	52	52	66	103
other oilseeds	104	195	190	299	398	bl	72	216	270	273	327	475	47	198	254	257	314	469
						bc	55	204	260	264	319	473	15	172	230	234	293	455
						mpc	93	242	299	301	358	509	75	230	289	291	350	509
						wc	226	389	454	459	520	678	247	415	483	489	551	713

Table 2/7: Model 2 – trade balances of crops (in 1,000 tonnes)

Model 2 trade balance (1,000 t)	**2000 - 2010**				**2015**	**Sce-nario**	**2030**						**2050**					
	min	mn	med	max			min	1st q	mn	med	3rd q	max	min	1st q	mn	med	3rd q	max
oilseed meals	388	451	441	509	382	bl	329	401	425	424	449	521	329	401	425	424	449	521
						bc	329	401	425	424	449	521	329	401	425	424	449	521
						mpc	329	401	425	424	449	521	329	401	425	424	449	521
						wc	329	401	425	424	449	521	329	401	425	424	449	521
protein crops	-8	0	2	4	21	bl	-21	21	37	36	52	94	-11	30	45	44	60	100
						bc	-31	14	30	29	46	90	-22	22	38	37	53	96
						mpc	-18	23	39	38	54	95	-6	34	49	48	63	102
						wc	12	46	60	59	73	110	23	55	69	68	82	120
vegetable oils	76	160	119	284	267	bl	17	167	213	215	264	381	24	179	227	228	279	399
						bc	17	167	213	215	264	381	24	179	227	228	279	399
						mpc	17	167	213	215	264	381	24	179	227	228	279	399
						wc	17	167	213	215	264	381	24	179	227	228	279	399
sugar	-164	-113	-114	-60	-124	bl	-186	-164	-152	-153	-141	-105	-266	-241	-227	-229	-215	-173
						bc	-169	-147	-134	-136	-123	-85	-252	-227	-212	-214	-199	-156
						mpc	-138	-116	-104	-105	-93	-56	-206	-182	-168	-169	-155	-114
						wc	97	120	131	129	141	177	124	147	158	157	168	205
starch crops	34	74	81	106	49	bl	-273	-177	-152	-151	-125	-53	-421	-315	-289	-287	-259	-181
						bc	-309	-206	-180	-179	-151	-75	-476	-362	-334	-332	-302	-219
						mpc	-190	-91	-66	-65	-38	37	-317	-209	-181	-180	-151	-71
						wc	349	442	471	474	502	579	388	485	514	517	546	625

Table 2/8: Model 2 – trade balances of crops (in 1,000 tonnes)

fruits	376	430	428	483	457	bl	394	509	547	550	585	694	439	557	596	600	635	746
						bc	394	509	547	550	585	694	439	557	596	600	635	746
						mpc	394	509	547	550	585	694	439	557	596	600	635	746
						wc	394	509	547	550	585	694	439	557	596	600	635	746
vegetables	327	407	414	456	468	bl	449	496	512	512	529	579	490	538	554	554	571	622
						bc	449	496	512	512	529	579	490	538	554	554	571	622
						mpc	449	496	512	512	529	579	490	538	554	554	571	622
						wc	449	496	512	512	529	579	490	538	554	554	571	622

Table 2/9: Model 2 – trade balances of animal products (in 1,000 tonnes)

model 2	2000 - 2010				2015	Sce-nario	2030						2050					
	min	mn	med	max			min	1st q	mn	med	3rd q	max	min	1st q	mn	med	3rd q	max
beef & veal	-77	-67	-69	-56	-75	bl	-87	-70	-64	-64	-58	-40	-86	-69	-63	-63	-56	-37
						bc	-109	-92	-86	-86	-80	-61	-109	-91	-85	-85	-78	-59
						mpc	-87	-70	-64	-64	-58	-40	-86	-69	-63	-63	-56	-37
						wc	-64	-48	-42	-42	-36	-18	-63	-46	-41	-41	-35	-16
sheep meat	1	2	2	3	2	bl	1	2	3	3	3	5	1	3	3	3	4	5
						bc	0	2	2	2	3	4	1	2	2	2	3	4
						mpc	1	2	3	3	3	5	1	3	3	3	4	5
						wc	2	3	4	4	4	5	2	3	4	4	4	6
pork	-39	-12	-11	7	-26	bl	-62	-22	-9	-9	-22	49	-55	-13	0	0	-13	60
						bc	-117	-74	-61	-61	-74	0	-110	-66	-52	-52	-66	10
						mpc	-62	-22	-9	-9	-22	49	-55	-13	0	0	-13	60
						wc	-7	31	43	43	31	99	1	39	52	51	39	109
poultry meat	31	42	43	53	51	bl	22	48	57	57	65	89	25	52	61	61	70	94
						bc	8	36	44	45	54	78	12	39	49	49	58	83
						mpc	22	48	57	57	65	89	25	52	61	61	70	94
						wc	36	61	69	69	77	100	39	65	73	73	82	105
eggs	28	30	30	33	32	bl	21	33	37	37	40	50	23	36	40	40	44	54
						bc	10	23	27	27	31	41	13	26	30	30	34	44
						mpc	21	33	37	37	40	50	23	36	40	40	44	54
						wc	31	43	47	47	50	59	34	46	50	50	53	63
fish	40	54	58	65	90	bl	48	70	81	81	92	117	49	73	84	84	96	121
						bc	48	70	81	81	92	117	49	73	84	84	96	121
						mpc	48	70	81	81	92	117	49	73	84	84	96	121
						wc	48	70	81	81	92	117	49	73	84	84	96	121

Table 2/10: Model 2 – trade balances of animals (in 1,000 tonnes)

model 2	2000 - 2010				2015	Sce-nario	2030						2050					
	min	mn	med	max			min	1st q	mn	med	3rd q	max	min	1st q	mn	med	3rd q	max
milk (raw)	0	0	0	0	0	bl	-103	64	116	115	167	347	-59	113	166	164	219	404
						bc	-452	-274	-219	-221	-163	23	-408	-226	-169	-171	-111	80
						mpc	-103	64	116	115	167	347	-59	113	166	164	219	404
						wc	246	402	451	448	500	670	290	450	501	498	552	727
butter	2	9	10	14	19	bl	10	15	17	17	19	25	11	16	18	18	21	27
						bc	6	11	14	14	16	22	7	12	15	15	17	24
						mpc	10	15	17	17	19	25	11	16	18	18	21	27
						wc	13	18	20	20	23	29	14	19	22	21	24	30
cheese	5	12	11	19	9	bl	-23	-5	0	1	6	19	-21	-2	3	4	10	22
						bc	-41	-22	-17	-16	-11	2	-39	-19	-14	-13	-7	6
						mpc	-23	-5	0	1	6	19	-21	-2	3	4	10	22
						wc	-6	12	18	18	24	35	-4	15	21	21	27	39

14.2. Resilience of Food-, Feed- and Energy Supply from Global Markets

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14.2.1. Methodology for Assessment of Resilience Levels

The *Resilience Level* is assessed by using a combination of various indices, based on a wide spectrum of parameters. These parameters describe the current situation in quantitative manner, using arbitrary units. For each country, representing a foreign key supplier of a particular component in the national food production of Austria, the numerical value of a defined index is given. For comparison, also the corresponding value is presented for Austria.

14.2.1.1. Political Resilience

The country-specific *Political Resilience* (PR) is defined as the aggregate of the following indices:

- Governance Index
- Corruption Perception Index
- Failed State Index
- Economic Freedom Index.

The *PR* is determined for each country which is a key supplier of products essential for Austrian food supply. The numerical value assigned ranges from 1 to 5, i.e. resilience equal 1 represents the highest and 5 represents the lowest resilience.

Governance Index (GI)

G*overnance* is defined as the traditions and institutions by which authority in a country is exercised.[199] This approach accounts for the following aspects:

- Process by which governments are selected, monitored and replaced;
- Capacity of the government to effectively formulate and implement sound policies;
- Respect of citizens and the state for the institutions that govern economic and social interactions among them.

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[199] World Bank (2012): http://info.worldbank.org/governance/wgi/index.asp (last visited: 12 January 2012)

The *Governance Indicator (GI)* for a given country provides information on six parameters:

- Voice and Accountability[200]
- Political Stability and Absence of Violence[201]
- Government Effectiveness[202]
- Regulatory Quality[203]
- Rule of Law[204]
- Control of Corruption.[205]

Each aggregate indicator itself is based on a list of individual indicators; for details, see http://info.worldbank.org/governance/wgi/sc_country.asp. These publically available, disaggregated data summarize information from 31 existing data sources. The data sources reflect the views and experiences of experts in the public, private and NGO sectors from around the world, as well as those of citizens and entrepreneurs.

The graphical representation of the results indicates the *country's %ile rank* on one of the six governance indicators (e.g., Figure A 14.2.1.4.1/1).[206]

Also included in the graph are the margins of error (dashed lines in the line charts), corresponding to a 90% confidence interval. This means that there is a 90% probability that governance is within the indicated range. For instance, a bar of length 75% with the thin black lines extending from 60% to 85% has the following interpretation: (a) In estimated 75% of the countries rate worse and an estimated 25% of the countries rate better than the country of choice. (b) At the 90% confidence level, only 60% of the countries rate worse, while only 15% of the countries rate better.

Individual ratings from different studies had to be rescaled to run from 0 (low) to 1 (high). Thereby, these scores are comparable over time and across countries since most individual measures are based on similar methodologies over time.

[200] World Bank (2012): http://info.worldbank.org/governance/wgi/pdf/va.pdf (last visited: 12 January 2012).

[201] World Bank: http://info.worldbank.org/governance/wgi/pdf/pv.pdf (last visited: 12 January 2012).

[202] World Bank: http://info.worldbank.org/governance/wgi/pdf/ge.pdf (last visited: 12 January 2012).

[203] World Bank: http://info.worldbank.org/governance/wgi/pdf/rq.pdf (last visited: 12 January 2012).

[204] World Bank: http://info.worldbank.org/governance/wgi/pdf/rl.pdf (last visited: 12 January 2012)

[205] World Bank: http://info.worldbank.org/governance/wgi/pdf/cc.pdf (last visited: 12 January 2012).

[206] Percentile ranks indicate the percentage of countries worldwide that rate below the selected country. Higher values thus indicate better governance ratings.

Scores from different individual indicators are not however directly comparable with each other since the different data sources use different units and cover different sets of countries. The data from the individual indicators are further rescaled to make them comparable across data sources before constructing the aggregate. For further background information, see Appendix or http://www.govindicators.org.

Corruption Perception Index (CPI)

The *Corruption Perception Index* (CPI) is an aggregate indicator. It combines data from sources that cover the past two years, i.e., for the CPI 2010 this includes surveys published between January 2009 and September 2010. The CPI 2010 is calculated by *Transparency International,* using data from 13 sources by 10 independent institutions.[207]

All sources measure the overall extent of corruption (frequency and/or size of bribes) in the public and political sectors, and all sources provide a ranking of countries, i.e. include an assessment of multiple countries. Evaluation of the extent of corruption in countries/territories is done by (a) country experts, both residents and non-residents, and (b) business leaders.

In the CPI 2010, the following seven sources provided data based on expert analysis: African Development Bank, Asian Development Bank, Bertelsmann Foundation, Economist Intelligence Unit, Freedom House, Global Insight and the World Bank. Three sources for the CPI 2010 reflect the evaluations by resident business leaders of their own country, IMD, Political and Economic Risk Consultancy, and the World Economic Forum.

For CPI sources with multiple years of the same survey, data for the past two years is included. For sources that are scores provided by experts (risk agencies/country analysts), only the most recent iteration of the assessment is included.[208]

The CPI score and rank are accompanied by the number of sources, the highest and lowest values given to every country by the data sources, the standard deviation and the confidence range for each country. The confidence range is determined by a bootstrap (non-parametric) methodology, which allows inferences to be drawn on the underlying precision of the results. A 90% confidence range is then established, where there is only a 5% probability that the value is below and a 5% probability that the value is above this confidence range. The lower the CPI Index value, the lower the perception of corruption in the country.

[207] Transparency International: http://www.transparency.org (last visited: 12 January 2012).

[208] These scores are generally peer reviewed with little change from year to year.

For further details on the calculation methodology, see *Transparency International*.[209]

Failed State Index (FSI)

The Failed States Index (FSI) is prepared by the *Fund for Peace*, in collaboration with the *Foreign Policy Magazine*. The Fund for Peace is an independent research and educational organization based in Washington, DC, with the mission to prevent conflict and promote sustainable security.[210]

The FSI reflects the different pressures states experience, such as political, economic and social. The Index ranks 177 countries using 12 social, economic, and political indicators of pressure on the state, along with over 100 sub-indicators.[211]

The following issues are addressed in calculating the FSI: Uneven Development, State Legitimacy, Group Grievance, and Human Rights, addressing these pressure parameters in particular:

- Mounting Demographic Pressures
- Massive movements of refugees
- Vengeance-seeking groups seeking revenge
- Chronic and sustained human flight
- Uneven economic development
- Poverty or severe economic decline
- Legitimacy of the State
- Progressive deterioration of Public Services
- Violation of human rights and rule of law
- Security apparatus
- Rise of factionalized elites
- Intervention of external actors

The FSI also accounts for pressure due to natural disasters, including earthquakes, floods and drought. Each indicator is rated on a scale of 1-10, based on the analysis of millions

[209] http://www.transparency.org/policy_research/surveys_indices/cpi/2010/in_detail#4 (last visited: 12 January 2012).

[210] For details on the *The Fund for Peace*. 1720 I Street NW, 7th Floor. Washington, D.C. 20006, USA. http://www.fundforpeace.org/global/ (last visited: 12 January 2012).

[211] For details on the *The Fund for Peace*. 1720 I Street NW, 7th Floor. Washington, D.C. 20006, USA. http://www.fundforpeace.org/global/ (last visited: 12 January 2012).

of publicly available documents, other quantitative data, and assessments by analysts. A high score indicates high pressure on the state, and therefore a higher risk of instability.

Economic Freedom Index (EFI)

The Economic Freedom Index *(EFI) is developed jointly by the newspaper* The Wall Street Journal *(USA) and* The Heritage Foundation*, a Washington think tank.*[212]

Economic freedom is defined as the right of every human to control his or her own labor and property. In an economically free society, individuals are free to work, produce, consume, and invest in any way they please, with that freedom both protected by the state and unconstrained by the state.

The EFI is calculated by measuring the components of economic freedom listed below, assigning a grade in each by using a scale from 0 to 100.[213]

- Business Freedom
- Trade Freedom
- Fiscal Freedom
- Government Spending
- Monetary Freedom
- Investment Freedom
- Financial Freedom
- Property Rights
- Freedom from Corruption
- Labor Freedom

Subsequently the ten component scores are averaged to give an overall economic freedom score for each country. The lower the EFI value, the higher the degree of restriction.

14.2.1.2. Social Resilience

The country-specific *Social Resilience* (SR) is defined as the aggregate of the following information:

- Lifestyle
- Education

[212] For details, see http://www.heritage.org/index/ (last visited: 12 January 2012).

[213] Note: 100 represents the maximum freedom.

- Health
- Employment

The *SR* is determined for each country which is a key supplier of products essential for Austrian food supply. The numerical value assigned ranges from 1 to 5, i.e. resilience equal 1 represents the highest and 5 represents the lowest resilience.

Lifestyle (LS)

The assessment of *Lifestyle* (LS) ranking is derived from the information on the following parameters:

Happiness net

This statistic is compiled from responses to the survey question: "Taking all things together, would you say you are: very happy, quite happy, not very happy, or not at all happy?". The "Happiness (net)" statistic was obtained via the following formula: the %age of people who rated themselves as either "quite happy" or "very happy" minus the %age of people who rated themselves as either "not very happy" or "not at all happy". The methodology was developed by World Values Survey Association.[214]

Life satisfaction inequality

This data is indicative of how much citizens differ in enjoyment of their life-as-a-whole. Life-satisfaction assessed by means of surveys in samples of the general population. Scores may be too low in some countries, due to under sampling of rural and illiterate population. In this ranking the focus is not on the level of happiness in the country, but on inequality in happiness among citizens. Inequality in happiness can be measured by the dispersion of responses to survey-questions. The degree of dispersion can be expressed statistically in the standard deviation and surveys items rated on a 10 step numerical scale are particularly useful for that purpose. Most scores are based on responses to the following question: "All things considered, how satisfied or dissatisfied are you with your life-as-a-whole now?[215] For details on the methodology see the dedicated Rank Report.[216]

The *Lifestyle Index* is based on the numerical values of the above two parameters and ranges from 1 (high value lifestyle) to 5 (low value lifestyle).

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[214] For details, see http://www.worldvaluessurvey.org/ (last visited: 12 January 2012).

[215] Note: 1 “dissatisfied” to10 “satisfied".

[216] World Database of Happiness, Happiness in Nations, Rank Report 2004/3b. Equality of happiness in 90 nations 1990-2000. (last visited: 12 January 2012).

Education (ED)

The assessment of *Education* (ED) ranking is derived from the information on the following parameters:

Class size > Age 13

Average number of 13-year-old students/class.[217]

Duration of compulsory education

Number of grades (or years) that a child must legally be enrolled in school.

Education spending (% of GDP)

Government Education Expenditure as %age of the Gross Domestic product.[218]

Tertiary enrollment

Gross enrolment ratio, tertiary level is the sum of all tertiary level students enrolled at the start of the school year, expressed as a %age of the mid-year population in the 5 year age group after the official secondary school leaving age.[219]

The *Education Index* is based on the numerical values of the above four parameters and ranges from 1 (high value education) to 5 (low value education).

Health (HE)

The assessment of *Health* (HE) ranking is derived from the information on the following parameters:

Crude birth rate per 1 000 people

Number of live births occurring during the year, per 1,000 population estimated at midyear. Subtracting the crude death rate from the crude birth rate provides the rate of

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[217] Eric, A.; Hanushek and Luque, J.A. (2002): Efficiency and Equity in Schools around the World, http://edpro.stanford.edu/eah/papers/TIMSS.pdf (last visited: 10 January 2012).

[218] http://www.nationmaster.com/graph/edu_ter_enr-education-tertiary-enrollment#source (last visited: 10 January 2012).

[219] http://www.nationmaster.com/graph/edu_ter_enr-education-tertiary-enrollment#source (last visited: 10 January 2012).

natural increase, which is equal to the population growth rate in the absence of migration.[220]

Total expenditure as % of GDP

Total health expenditure is the sum of public and private health expenditure. It covers the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health but does not include provision of water and sanitation.[221]

Infant mortality rate

The number of deaths of infants under one year old in a given year per 1,000 live births in the same year. This rate is often used as an indicator of the level of health in a country.[222]

Suicide rate among young males

Suicide rate among 15 to 24 year-olds per 100,000 people.[223]

The *Health Index* is based on the numerical values of the above four parameters and ranges from 1 (high value public health) to 5 (low value public health).

220 http://www.nationmaster.com/graph/hea_bir_rat_cru_per_1000_peo-crude-per-1-000-people (last visited: 10 January 2012).

221 World Development Indicators database (last visited: 10 January 2012).

222 CIA World Factbook, (last visited: 10 January 2012).

223 http://www.nationmaster.com/graph/hea_sui_rat_you_mal-health-suicide-rate-young-males (last visited: 10 January 2012).

Labour & Wealth (LW)

The assessment of Labour & Wealth is derived from the information on the following parameters:

Employment growth

Seasonally adjusted job creation at the national level in first quarter of 2011.[224]

Overall productivity>PPP

GDP (PPP) per person employed in US$.[225]

Population below median income

Population living below 50% of median income (%).[226]

The Labour & Wealth Index (LW) is based on the numerical values of the above three parameters and ranges from 1 (well balanced labour & wealth distribution) to 5 (distorted labour & wealth distribution).

14.2.1.3. Additional Information on Indices used

The so-called "sub-indices" defined in the sections 1.1.1-4 and 1.2.1-4 are themselves based on a broad variety of indices that were previously defined and raised by renowned organizations. Together they paint a profound picture of the subordinate parameter that is used to assess the Political (PR) and Social (SR) Resilience, respectively.

It is not the objective of this section to provide a detailed list of all parameters used in the underlying surveys. However, in order to get an idea of the sub-indices' scientific basis, the Governance Index (GI) is presented in depth.

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[224] World of Work Report (2011): Making markets work for Jobs - First published 2011 by International Labour Office, CH-1211 Geneva 22, Switzerland.

[225] http://www.nationmaster.com/graph/eco_gdp_per_cap_ppp_cur_int-per-capita-ppp-current-international (last visited: 10 January 2012).

[226] http://www.nationmaster.com/graph/eco_pop_bel_med_inc-economy-population-below-median-income (last visited: 10 January 2012).

Case Study: Governance Index (GI)

The GI covers over 200 countries and territories, measuring six dimensions of governance from 1996 on. It is an aggregate of several hundred underlying variables originating from 31 different data sources. These data reflect the views of experts from the public, private and NGO sector, respectively. Further, margins of error are explicitly reported by the GI. Both, the six aggregate indicators as well as the underlying source data, are transparent and available for public[227].

Definition: Governance

To appropriately evaluate governance, it has to be defined in the first place. This is done by Kaufmann et. al.[228] as the traditions and institutions by which authority in a country is exercised. This includes (a) the process by which governments are selected, monitored and replaced; (b) the capacity of the government to effectively formulate and implement sound policies; and (c) the respect of citizens and the state for the institutions that govern economic and social interactions among them.

Each, a), b) and c) is monitored by two aggregate indicators:

a) *Voice and Accountability (VA) and Political Stability and Absence of Violence/Terrorism (PV)*

b) Government Effectiveness (GE) and Regulatory Quality (RQ)

c) Rule of Law (RL) and Control of Corruption (CC)

Source Data

For all calculations performed in association with the GI solely perceptions-based governance data sources, 31 in total, are used. These sources include surveys of firms and households, as well as the subjective assessments of a variety of commercial business information providers, non-governmental organizations, and a number of multilateral organizations and other public-sector bodies. Each of the data sources provides us with empirical, numerical values for the evaluation of the 6 aggregate indicators. These numerical values are generally updated annually. If the data can not be updated, the data lagged one year is used to construct an estimate. Small changes in the

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[227] World Bank: www.govindicators.org (last visited: 14 January 2012).

[228] Kaufmann, D.; Kraay, A. and Mastruzzi; M. (2010): The Worldwide Governance Indicators. The World Bank Policy Research Working Paper No. 5430.

data sources are possible since existing data sources may stop publication and/or new sources become available.

The data sources may be categorized:

1) Commercial business information providers

2) Surveys

3) NGO's

4) Public sector Providers

The data used is fairly evenly divided among these categories. The commercial business information providers typically give data for the largest country samples. The report "Global Insight Business Conditions and Risk Indicators" provides information on over 200 countries in each of the 6 aggregates. The largest surveys used cover up to 130 countries.

Constructing the Aggregate Measures

All underlying variables are rescaled to run from 0 to 1. Higher values indicate better outcomes. That way, the evolution of individual indicators may be used to compare countries over time. However, comparison of individual indicators originating from different sources for a single country is not recommended. Due to the varying methodology margins of error arise. In the following a method to meaningfully aggregate the individual sources is presented.

For that purpose, a statistical tool, the unobserved components model[229] (UCM), is applied. This model requires a simple statistical approach: Each of the individual data sources provides an imperfect signal of an underlying notion of governance that cannot be observed directly. As a result, some information of the signal has to be extracted.

For each of the six aggregates defined in 14.2.1.1.1, it is assumed that the observed score of country j on indicator k, y_{jk}, is a linear function of unobserved governance in country j, gj, and an error term, ε_{jk}:

$$y_{ik} = \alpha_k + \beta_k (g_g + \varepsilon_{jk})$$

[229] Goldberg, A. (1972): Maximum Likelihood Estimation of Regressions Containing Unobservable Independent Variables. International Economic Review, 13:1-15.

where g_j is normally distributed with mean zero and variance one. The unobserved governance in country j is mapped into the observed data y_{jk} from source k by the parameters α_k and β_k. This is necessary since the different sources use varying units to measure governance. Estimates on the mapping parameters are then used to rescale the data from each source into common units. Analogously to the unobserved governance, the error term ε_{jk} is assumed to be normally distributed with mean zero and variance one. Further, the error terms are independent across sources.

Now, estimates for the g_j (which is tantamount to the GI) can be constructed. They range from about -2.5 to 2.5 or in %ile rank terms from the minimum 0 to the maximum 100.

14.2.1.4. Country-specific Resilience Level

Country-specific GI

This section contains the GI for the main countries which are key suppliers of products essential for Austrian food supply. For comparison, also the data are evaluated for Austria.

Table A 14.2.1.4.1/1 provides a summary of the numerical values for the different Worldwide Governance Indicators for Austria.

Table A 14.2.1.4.1/1: Worldwide Governance Indicators (GI) for Austria

Parameter	Austria (GI in 2010)
Voice and Accountability	96/100
Political stability and absence of violence	89/100
Government effectiveness	98/100
Regulatory quality	93/100
Rule of Law	99/100
Control of corruption	94/100

Figure A 14.2.1.4.1/1 shows the 90 %ile rank of Austria on each governance indicator for the years 2001, 2005, and 2010. The statistically likely range of the governance indicator is shown as a thin black line.

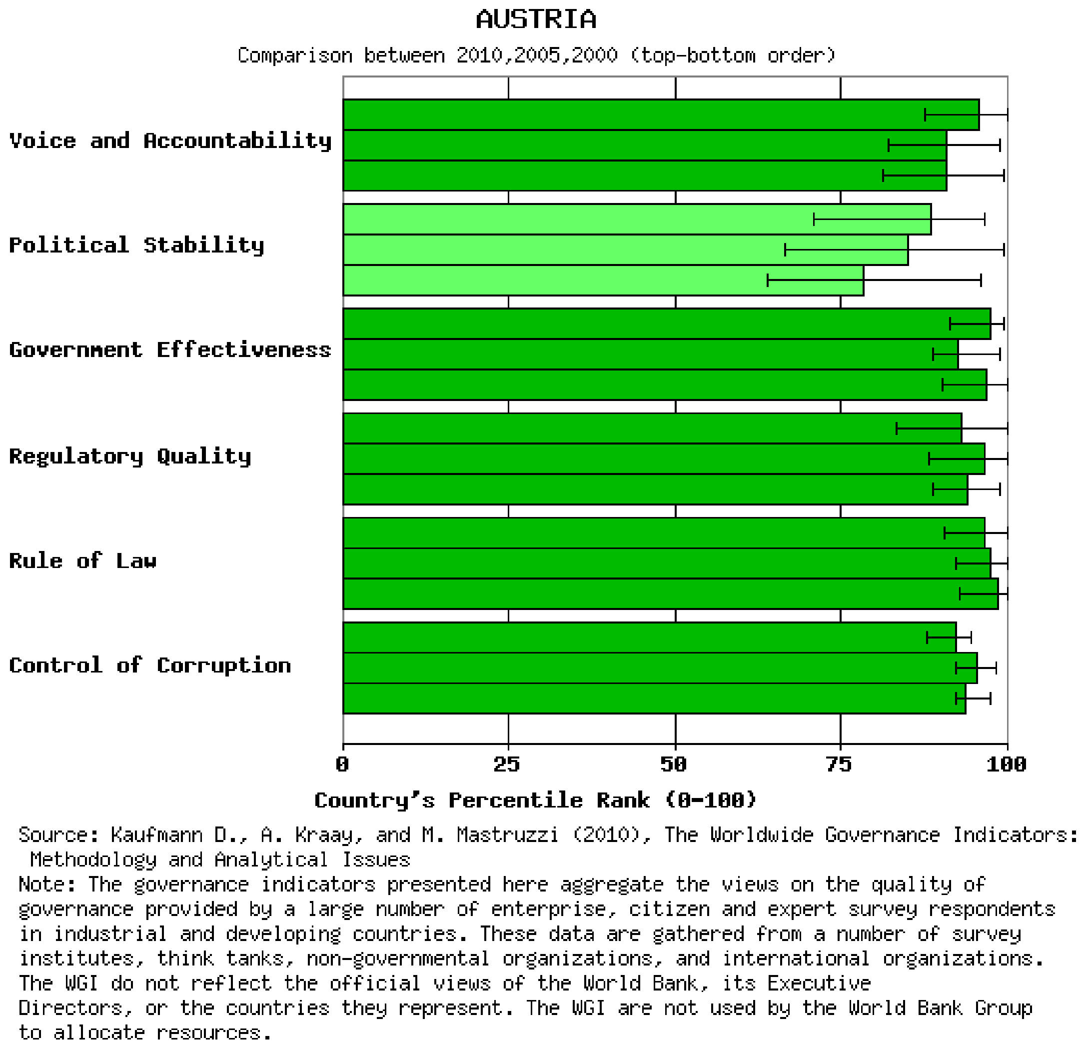

Figure A 14.2.1.4.1/1: %ile rank of Austria on each of the six Worldwide Governance Indicators

For the main exporters relevant for feed-, food- and energy supply to Austria the corresponding GI-values are summarized in Table A 14.2.1.4.1/2.

Table A 14.2.1.4.1/2: Worldwide Governance Indicators (GI) for main exporters relevant for feed-, food- and energy supply to Austria

COUNTRY	Worldwide Governance Indicators (GI)
Argentina	42+/-11
Belorussia	18+/-13
Brazil	57+/-5
China (P. R.)	35+/-19
Columbia	43+/-19
Costa Rica	70+/-6
Ecuador	23+/-11
India	43+/-18
Japan	85+/-6
Jordan	49+/-15
Libya	15+/-14
Kazakhstan	35+/-18
Morocco	43+/-12
Nigeria	15+/-9
Norway	93+/-3
Russia	25+/-12
Switzerland	94+/-3
Syria	22+/-12
United States (USA)	85+/-14
Venezuela	10+/-8

Country-specific CPI

This section contains the CPI for the main countries which are key suppliers of products essential for Austrian food supply. For comparison, also the data are evaluated for Austria.

Table A 14.2.1.4.2/1 provides a summary of the numerical values for the Corruption Perception Index for Austria.

Table A 14.2.1.4.2/1: Corruption Perception Index (CPI) for Austria

Country	CPI 2010 Score	Country Rank	No. Surveys Used	Std. Dev	Min/Max	90% Conf. Int.
Austria	7.9/10	15/178	6	0.7	6.8/8.9	7.4/8.4

For the main suppliers relevant for feed-, food- and energy supply to Austria the corresponding CPI values are summarized in Table A 14.2.1.4.2/1.

Table A 14.2.1.4.2/2: Corruption Perception Index (CPI) for main exporters relevant for feed-, food- and erngy supply to Austria

COUNTRY	Corruption Perception Index (CPI) Score
Argentina	2.7/10
Belorussia	2.5/10
Brazil	3.7/10
China (P. R.)	3.5/10
Columbia	3.5/10
Costa Rica	5.3/10
Ecuador	2.5/10
India	3.3/10
Japan	7.8/10
Jordan	4.7/10
Libya	2.2/10
Kazakhstan	2.9/10
Morocco	3.4/10
Nigeria	2.4/10
Norway	8.6/10
Russia	7.9/10
Switzerland	8.7/10
Syria	2.5/10
United States (USA)	7.1/10
Venezuela	2.0/10

Country-specific FSI

This section contains the FSI for the main countries which are key suppliers of products essential for Austrian food supply. For comparison, also the data are evaluated for Austria.

Table A 14.2.1.4.3/1 provides a summary of the numerical values for the Failed State Index (FSI) for Austria.

Table A 14.2.1.4.3/1: Failed State Index (FSI) for Austria for different pressure parameters

PRESSURE PARAMETER	AUSTRIA
Mounting Demographic Pressures	2.6/10
Massive movements of refugees	2.6/10
Vengeance-seeking groups seeking revenge	3.8/10
Chronic and sustained human flight	1.6/10
Uneven economic development	4.4/10
Poverty or severe economic decline	2.3/10
Legitimacy of the State	1.2/10
Progressive deterioration of Public Services	1.6/10
Violation of human rights and rule of law	1.5/10
Security apparatus	1.1/10
Rise of factionalized elites	2.4/10
Intervention of external actors	2.2/10
Total	27.3/120
Rank	169/177

For the main suppliers relevant for feed-, food- and energy supply to Austria the corresponding FSI values are summarized in Table A 14.2.1.4.3/2.

Table A 14.2.1.4.3/2: Failed State Index (FSI) for different pressure parameters for main exporters relevant for feed-, food- and energy supply to Austria

COUNTRY	Failed State Index (FSI) for different pressure parameters
Argentina	46.8/120
Belorussia	77.6/120
Brazil	65.1/120
China (P. R.)	80.1/120
Columbia	87.0/120
Costa Rica	50.6/120
Ecuador	82.2/120
India	79.3/120
Japan	31.0/120
Jordan	74.5/120
Libya	68.7/120
Kazakhstan	70.2/120
Morocco	76.3/120
Nigeria	99.9/120
Norway	20.4/120
Russia	77.7/120
Switzerland	23.2/120
Syria	85.9/120
United States (USA)	34.8/120
Venezuela	78.2/120

Country-specific EFI

This section contains the EFI for the main countries which are key suppliers of products essential for Austrian food supply. For comparison, also the data are evaluated for Austria.

Table A 14.2.1.4.4/1 provides a summary of the numerical values for the Economic Freedom index (EFI) for Austria.

Table A 14.2.1.4.4/1: Economic Freedom Index (EFI Score) for Austria for different pressure parameters

COUNTRY (Rank/Score)	Business Fdm.	Trade Fdm.	Fiscal Fdm.	Gov. Spend.	Monetary Fdm.	Investm. Fdm.	Financial Fdm.	Property Rights	Fdm. f. Corruption	Labour Fdm.
Austria (21/71.9)	72.8 /100	87.6 /100	50.3 /100	28.0 /100	82.9 /100	80.0 /100	70.0 /100	90.0 /100	79.0 /100	78.2 /100

For the main suppliers relevant for feed-, food- and energy supply to Austria the corresponding EFI values are summarized in Table A 14.2.1.4.4/2.

Table A 14.2.1.4.4/2: Economic Freedom Index (EFI Score) for different pressure parameters for main exporters relevant for feed-, food- and energy supply to Austria

COUNTRY	Economic Freedom Index (EFI Score) for different pressure parameters
Argentina	51.7/100
Belorussia	47.9/100
Brazil	56.3/100
China (P. R.)	52.0/100
Columbia	68.0/100
Costa Rica	67.3/100
Ecuador	47.1/100
India	54.6/100
Japan	72.8/100
Jordan	68.9/100
Libya	38.6/100
Kazakhstan	62.1/100
Morocco	59.6/100
Nigeria	56.7/100
Norway	70.3/100
Russia	50.5/100
Switzerland	81.9/100
Syria	51.3/100
United States (USA)	77.8/100
Venezuela	37.6/100

Country-specific LS

This section contains the LS assessment for the main countries which are key suppliers of products essential for Austrian food supply. For comparison, also the data are evaluated for Austria.

Table A 14.2.1.4.5/1 provides a summary of the numerical values for the Lifestyle (LS) assessment.

Table A 14.2.1.4.5/1: Lifestyle assessment for Austria for different parameters

COUNTRY	Happiness net	Life satisfaction inequality	LS
AUSTRIA	81%	2.1/10	1/5

For the main suppliers relevant for feed-, food- and energy supply to Austria the corresponding LS values are summarized in Table A 14.2.1.4.5/2.

Table A 14.2.1.4.5/2: Lifestyle assessment for main exporters relevant for feed-, food- and energy supply to Austria

COUNTRY	Lifestyle assessment
Argentina	3
Belorussia	5
Brazil	3
China (P. R.)	3
Columbia	4
Costa Rica	-
Ecuador	-
India	4
Japan	2
Jordan	4
Libya	-
Kazakhstan	-
Morocco	4
Nigeria	3
Norway	1
Russia	4
Switzerland	1
Syria	-
United States (USA)	1
Venezuela	2

Country-specific ED

This section contains the ED assessment for the main countries which are key suppliers of products essential for Austrian food supply. For comparison, also the data are evaluated for Austria. Table A 14.2.1.4.6/1 provides a summary of the numerical values for the Education (ED) assessment for Austria.

Table A 14.2.1.4.6/1: Education assessment for Austria for different parameters

COUNTRY	Class-size >Age 13	Duration of compulsory education (years)	Education spending (% of GDP)	Tertiary enrollment	ED
AUSTRIA	4.7	9	5.7	57.7	2/5

For the main suppliers relevant for feed-, food- and energy supply to Austria the corresponding ED values are summarized in Table A 14.2.1.4.6/2.

Table A 14.2.1.4.6/2: Education assessment for main exporters relevant for feed-, food- and energy supply to Austria

COUNTRY	Education assessment
Argentina	3
Belorussia	2
Brazil	4
China (P. R.)	4
Columbia	4
Costa Rica	4
Ecuador	5
India	4
Japan	2
Jordan	4
Libya	3
Kazakhstan	4
Morocco	4
Nigeria	5
Norway	1
Russia	2
Switzerland	2
Syria	5
United States (USA)	1
Venezuela	4

Country-specific HE

This section contains the HE assessment for the main countries which are key suppliers of products essential for Austrian food supply. For comparison, also the data are evaluated for Austria.Table A 14.2.1.4.7/1 provides a summary of the numerical values for the Health (HE) for Austria.

Table A 14.2.1.4.7/1: Health assessment different parameters for Austria

COUNTRY	Crude birth rate per 1 000 people	Total expenditure as % of GDP	Infant mortality rate	Suicide rate young males per 100 000	HE
AUSTRIA	9.5	10.3	4.68	21.1	1/5

For the main suppliers relevant for feed-, food- and energy supply to Austria the corresponding HE values are summarized in Table A 14.2.1.4.7/2.

Table A 14.2.1.4.7/2: Health assessment for main expoerters relevant for feed-, food- and energy supply to Austria

COUNTRY	Health assessment
Argentina	3
Belorussia	3
Brazil	4
China (P. R.)	4
Columbia	4
Costa Rica	3
Ecuador	4
India	5
Japan	1
Jordan	4
Libya	5
Kazakhstan	5
Morocco	5
Nigeria	5
Norway	1
Russia	4
Switzerland	1
Syria	4
United States (USA)	2
Venezuela	4

Country-specific LW

This section contains the LW assessment for the main countries which are key suppliers of products essential for Austrian food supply. For comparison, also the data are evaluated for Austria.

Table A 14.2.1.4.8/1 provides a summary of the numerical values for the Labour & Wealth assessment for Austria.

Table A 14.2.1.4.8/1: Labour & Wealth assessment for Austria for different parameters

COUNTRY	Employment growth	Overall productivity>PPP	Population below median income (%)	LW
AUSTRIA	0.5[230]	$57,781.10	10.6	1/5

For the main suppliers relevant for feed-, food- and energy supply to Austria the corresponding LW values are summarized in Table A 14.2.1.4.8/2.

[230] First quarter 2011.

Table A 14.2.1.4.8/2: Labour & Wealth assessment for main exporters relevant for feed-, food- and

COUNTRY	Labour & Wealth assessment
Argentina	4
Belorussia	4
Brazil	4
China (P. R.)	4
Columbia	4
Costa Rica	4
Ecuador	4
India	5
Japan	1
Jordan	5
Libya	4
Kazakhstan	4
Morocco	5
Nigeria	5
Norway	1
Russia	4
Switzerland	1
Syria	5
United States (USA)	2
Venezuela	4

14.2.2. Resilience Score Card

The assessment of the resilience of a specific country to political- and social threats to the feed-, food- and energy supply is based on the above determined indices, together with the assessment of the current self-sufficiency rate.

The resilience of a given country is characterised by a *Score Card*. A national resilience score value is determined for each country which is a key supplier of products essential for Austrian feed-, food- and energy supply. The numerical value assigned ranges from 1 to 5, i.e. resilience equal 1 represents the highest and 5 represents the lowest resilience.

The *National Resilience* (NR) reflects the national self sufficiency in a particular item (feed, food, energy). NR is defined as the sum of the average value of the *Political Resilience* (PR) and the *Social Resilience* (SR) and the *Self Sufficiency Index (SSI):*

$$NR = \frac{(PR + SR)}{2} + SSI$$

Note: Equation 2.1

The Self Sufficiency Index defined as:

SSI = 0	if Self Sufficiency rate is >130%
SSI = 1	if Self Sufficiency rate is 100%-130%
SSI = 2	if Self Sufficiency rate is <100%

For comparison between countries, the corresponding data are also evaluated for Austria.

Political Resilience of Austria

A summary of the relevant indices for Austria is shown in Table A 14.2.2/1. Globally Austrian management at the Federal and State level ranks among the top in terms of Good Governance, i.e., only 10 to 14% of the countries are better. This is also reflected in the relatively high ranking with regard to the absence of corruption, placing Austria among the top 15 countries and rank 169 concerning the threats associated with a failed state. Although the Austrian approach to economic freedom is somewhat weaker (rank 21), Austrian property rights are internationally acknowledged as strong and the country still is well above the global average concerning labour laws and property. In summary, Austrian PR is assigned the value 1.

Table A 14.2.2/A: Indices used for assigning the Political Resilience value PR for Austria

COUNTRY	GI	CPI	FSI	EFI	PR
AUSTRIA	95 +/-4	15 rank	169 rank	21 rank	1

Where:

GI	Governance Indicator
CPI	Corruption Perception Index
FSI	Failed State Index
EFI	Economic Freedom Index

Social Resilience of Austria

A summary of the relevant indices for Austria is shown in Table A 14.2.2/B. The overall satisfaction of the population with the current living conditions, reflecting the high standards in public health and the relatively low level of poverty, respectively even wealth distribution, is mirrored in all but one of the indices used. Only the topic of *education* warrants further improvement as compared to global excellence. Since the society is largely void of any factors with significant conflict potential and lives in an environment of a densely knit social network, the Austrian SR is assigned the value 1.25.

Table A 14.2.2/B: Information used for assigning the Social Resilience value for Austria

COUNTRY	LS	ED	HE	LW	SR
AUSTRIA	1	2	1	1	1.25

14.2.2.1. Country-Specific Resilience Assessment

This section assesses the resilience of a given country against political and social disturbances. For that purpose the individual indices are combined to provide the numerical values for the national *Political Resilience*, respectively the national *Social Resilience*. Using equation 2/1, together with the national self-sufficiency rate, the *National Resilience* is determined for a certain item.

National Political Resilience

Table A 14.2.2.1.1/A provides a summary of the different indices and the resulting numerical values for the Political Resilience (PR) for the main suppliers of Austria with regard to food, feed and energy.

Table A 14.2.2.1.1/A: Political Resilience (PR) for main suppliers of food, feed and energy to Austria as derived from different indices

COUNTRY	GI	CPI	FSI	EFI	PR
Argentina	42+/-11	105/178	145	138/51.7	3
Belorussia	18+/-13	127/178	83	155/47.9	4
Brazil	57+/-5	69/178	123	113/56.3	3
China (P. R.)	35+/-19	78/178	72	135/52.0	2
Columbia	43+/-19	78/178	44	45/68	3
Costa Rica	70+/-6	41/178	137	49/67.3	2
Ecuador	23+/-11	127/178	62	148/47.1	4
India	43+/-18	87/178	76	124/54.6	3
Japan	85+/-6	17/178	164	20/72.8	1
Jordan	49+/-15	50/178	96	38/68.9	3
Libya	15+/-14	146/178	111	173/38.6	5
Kazakhstan	35+/-18	105/178	107	78/62,1	2
Morocco	43+/-12	85/178	87	93/59.6	3
Nigeria	15+/-9	134/178	14	111/56.7	4
Norway	93+/-3	10/178	176	30/70.3	1
Russia	25+/-12	164	82	143/50.5	3
Switzerland	94+/-3	8/178	174	5/81.9	1
Syria	22+/-12	127/178	48	140/51.3	4
United States (USA)	85+/-14	22/178	148	9/77.8	2
Venezuela	10+/-8	164/178	80	175/37.6	4

Where:

GI	Governance Indicator
CPI	Corruption Perception Index
FSI	Failed State Index
EFI	Economic Freedom Index
PR	National Political Resilience

National Social Resilience

Table A 14.2.2.1.2/A provides a summary of the different indices and the resulting numerical values for the Social Resilience (SR) for the main suppliers of Austria with regard to food, feed and energy.

Table A 14.2.2.1.2/A Social Resilience (SR) for main suppliers of food, fedd and energy to Austria as derived from different indices

COUNTRY	LS	ED	HE	LW	SR [231]
Argentina	3	3	3	4	**3.3**
Belorussia	5	2	3	4	**3.5**
Brazil	3	4	4	4	**3.8**
China (P. R.)	3	4	4	4	**3.8**
Columbia	4	4	4	4	**4.0**
Costa Rica	-	4	3	4	**3.7**
Ecuador	-	5	4	4	**4.3**
India	4	4	5	5	**4.5**
Japan	2	2	1	1	**1.5**
Jordan	4	4	4	5	**4.3**
Libya	-	3	5	4	**4.0**
Kazakhstan	-	4	5	4	**4.3**
Morocco	4	4	5	5	**4.5**
Nigeria	3	5	5	5	**4.5**
Norway	1	1	1	1	**1.0**
Russia	4	2	4	4	**3.5**
Switzerland	1	2	1	1	**1.3**
Syria	-	5	4	5	**4.7**
United States (USA)	1	1	2	2	**1.5**
Venezuela	2	4	4	4	**3.5**

Where:

LS Lifestyle Index
ED Education Index
HE Health Index
LW Labor & Wealth Index
SR National Social Resilience

[231] Rounded off value.

14.2.2.2. Self Sufficiency

Self sufficiency rates for relevant products in the categories *feed, food* and *energy* are derived from WP1.

14.2.2.3. Resilience Score

The *National Resilience* (NR) is derived from the application of equation 2/1. The tables below contain the NR score for Austria.

NR is defined as the arithmetic average of the national Political Resilience (PR) and the national Social Resilience (SR) plus the Self Sufficiency Index (SSI). The lower the NR value, the higher the resistance of that country against disturbances in the supply of a given item.

Table A 14.2.2.3/A: National Resilience Score with regard to crude oil for Austria

COUNTRY	Political Resilience (PR)	Social Resilience (SR)	Self Sufficiency Index (SSI)	Resilience Score (NR)
Austria	1	1.25	2	**3**

Table A 14.2.2.3/B: National Resilience Score with regard to natural gas for Austria

COUNTRY	Political Resilience (PR)	Social Resilience (SR)	Self Sufficiency Index (SSI)	Resilience Score (NR)
Austria	1	1.25	2	**3**

Table A 14.2.2.3C: National Resilience Score with regard to diesel fuel for Austria

COUNTRY	Political Resilience (PR)	Social Resilience (SR)	Self Sufficiency Index (SSI)	Resilience Score (NR)
Austria	1	1.25	2	**3**

Table A 14.2.2.3D: National Resilience Score with regard to potassium for Austria

COUNTRY	Political Resilience (PR)	Social Resilience (SR)	Self Sufficiency Index (SSI)	Resilience Score (NR)
Austria	1	1.25	2	**3**

Table A 14.2.2.3/E: National Resilience Score with regard to phosphate for Austria

COUNTRY	Political Resilience (PR)	Social Resilience (SR)	Self Sufficiency Index (SSI)	Resilience Score (NR)
Austria	1	1.25	2	3

Table A 14.2.2.3/F National Resilience Score with regard to soy for Austria

COUNTRY	Political Resilience (PR)	Social Resilience (SR)	Self Sufficiency Index (SSI)	Resilience Score (NR)
Austria	1	1.25	2	3

Table A 14.2.2.3G: National Resilience Score with regard to vitamins and essential amino acids for Austria

COUNTRY	Political Resilience (PR)	Social Resilience (SR)	Self Sufficiency Index (SSI)	Resilience Score (NR)
Austria	1	1.25	2	3

Table A 14.2.2.3/H: National Resilience Score with regard to bananas for Austria

COUNTRY	Political Resilience (PR)	Social Resilience (SR)	Self Sufficiency Index (SSI)	Resilience Score (NR)
Austria	1	1.25	2	3

Table A 14.2.2.3/I: National Resilience Score with regard to pesticides for Austria

COUNTRY	Political Resilience (PR)	Social Resilience (SR)	Self Sufficiency Index (SSI)	Resilience Score (NR)
Austria	1	1.25	2	3

14.3. Impact of climate change on pests and diseases

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Table A 14.3/A: Scientific literature search in the context of climate change of impact on agricultural pests and diseases; search terms and combinations as well as the databases used for identifying relevant literature are reported.

Database	Search Strategy	results
CAB Abstracts <1973 to 2013	1 (phytosanitary and risks and climate and change).af.	6

Week 38>		
	2 (pest and diseases and climate and change and Austria).af.	11
	3 (pests or diseases) and climate and change and Europe).af.	1429
	4 (pests or diseases) and agriculture and climate and change and Europe).af.	172
	5 limit 4 to yr="1990 -Current"	166
CAB Abstracts <1973 to 2012 Week 12>	1 pets and climate and change	1782
CAB Abstracts <1973 to 2013 Week 37>	1 Emerging and pests and agriculture and food and security	9
	2 Agriculture and pests and food and security and emerging	23
	3 Emerging and pests and soybean	43
	4 food and security and pests and European and community	8
	5 emerging and food and risks and agriculture and production	38
AGRIS 1975 to August 2013	1 (fruit and flies and climate and change and impact and agriculture).af.	0
	2 (Tephritidae and climate and change and impact and agriculture).af.	0
CAB Abstracts 1973 to 2013 Week 38	1(Tephritidae and climate and change).af.	30
	2 (Tephritidae and climate and change and food and security).af.	0