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ÖSTERREICHISCHES INSTITUT FÜR WIRTSCHAFTSFORSCHUNG

Austrian Agriculture 2010-2050

Quantitative Effects of Climate Change Mitigation Measures – An Analysis of the Scenarios WEM, WAM and a Sensitivity Analysis of the Scenario WEM

Franz Sinabell (WIFO),
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Research assistance: Dietmar Weinberger (WIFO)

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Austrian Institute of Economic Research, University of Natural Resources and Applied Life Sciences, Vienna

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Abstract

A significant share of gaseous emissions responsible for climate change is due to agricultural activities. Forecasts on land use, fertiliser use and livestock production for the Austrian agricultural sector are provided for two scenarios. The time period under consideration is 2020 to 2050. The scenarios analyse different strategies to reduce emissions due to agricultural activities. In the scenario WEM (with existing measures) the effects of policies and mitigation measures already in place are analysed. Additional efforts to reduce emissions from agriculture are analysed in the scenario WAM (with additional measures). A sensitivity analysis of the WEM scenario shows the scope of results due to a plausible set of different exogenous assumptions.

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Contents

Figures and Tables

Austrian Agriculture 2010 – 2050

Quantitative Effects of Climate Change Mitigation Measures

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1 Introduction

In its effort to meet the international obligations to reduce the emission of greenhouse gases Austria implemented the Climate Protection Act (KSG, BGBL. I Nr. 106/2011) in 2011. One of the novelties introduced by this act is the definition of specific emission targets (actually upper bounds) for those sectors that are not part of the European Emission Trading System (EU ETS), among them the agricultural sector. Concrete emission reduction objectives were defined for all relevant sectors – which includes agriculture– in a separate regulation (BGBl. I Nr. 94/2013).The target value for the agricultural sector was 5.5 mio t CO_2eq for the period 2008 to 2012 (the share of agricultural emissions was 9.4% in 2012). The annual target value was 7.1 mio t CO_2eq and the emission was 7.5 mio t CO_2eq in 2012 (BMLFUW, 2014a).In order to reach these targets the Austrian Climate Protection Act developed a framework for establishing sector specific measures that are considered to contribute to lower emission.

A program of measures was developed between federal and Länder authorities in compliance with the Climate Protection Act (BMLFUW, w.y.). Not all measures are traditional environmental policy instruments like standards or regulations. Concerning agriculture, a specific policy instrument is considered to be important, the Agri-Environmental Program that is financed by the Common Agricultural Policy as part of the Program of Rural Development. This program was put into force in December 2014 and will be effective until 2020. The measures put into operation by the Austrian Climate Protection Act and the Austrian Agri-Environmental Program are likely to establish a new trajectory for the agricultural sector. The development of the Austrian agricultural sector for the period 2020 to 2050 and its production and environmental impacts are the core focus of this analysis. The report is structured as follows: Likely sector developments are outlined next, followed by a short summary of the international situation on agricultural markets. Then, the model for the analysis is introduced before major assumptions are stated together with brief scenario descriptions. Finally, a discussion of the model results and the major findings of the sensitivity scenario are presented. In the Appendix the detailed results of the scenarios are presented along with supplementary material that helps to understand the results of the analysis.

Because there is considerable uncertainty about the future situations on international markets, several scenarios are analysed. The scenario "with existing measures" (WEM) takes into account the currently existing legal framework, recently implemented changes of the agri-environmental program and assumptions about market conditions as perceived in mid 2014. In the scenario "with additional measures" (WAM) the consequences of alternative future developments and ways to reduce agricultural emissions are analysed.

For the interpretation of the results it has to be considered that none of the scenarios analysed in this study is a "business as usual scenario". Such a scenario would not reflect the current incentive structure for the agricultural sector. Because both, Climate Protection Act measures and the measures of the new agri-environmental program have been implemented only recently it is not possible to conjecture that observed trends are likely to prevail for the coming years.

2 Framework of the analysis

The development of the agricultural sector is mainly analysed from impacts of the demand for farm commodities and public services, and of technological progresses. The commodity markets are increasingly characterized by a reduction of trade impediments. Global demand for food and technological progresses are the main driving force of sector developments. The transmission of demand and supply takes place via prices which are assumed to be set on global markets. Given the small size of Austria within EU-28, an assumption can be made that any supply or demand shift does not affect equilibrium prices in the common market.

In the past, many agricultural commodity prices were either set directly by policy makers or reflected heavy policy intervention (see details in the next chapter). In some markets (e.g. milk and sugar) this is even true today. However, a reduction of farm commodity prices, initiated in 1992 in the EU (1995 adopted in Austria, as well) with a further bold step during the Agenda 2000 reform in 1999 and a further corroboration during the 2003 reform of the Common Agricultural Policy (CAP). Domestic prices of many important markets (grains and meat) have been near world market equilibrium during 2000 to 2006 and since 2007 agents on EU markets have been exposed to the high price volatility that had been confined to world markets in the past. Currently there are no signs that farm policy will intervene in markets as heavily as it did in past decades. Nevertheless EU farm policy is concerned about price volatility and several EU member states have implemented schemes to help farmers to confine the consequences of volatile markets. Apart from this, existing foreign trade rules restrict the flow of agricultural commodities (e.g. sugar) and for many goods of the downstream sectors of agriculture (e.g. ethanol derived from sugar) levies raise internal market prices above world market levels.

The demand for agricultural commodities has surged in recent years due to two major developments:

- several states - including the EU - have implemented very ambitious targets for biofuels which require feedstocks that are produced on agricultural land;

- economic growth at a global scale has been relatively high during recent years (apart from the dip in 2008 and 2009) and large populations can afford more and more protein rich food.

Apart from demand for farm commodities, there is a significant demand for public goods which are provided by agriculture. This demand is no longer increasing - compared to the situation around 2005 - but it is still relevant for most production decisions in Austria. There are aspects that fall in two classes:

- the active provision of goods and services for which private markets do not exist (like open landscape, bio-diversity), and
- the reduction of production intensities and emissions below the legally binding level of standards (e.g. support for organic farming, plantation of winter cover crops).

To the extent that discretionary policy interventions in farm commodity markets were reduced over the last decade, programmes to stimulate the support of public goods which addressed the farm sector, have proliferated.

The framework of the analysis is given by three major assumptions

- The development on farm commodity prices is mainly driven by the demand for farm commodities and technological progresses. In affluent societies with low population growth, the overall volume of food consumption will be relatively constant. Therefore, changing demand trends affect mainly the composition of food components (e.g. substitution of red meat by white meat). The demand from domestic market is only one determinant in agricultural markets. Due to a world-wide growing population with higher incomes the demand for food will be increasing at a faster pace. Given that EU markets are globally integrated this development will have an impact on EU agriculture.
- Society will be willing to pay for non-commodity outputs of the agricultural sector in future; however, the large increase observed in recent years will come to a halt.
- Technical progress will further shift agricultural supply curves to the right, however, likely at a lesser scale than previously observed due to environmental programmes.

These assumptions are made operational in an agricultural sector model for Austria which was developed to evaluate farm policy changes. Given the partial character of the model, further assumptions must be made concerning the actual price levels. These are taken from publication focussing on market trends at EU-level.

3 Modelling the Austrian Agricultural Sector

In this chapter, we present an approach that strives to meet these challenges of forecasting agricultural production in a very detailed manner. The Positive Agricultural Sector Model Austria (PASMA) is employed to estimate the impact of the 2003 CAP reform on selected agricultural and environmental indicators to measure rural/agricultural development. PASMA depicts the political, natural, and structural complexity of Austrian farming in a very detailed manner (Figure 1).

The structure ensures a broad representation of production and income possibilities that are essential in comprehensive policy analyses, i.e., development analysis. Data from the Integrated Administration and Control System (IACS), Economic Agricultural Account (EAA), Agricultural Structural Census (ASC), Farm Accountancy Data Network (FADN), the Standard Gross Margin Catalogue, and the Standard Farm Labour Estimates provide necessary information on resource and production endowments for 40 regional and structural (i.e., alpine farming zones) production units in Austria.

Consequently, PASMA is capable to estimate production, labour, income, and environmental responses for each single unit. Most production activities are consistent with EAA, IACS and ASC activities to allow comparable and systematic policy analyses with official, standardised data and statistics.

The model considers conventional and organic production systems (crop and livestock), all other relevant management measures from the Austrian Agri-Environmental Programme ÖPUL, and the support programme for farms in less-favoured areas (LFA). Thus the two most important components of the programme for rural development are covered on a measure by measure basis. Future model development will focus on farm investment aid and additional diversification measures. Apart from major components of the programme for rural development the complete set of CAP policy instruments is accounted for, as well. Both, the set of instruments before and after the 2013 reform are modelled explicitly.

The model maximises sectoral farm welfare and is calibrated to historic crop, forestry, livestock, and farm tourism activities by using the method of Positive Mathematical Programming (PMP). Howitt (1995) has initially published PMP and since then it has been modified and applied in several models e.g., Lee and Howitt (1996), Paris and Arafini (1995), Heckelei and Britz (1999), Cypris (2000), Röhm (2001), Röhm and Dabbert (2003). This method assumes a profit-maximizing equilibrium (e.g., marginal revenue equals marginal cost) in the base-run and derives coefficients of a non-linear objective function on the basis of observed levels of production activities.

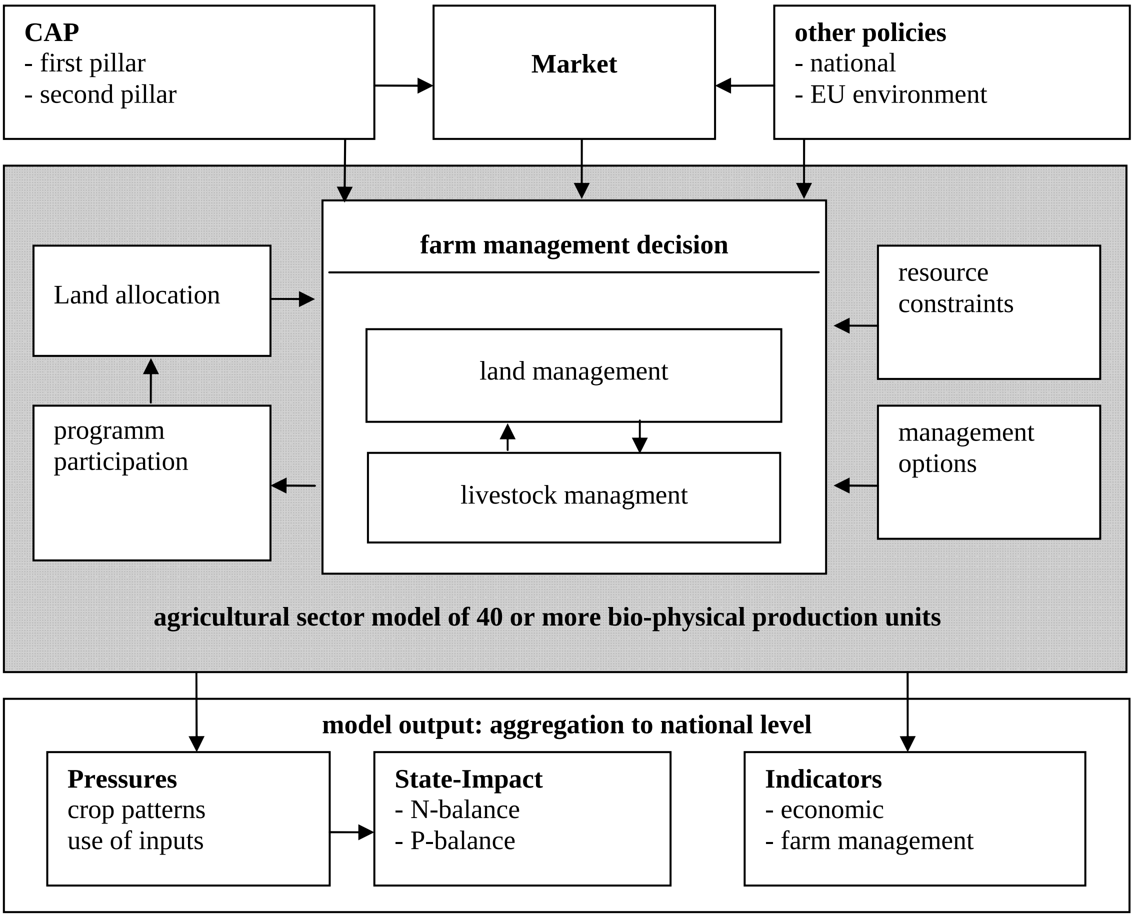


Figure 1: Structure of the agricultural sector model PASMA

Source: own construction.

Two major conditions need to be fulfilled: (i) the marginal gross margins of each activity are identical in the base-run, and (ii) the average PMP gross margin is identical to the average LP gross margin of each activity in the base-run. These conditions imply that the PMP and LP objective function values are identical in the base-run. Another important assumption needs to be made by assigning the marginal gross margin effect to either marginal cost, marginal revenue or fractional to both. In PASMA, the marginal gross margin effect is completely assigned to the marginal cost and consequently coefficients of linear marginal cost curves are derived.

In PASMA, linear approximation techniques are utilized to mimic the non-linear PMP approach (Schmid and Sinabell, 2005). Thus large-scale models can be solved in reasonable time. In combination with an aggregation procedure, i.e., building convex combinations of historical crop and feed mixes (Dantzig and Wolfe, 1961; McCarl, 1982; Önal and McCarl, 1989, 1991), the model is robust in its use and results.

PASMA is a set of three almost identical Linear Programming models. The purpose of the first one is to assign all farm activity levels i.e., crop, forestry, livestock, and farm tourism, and remaining cost shares from feed and manure balances. For instance, the area of meadows is recorded in various data sources listed above. However, information on which activities are actually carried out and to what extent are not available (e.g., grazing, hay, silage, or green fodder production activities). In the model, these activities and remaining cost shares (i.e., fertilizer and feed) are accordingly assigned using historical livestock records and detailed feed and fertilizer balances (phase 1). Phase 2 is the second LP in which the perturbations coefficients (Howitt, 1995) are incorporated to compute the calibration coefficients of a linear marginal cost curve primarily following the approach of Röhm and Dabbert (2003). The third LP (phase 3) is the actual policy model. Calibration coefficients are built in using linear approximation techniques that allow calibration of crop, forestry, livestock, and farm tourism activities to observed and estimated shares. Other model features such as convex combinations of crop and feed mixes, expansion, reduction and conversion of livestock production, a transport matrix, and imports of feed and livestock are included to allow reasonable responses in production capacities under various policy scenarios.

PASMA is a partial equilibrium programming model. The advantage of this type of models is that detailed specifications can be made.

4 Farm policy environment – a decade of efforts to reduce greenhouse gas emission

4.1 The CAP Reform in 2003

In 1992, farm commodity prices that had been kept at high levels via government intervention were reduced significantly with a view to controlling excess production. In order to restrict to a minimum the resultant effects on farm incomes, premiums were introduced which were linked to the amount of land used for production and the number of livestock raised. Direct production incentives of higher prices were reduced, but it is still necessary to produce some crop such as wheat in order to get a crop premium. Additional premiums are granted when specified animals are slaughtered (bulls, oxen, calves, cows, heifers) or reared on the farm (suckler cows and heifers) and an extensification premium is granted when the number of livestock per hectare of land is below a specified limit.

In mid 2002, the European Commission published a mid-term review of the Agenda 2000 reform. The European Commission planned to decouple these premiums from production and to grant a transfer for the farm instead (dubbed "single farm payment"). This subsidy would be paid even if a farmer chose to produce nothing, as long as "land is maintained in good agronomic condition". The transfers which would be subject to decoupling (dubbed "crop premiums" or "livestock premiums" or "CAP premiums") are equivalent to more than half of the EU funds spent on agriculture

A final compromise on the proposals of the reform was reached on 26th June 2003. The key element is the introduction of a single farm payment (Greek Presidency, 2003; Fischler, 2003). This payment will replace premiums formerly linked to output or land.

When the reform proposals were drafted, it was anticipated that decoupled premiums have considerable impact on production incentives. Farmers will not need to plant certain crops or raise bulls in order to obtain financial support. In future, production decisions are expected to be based on market signals (i.e., prices) and consequently resource allocations are likely to improve.

The policy change has become effective on 1st January 2005. Payment entitlements are calculated on the basis of direct payments received in the reference period 2000-2002, they are transferable with or without land and between farmers within a region or a country. They can be only received if accompanied by eligible hectares and agricultural land is maintained in good ecological conditions.

Member States may choose to introduce the single farm payment in full or they may opt to keep some premiums attached to output or factor usage or to retain up to 10 % of direct payments for measures that have a positive environmental effect or improve the quality and marketing of agricultural products. In addition, they may implement the single farm payment at regional level. This implies a redistribution of money between farm enterprises (this option is chosen by Germany) and may lead to redistributions between regions.

Farm operators (but not the owners of land if they have rented it) are entitled to premiums based on historic payment entitlements (average of 2000 to 2002). These entitlements are weighted by premiums and will be adjusted during the reform period. The total of premiums per farm is divided by the sum of the relevant crop and forage area, thus obtaining the average farm premium per hectare. Premiums per hectare will therefore vary among farms.

All farmers receiving direct payments must set aside part of their land (small farms and organic farms are exempt) and will be subject to compulsory cross-compliance. Recipients of farm payments must abide by a list of 18 statutory European standards in the field of environment, food safety, and animal health and welfare (cross compliance). Direct payments to larger farms (above a threshold of EUR 5,000) will be reduced by 3 % in 2005, 4 % in 2006 and 5 % from 2007 to 2013 (modulation). Channelling expenditure away from market policies will make more than EUR 1.2 billion available for rural development.

For cereals (apart from rye), the intervention price remains the same with some modifications. Other crop regulations were simplified, but some production related premiums (notably those for durum wheat, protein crops, and energy crops) have been introduced by the reform. A reformed milk quota system will be maintained until the 2014-15 marketing year (see Sinabell and Schmid, 2008). Regulated prices of butter and skimmed milk powder have been cut asymmetrically in four stages. The quota expanded moderately in 2006 and a decoupled milk quota premium was added to the single farm payment.

4.2 The CAP Reform in 2008

As decided in the 2003 reform a "health check" was carried out 5 years later. The objective was to make adjustments to guarantee that the intended objectives of the reform will be met.

On 20 November 2008 the EU agriculture ministers reached a political agreement on the Health Check of the Common Agricultural Policy. Among a range of measures, the following agreements are of major importance for agricultural market today (EC, 2011):

- Phasing out milk quotas: As milk quotas will expire by April 2015 a 'soft landing' is ensured by increasing quotas by one percent every year between 2009/10 and 2013/14. For Italy, the 5 percent increase will be introduced immediately in 2009/10. In 2009/10 and 2010/11, farmers who exceed their milk quotas by more than 6 percent will have to pay a levy 50 percent higher than the normal penalty.
- Decoupling of support: The CAP reform "decoupled" direct aid to farmers i.e. payments were no longer linked to the production of a specific product. However, some Member States chose to maintain some "coupled" – i.e. production-linked - payments. These remaining coupled payments will now be decoupled and moved into the Single Payment Scheme (SPS), with the exception of suckler cow, goat and sheep premia, where Member States may maintain current levels of coupled support.
- Assistance to sectors with special problems (so-called 'Article 68' measures): Up to 2008, Member States could retain by sector 10 percent of their national budget ceilings for direct payments for use for environmental measures or improving the quality and marketing of products in that sector. This possibility will become more flexible.
- Using currently unspent money: Member States applying the Single Payment Scheme are allowed either to use currently unused money from their national envelope for Article 68 measures (which finance measures to control income volatility in some EU member states) or to transfer it into the Rural Development Fund.
- Shifting money from direct aid to Rural Development: All farmers receiving more than EUR 5,000 in direct aid had their payments reduced by 5 percent and the money was transferred into the Rural Development budget. This rate was increased to 10 percent by 2012.
- Abolition of set-aside: The requirement for arable farmers to leave 10 percent of their land fallow was abolished.

- Cross Compliance: Aid to farmers is linked to the respect of environmental, animal welfare and food quality standards. Farmers who do not respect the rules face cuts in their support. This so-called Cross Compliance was simplified, by withdrawing standards that were not relevant or linked to farmer responsibility. New requirements were added to retain the environmental benefits of set-aside and improve water management.
- Intervention mechanisms: Intervention was abolished for pig meat and set at zero for barley and sorghum. For wheat, intervention purchases will be possible during the intervention period at the price of EUR 101.31/tonne up to 3 million tonnes. Beyond that, it will be done by tender. For butter and skimmed milk powder, limits will be 30,000 tonnes and 109,000 tonnes respectively, beyond which intervention will be by tender.
- The energy crop premium was abolished.

4.3 The CAP Reform in 2013 and the Multiannual Framework 2014-2020

The most recent reform of the CAP was initiated by the Commission in 2011. For the first time the entire CAP was reviewed all at once and the European Parliament acted as co-legislator with the Council. This new role was due the Lisbon Treaty that gave more power to the European Parliament.

The new CAP maintains the two pillars but it introduces a new architecture of direct payments. The objective is to have payments better targeted, more equitable and greener. The role of direct payments as a safety net that strengthen rural development has become more important.

During the phase of the debate on the reform scenarios which would have implied substantial reductions of farm payments were seen to be realistic. To the surprise of many observers, the overall budget for agriculture did not change very much. The instruments of the CAP and how they are implemented is decided by the farm ministers in co-operation with the parliament (see Hofreither and Sinabell, 2013 for a detailed account of the debate). For the allocation of funds available, the heads of Member States and the European Parliament must find and agreement. The Commission had proposed that, in nominal terms, the amounts for both pillars of the CAP for 2014-2020 would be frozen at the level of 2013. Compared to the Commission proposal, the amount for pillar 1 was cut by 1.8% and for pillar 2 by 7.6% (in 2011 prices).A total amount of EUR 362.8 billion for 2014-2020, of which EUR 277.9 billion is foreseen for Direct Payments and market-related expenditure (Pillar 1) and EUR 84.9 billion for Rural Development (Pillar 2) in 2011 prices.

The reform aims at improving sustainability by the combined and complementary effects of various instruments:

- there is a simplified cross-compliance which is a compulsory basic layer of environmental requirements and obligations to be met in order to receive direct payments from Pillar 1
- on top of this 30% of direct payments are reserved, from 2015 onwards, for a new policy instrument in Pillar 1, the Green Direct Payment (for the maintenance of permanent grassland, ecological focus areas and crop diversification)
- at least 30% of the budget of each Rural Development programme must be reserved for voluntary measures that are beneficial for the environment and climate change

Equity concerns were addressed in the CAP reform as well. A more balanced, transparent and more equitable distribution of direct payments among countries and among farmers was agreed upon. The outcome of the agreement is not a uniform payment throughout the Union but a reduction in disparities of the level of direct payments between Member States, known as *external convergence*. Agricultural policy makers hope to reinforce the credibility and legitimacy of the support system at EU level by this step.

The level of direct payments per hectare, which is currently based on historic parameters in many countries including Austria, will be progressively adjusted with the introduction of a minimum national average direct payment per hectare across all Member States by 2020.This element of the reform is called *internal convergence* within the Member States. Payments will no longer be based on uneven historical references of more than a decade ago but rather on a fairer and more converging per hectare payment at national or regional level.

In addition Member States will have further possibilities to rebalance payments with the introduction of the redistributive payment, voluntary capping and degressivity (=reduction) of payments, beyond the mandatory cuts which will apply to the Basic Payment above a certain threshold.

In a nutshell, the most important changes compared to the previous CAP reforms from an Austrian perspective are

- The annual volume of direct payments (1st Pillar) in Austria will be 693 Mio. EUR until 2020 (compared to 733 Mio. EUR (2007-2013).
- The annual volume of the Program of Rural Development (2nd Pillar) will be the same as in the previous phase with 1.1 Billion EUR financed by the EU by 50% and federal funds and funds of Länder.
- Young farmers will qualify for special support financed from the 1st pillar – this will make investments in new production facilities more likely.
- Part of the support from the 1st pillar will be granted as "coupled support". In order to qualify for such payment, farmers have to produce farm products. In the case of Austria 2% of direct payments will be channeled to Alpine farming which will make cattle and mil production in alpine region more profitable.
- The internal convergence of direct payments brings about considerable changes of the distribution of farm payments in Austria. The consequence will be that regions in

which cattle and milk production prevails will benefit (Kirner and Wendtner, 2012 and Kirner, 2011).

4.4 The Programme for Rural Development – an important policy to mitigate greenhouse gas emission of agriculture

After the Agenda 2000 reform in 1999, the programme for rural development (dubbed "second pillar of the CAP") was introduced in the EU. A volume of 91 bn EUR from EU funds was allocated for the programme period 2007-2013 (EK, 2009) but this amount was reduced to 85 bn EUR for the period until 2020. This amount will be topped by contributions of Member States up to 50% depending on the level of development.

The programme for rural development is of eminent importance for the Austrian agricultural sector, because transfers from this source outweigh transfers from the "first pillar of the CAP", e.g. instruments that have been commodity related.

The previous programme ended in 2014and the new programme will start in 2015.

The main elements of the previous programme which are also prevalent for the current period were:

- a genuine EU strategy for rural development will serve as the basis for the national strategies and programmes;
- less detailed rules and eligibility conditions will leave more freedom to the Member States on how they wish to implement their programmes;
- a strengthened bottom-up approach will better tune rural development programmes to local needs.

The policy from 2007 to 2014 had three major objectives:

Axis 1: Improving competitiveness of farming and forestry: The restructuring strategy would be built on measures relating to human and physical capital and to quality aspects.

Axis 2: Environment and land management: agri-environmental measures are a compulsory component. A general condition for the measures under axis 2 at the level of the beneficiary is respect of the EU and national mandatory requirements for agriculture and forestry. One item listed in this axes with great importance for Austria natural handicap payments to farmers in mountain areas.

Axis 3: Wider rural development. The preferred implementation method is through local development strategies targeting sub-regional entities, either developed in close collaboration between national, regional and local authorities or designed and implemented through a bottom up approach using the LEADER approach.

The implementation of the programme in Austria was evaluated (Sinabell et al., 2011) and the results corroborate the view that this programme had major effects on the production of the agricultural sector. An important effect of the program is that agricultural production is maintained in places where agriculture would not be competitive under current market condition. An important instrument is the less favoured areas program. For the period the come, farmers in regions with natural handicaps that are significant will get more support. This will make farming in peripheral regions more profitable and likely contribute to the maintenance if not expansion of cattle and milk production.

For the new programme, to be implemented from 2015 on, Member States had to build their RDP's based upon at least four of the six common EU priorities:

- Fostering knowledge transfer and innovation in agriculture, forestry, and rural areas
- Enhancing farm viability and competitiveness of all types of agriculture in all regions and promoting innovative farm technologies and sustainable management of forests
- Promoting food chain organization, including processing and marketing of agricultural products, animal welfare and risk management in agriculture
- Restoring, preserving and enhancing ecosystems related to agriculture and forestry
- Promoting resource efficiency and supporting the shift towards a low carbon and climate resilient economy in agriculture, food and forestry sectors
- Promoting social inclusion, poverty reduction and economic development in rural areas

In Austria, the priorities of the program are – according to the funds allocated: agri-environment (29%), less favoured areas payments (23%), physical investments (12%), basic services, nature conservation, renewable energy and infrastructure (95).

The Agri-Environmental Programme 2015-2020 program is not organized in axes as was the case with the previous program. Goals are bundled according to priorities and focal points. Climate protection goals are ranking high in this program. Specific targets are set in priority 1, 4, and 5 because climate mitigation (and adaptation) is a horizontal issue that has to be addressed in every program (see details in European Commission, 2013).

The relevant measures (and the relevant support schemes of the agri-environmental programme) are (see Kaupe, s.a. and BMLFUW, 2014b):

- increase pasture and alpine grazing (information, knowledge transfer, advisory services, specific agri-environmental measures)
- adaptations in pork feeding management (knowledge transfer, advisory services, investment aid)
- coverage of slurry tanks (investment aid)
- slurry fermentation (diversification aid, investment aid, renewable energy support, elementary services support)
- drag hose slurry spreading (investment aid, AE climate measures)
- organic farming (specific AE support scheme)
- reduction of mineral fertilizer use (specific AE support scheme)
- sustainable nitrate management, winter cover crops, permanent soil cover (specific AE support scheme focussed on groundwater protection)
- minimum tillage, strip tillage and mulch seeding (specific AE support scheme)
- fuel efficient driving of tractors (investments in elementary services support)

- electric engines for irrigation facilities (investments in elementary services support)

5 Market and economic environment

5.1 International food markets

European farm commodity markets are interlinked with international food markets in many ways. Given the imbalances between supply and demand in many markets, the EU is a major exporter, in particular of cereals, milk and white meat. The policy efforts to bring domestic market prices closer to equilibrium prices (see above) brings about that the gap between domestic prices world market prices is narrowing. Domestic supply – apart from heavily regulated products like milk – therefore is increasingly determined by the fluctuation of world market prices. Global demand for food and technological progresses (e.g., the adoption GMO crops in major producing countries, organic food production) will be major driving forces of agricultural production during the next decade to come. Over the medium-term, world agricultural markets are projected to be essentially supported by rising food demand driven by an improved macro-economic environment, higher population, urbanisation and changes in dietary patterns (OECD-FAO, 2014). Widespread economic growth and an expanding livestock sector are projected to combine to set the stage for a strengthening of world demand and maintaining a low stock-to-use ratio.

Cereals trade would also expand, particularly in developing economies, driven by rising income, diet diversification and higher demand for livestock products and feeds, allowing for a gradual, albeit moderate, price increase over the medium term. The medium-term prospects for the oilseed sector are expected characterised by increasing demand due to expanding growth of the biofuel market.

Meat markets are projected to be characterised by an expansion in production, consumption and trade with world meat prices showing moderate strength. Prospects for rising meat demand would mainly emerge from a favourable macro-economic environment of sustained income growth, notably in Asia and Latin America. World meat trade would increase and prices remain firm over the medium term as growing consumption is mostly expected to take place in countries that are net importers with limited possibilities to proportionally and competitively increase domestic supply (in quantity and quality).

The medium-term outlook for the dairy sector is expected to remain dominated by a strong expansion in global demand for dairy products. The latter would reflect not only income growth in many regions of the world, but also changes in consumer preferences towards dairy products.

At the time of writing this report, the times of low prices for farm commodities in Europe seem to be gone. Given that the value marginal product of inputs (among them land) is determined by both, technology and output prices, higher commodity prices mean that more intensive farming systems will become more profitable. However, because input prices (in particular fuels and fertilizers) will change as well, the effect on total output has to be analysed with the help of models which account for all three aspects: change of technology, change of output prices and change of input prices.

5.2 National energy policies

Austrian energy policy is committed to substitute non-renewable energy sources by renewable ones. Raw materials produced by agriculture are a major alternative source. Two major legal sources are of interest in this context: the Austrian law for the provision of green electricity (Ökostromgesetz) and the European bio-fuel directive (EU, 2003) which has been recently repealed by the EU Directive on Renewable Energy (Directive 2009/28/EC).

Both measures are channelled to the agricultural via the price system: the regulations to boost bioenergy crop production work like a subsidy on farm commodities. Because Austrian sources of feedstock are not favoured over imported ones, the relevant production incentives in Austria are dominated by the price signals from regional and global markets.

Due to the mechanism of the bioenergy policies currently in place, the best approach to model them is to take prices which are relevant for markets in the EU as a reference and to analyse their effects on local production. This approach is motivated by the observation that the previously observed large expansion of biogas production plants has stopped abruptly. Only approximately 30,000 ha of land are used to produce material for these plants. The fact that there is no longer an expansion is important because biogas production competes in most cases directly with beef and milk production. A more profitable biogas sector would weaken the perspectives of milk production in Austria.

5.3 Baseline economic assumptions

Several assumptions must be made to run the model outlined above. These are basically input prices which are derived from other sources (OECD-FAO, 2014). Price projections are based on assumption about the development of key indicators like population and GDP growth, and GDP deflator taken from OECD-FAO (2014).Forecasts on world oil prices are based on Umweltbundesamt (s.a.) (see Table 2) which are slightly higher than those of OECD-FAO (2014).

Table 1: Assumptions on macro-economic variables in the European Union, 2014 – 2023

		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
real GDP	%	1.3	1.9	1.7	1.8	1.7	1.7	1.7	1.8	1.7	1.7
price deflator	%	1.9	1.5	1.9	2.0	1.9	1.9	1.9	2.0	1.9	1.9
Population	%	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
GDP deflator	%	1.4	1.5	1.8	1.9	1.8	1.8	1.9	1.8	1.8	1.8
world oil price	USD/barrel	113.1[1]	118.1	121.4	124.7	128.1	131.6	135.2	139.0	143.0	147.1

Source: OECD-FAO, 2014, Table A1 Economic assumptions.[1] The price actually observed in 2014 was 98.99 USD/barrel

Table 2: Assumptions on macro-economic variables for Austria, 2010 – 2040

parameter	2010	2020	2030	2040
GNP [bn € 2010]	285	330	383	435
population [1,000]	8382	8733	9034	9277
Exchange rate US$/€	1.3	1.3	1.3	1.3
oil price [US$/bbl] (nominal)	78	148	212	267
oil price [US$/bbl] (real 2010)	78	118	135	139

Source: Umweltbundesamt, s.a.

Several sources are available which can be used as basis of price forecasts. In this study, all prices but energy prices are derived from OECD-FAO outlooks on agricultural markets (see OECD-FAO, 2014). A comparison of this OECD-forecasts with projections of the Commission of the EU (European Commission, 2014) shows that international bodies have very similar assumptions about future development of key economic indicators. Due to the type of model, assumptions on the Austria economic environment (GDP growth, population dynamics, etc.) are not necessary. But they are embedded in the exogenous price assumptions. Other driving forces (prices, technology, constraints) are referenced in the following sections.

The simulations are calculated for a number of years for which the most important policy changes will be the abolition of the suckler cow premium and the milk quota in 2015. Many other changes, like the abolition of set-aside, the decoupling of direct payments, reforms for the sugar sector have taken place in recent years and the farm sector has already adjusted to these changes.

For the period from 2023 to 2050 constant price trends (of both inputs and outputs) were assumed, and technological progress is assumed to go on. Technically, results for the years between these dates, linear approximation techniques were used to obtain the specific results.

Exogenous economic assumptions for Austria (like GDP or population size) are not explicitly necessary for the model used for this analysis because the reaction of the agricultural sector is mainly depending on prices of outputs and inputs. Input prices were chosen to be consistent with recent forecasts for the Austrian energy sector (Kratena, Meyer and Sommer, 2013). Since production is driven by resource availability, prices and technological development, and since Austrian agriculture is an integrated part of the common market, European demand patterns carry over and determine the results.

5.4 Specific assumptions on farm commodity prices

The assumptions underlying future policy variables and future prices of farm commodities are referenced in the appendix. The forecast period in this study is going until 2050. For the period beyond 2023OECD-FAOforecasts are not available. Therefore, the assumption is made that beyond this year, prices will follow the trend.The assumptions on prices are referenced in Table 3and Table 4.

All price projections apart from milk price projections are based on OECD-FAO 2014 forecasts. Price estimates are specific for the Austrian market situation. Based on previously observed wedges between EU and Austrian prices estimates for the coming periods were made. For this analysis, lower milk prices for Austria are assumed than those forecast by OECD-FAO (2014) for the EU. The reasoning behind the deviation is that for countries which are likely to expand milk production, lower prices may prevail over a long period until a new equilibrium establishes (see Schmid et al., 2011 for more elaborations on this expectation). Similar considerations are explored in depth in the recent agricultural perspectives report of the European Commission (2014) where a scenario with lower milk prices is analysed. Nevertheless, in the baseline scenario of the European Commission, expected milk prices are closer to the forecasts of OECD-FAO (2014) though slightly lower.

Other assumption, in particular technical progress in plant and animal production are based on Sinabell and Schmid (2005). Deviating from this source, estimates of future milk yields per dairy cows (Table 4) are adapted according to the estimates discussed in an expert panel in November 2014.

5.5 Baseline data

PASMA, applied for the quantitative analysis, is a positive mathematical programming model (see chapter 3). Such models are calibrated to observed data. The data for which the model is calibrated are describing the Austrian agricultural sector in 2007-2009. This data set was established for a study on the evaluation of the program of rural development (Sinabell et al., 2011).In order to reflect recent market and production developments in the results, observations of the baseline period 2010 to 2012 determine the future level shifts of outputs and production activities.

The major sources of baseline data are various Statistik-Austria statistics on the agricultural sector, published in the monthly "Statistische Nachrichten", data from integrated administration and control system (IACS), administrative sources and data derived from the annual farm income report ("Grüner Bericht", BMLFUW, 2008 until 2014).

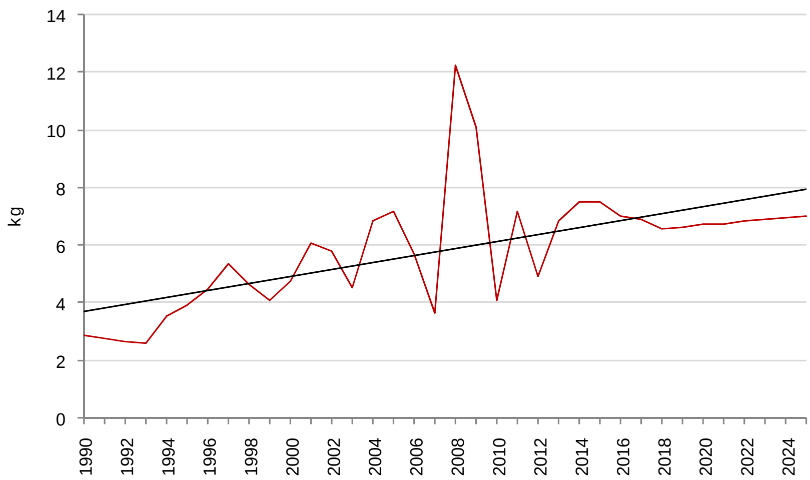
Table 3: Observed and expected nominal farm prices in Austria (€ per ton or 100 l)

	organic prices[1)]	ø2007/2009	ø2010/2012	2020	2030	2050
Wheat	1.60	143.17	188.23	163.21	166.72	175.14
Coarse wheat	0.75	114.46	150.45	131.45	134.27	141.05
Durum	1.60	209.47	243.57	220.83	225.57	236.97
Rye	1.50	120.13	174.73	143.86	139.35	129.34
Coarse rye	0.60	101.50	149.29	118.38	114.67	106.44
Winter barley	0.75	113.52	144.37	135.61	138.52	145.52
Summer barley	0.75	113.52	144.37	133.41	129.24	119.95
Oats	0.60	110.30	152.80	143.14	138.65	128.69
Triticale	0.70	108.88	144.11	127.21	123.22	114.37
Spelt	2.20	261.83	304.46	276.04	281.97	296.21
Maize	0.80	131.00	182.79	155.70	150.82	139.98
Beans	0.75	223.37	298.82	257.71	272.05	299.15
Peas	0.75	142.29	173.11	157.80	166.58	183.17
Soy-beans	0.75	282.54	377.99	360.10	397.17	474.68
Sunflower	0.75	228.95	368.90	296.12	326.60	390.34
Sugar-beet	0.00	27.97	26.29	19.30	22.14	27.20
Starch potatoes	0.00	55.09	63.35	63.80	61.80	57.36
Rape-seed	0.75	275.35	402.03	360.18	397.26	474.79
Fruits	1.50	343.47	345.70	424.11	424.14	421.98
Wine	1.50	365.00	744.64	739.64	738.33	737.76

Source: own assumptions based on OECD, 2014.

Note: [1)] Price mark-up of organic products relative to conventional ones.

Figure 2: Rate of exchange between 1 kg N (mineral fertilizer) and kg of maize



Source: Statistik Austria, AMA, own estimates based on OECD-FAO, 2014 and Umweltbundesamt, s.a.

The expected physical rate of exchange between agricultural outputs and agricultural inputs is likely to prevail as in the past (see Figure 2). Following the trend, approximately 4 kg of maize were necessary to buy 1 kg of N in 1990 whereas 8 kg of maize will be necessary to buy

1 kg of N in 2025. According to the price forecasts of OECD-FAO (2014) and Umweltbundesamt (s.a.) ever more agricultural products will become necessary to purchase the same amount of fertilizers. This makes both organic and inorganic fertilizers more valuable which stimulates more efficient use and more care when applying fertilizers on land.

Table 4: Observed and expected nominal farm prices in Austria and milk yields

	organic prices[1)]	unit € per	ø2007/2009	ø2010/2012	2020	2030	2050
milk-A-quota	0.091	kg	0.32	0.32	0.28	0.32	0.43
milk-D-quota[3]	0.091	kg	0.36	0.35	0.31	0.36	0.47
milk home consumption	0.091	kg	0.17	0.17	0.28	0.32	0.43
milk yield per cow		t/cow					
Veal	0.25	kg SW[2)]	5.02	5.38	6.07	6.39	7.18
heifer for breeding	0.15	head	1,632	1,716	1,903	2,002	2,251
heifer for suckler cow	0.15	head	1,212	1,245	1,380	1,453	1,633
beef of heifer	0.15	kg SW	2.72	3.06	3.55	3.73	4.20
Mutton	1.15	kg SW	4.11	4.10	4.53	5.32	6.87
beef (oxen)	1.15	kg SW	3.15	3.60	4.09	4.31	4.84
sheep cheese	0.15	head	0.54	0.61	0.68	0.72	0.82
Pork	0.3	kg SW	1.42	1.54	2.03	2.30	2.96
Beef	0.0	kg SW	3.09	3.51	3.99	4.20	4.72
Turkey	0.1	kg SW	1.18	1.29	1.34	1.35	1.38
fallow deer	1.5	kg SW	2.38	2.56	2.75	2.90	3.26
Wool	0.0	kg	0.53	0.56	0.59	0.59	0.59
Boar	0.0	head	38.54	42.23	55.48	62.84	80.73
goat meat	0.0	kg SW	2.89	3.05	3.47	4.08	5.26
goat cheese	0.15	head	1.37	1.45	1.60	1.71	1.93
male calves	0.15	head	383	413	454	478	538
male calves for beef	0.4	kg SW	441	176	523	551	619
female calves	0.25	head	294	279	312	328	369
female calves for beef	0.25	kg SW	425	404	451	474	533
Eggs	0.25	unit	0.14	0.18	0.18	0.18	0.18
Chicken	0.25	kg SW	0.88	0.92	0.94	0.95	0.97
young sow	0.8	head	270	290	376	426	547
young chicken	1.5	head	3.34	3.52	3.58	3.61	3.69
Cow	0.3	kg SW	2.14	2.47	2.90	3.05	3.43
Sow	1.5	kg SW	0.99	1.14	1.52	1.72	2.21
sheep meat	0.15	kg SW	0.60	0.61	0.66	0.78	1.01

Source: own assumptions based on OECD, 2014.

Note: [1)] Price mark-up of organic products relative to conventional ones.[2)] kg SW is kg carcasse. [3)] Milk-D-quota will no longer be in effect after March 2015. But direct sales from farms to consumers will prevail throughout the period.

5.6 Further assumptions

The **storage of manure** has an essential influence on the level of emission from livestock. Structural information on storage facilities on Austrian farms was made available by the Austrian farm survey from 1999. These data were used to estimate the actual requirements of storage facilities depending on the type of livestock.

Multiple regression analysis was used to make these estimates. Two multiple linear regression models were used to explain the capacity of both, slurry and solid manure storage capacity (see Sinabell and Schmid, 2005).

Future **milk yields** per cow are based on assumptions which are made explicit in Table 1. The milk yield per cow of is taken from BMLFUW. The future development of milk yields is based on estimates of an exponential trend of data from 2002 to 2013from the same source. The estimates were limited to this period because a statistics revision in 2001 brought about a large yield increase per cow. Thus future milk yields per cow are estimated relatively conservatively. Milk output at sector level is evaluated as the sum of regional milk yields times the number of dairy cows in each region minus 3 % losses. The average milk production at sector level is the consequence of three processes:

- the productivity gains per cow in each region,
- the regional shift of the cow population and
- the relation of non-organic cows o organic cows (with 5% lower yields).

The usage of **mineral fertilizers** is calculated in two ways: the consumption of urea is not derived from the model but given exogenously based on a linear trend of past observations. The level of input of all other nutrients is determined by the model based on nutrient balances (crop demand + observed surplus = mineral inputs + manure inputs + accumulation in soil). These balances are calculated for each structural unit therefore the aggregation error can be kept at a minimum (Sinabell and Schmid, 2005). The forecasts of mineral fertilizer are therefore reflecting the consequences of land use changes (e.g. more legumes when organic farming is expanding) and changes of the livestock-herd (e.g. less manure when less bulls are produced). Technical progress in crop production eventually has the consequence that less fertilizer is needed to produce the same amount of output. This can be achieved by diminishing losses due to better technology and management.

6 Scenarios

In this section, the scenarios which are investigated in this study are outlined. We compare two sets of policy scenarios

- scenario “with existing measures” WEM (farm policy after reform from 2013 and climate change measures as implemented in the Austrian agri-environmental programme)
- scenario “with additional measures” WAM (similar to WEM but assuming more efficient use of nutrients and higher support for organic and extensively managed farms)
- sensitivity analyses WEM: a sensitivity scenario (similar to WEM with alternative assumptions on farm land availability and milk yields per cow)

A detailed overview of the scenarios is provided in Table 6. It shows the discrete choices set in order to differentiate between the scenarios.

With existing measures – WEM

The following policy measures are implemented:

- sector specific measures implemented according to the Austrian Climate Protection Act, in particular in the context of the Austrian agri-environmental programme
- implementation of the CAP health check reform 2008 (mainly abolition of milk quota in 2015)
- implementation of the CAP 2013 reform (in particular abolition of sugar quota and suckler cow premium)
- internal convergence of direct payments ("regional premium" scheme instead of historic payments)
- land is maintained in good agricultural and ecological condition ("cross compliance" and requirements for "greening" (in particular crop rotation requirement) are met)
- the programme for rural development is maintained in a modified way with different premiums (in particular for less favoured areas and organic farms) and measures
- loss of agricultural land following the long term trend
- increase of milk yield per cow from 15% (2020) to 35% (2050) relative to reference period

With additional measures – WAM

- all adjustments considered in WEM
- slightly more efficient usage of mineral fertilizer
- reduced losses of organic fertilizer
- more efficient livestock production in dairy (increase of lactations of milk cows)
- more efficient feed usage in fattening pigs (adjusted to phases of maturity)
- increase of quality (energy and protein) of grassland and maize forage production
- a further stimulation of organic farming and other measures aimed at reducing mineral fertilizer inputs by granting higher subsidies

Sensitivity analysis WEM

- no loss of agricultural land in the future

- same milk yield per cow as in reference period (other scenarios assume increase by 15% to 35% until 2050)

Table 5: Detailed description of climate change abatement measures (see also Table 6*)*

Climate measure	Description
Increase in lactation dairy cows	Increases number of lactations per cow; as a consequence reduced demand of heifers for replacement
Increase in efficiency of livestock	Increases yields of all livestock products except for dairy; assumed to be result of breeding and better (herd) management; but no additional feed demand and costs assumed; milk increases are covered by index milk yield per cow
Increase in quality grassland/silage	Increases protein and energy content of all forage products, i.e. forage from permanent and temporary grasslands and silage maize; assumed to be the result of improved crops, better management; but no additional costs assumed
Feeding efficiency increase	Reduced protein and energy demand of pig production; no changes in costs and manure production assumed
Reduction of losses manure nutrients	Reduced loss of nitrogen from all livestock manure; assumed to be the result of better management but free of additional costs
Reduction of losses of fertilizer	Reduced loss of nitrogen from all mineral fertilizer; assumed to be the result of better management and spreading equipment– but free of additional costs

Table 6: An overview of the scenarios and assumptions

	REF	**WEM**			**WAM**			**WEM sens**
		2020	2030	2050	2020	2030	2050	
market prices								
OECD/FAO 2014 Crops/Livestock		yes			yes			yes
OECD/FAO 2014 Trend Crops/Livestock			yes/yes	yes/yes		yes/yes	yes/yes	
specific price milk		yes	yes	yes	yes	yes	yes	
Energy AT-Forecast		yes	yes	yes	yes	yes	yes	yes
CAP 1st pillar								
milk quota	yes	no	no	no	no	no	no	no
livestock premia	yes	no	no	no	no	no	no	no
regional dircect payments	no	yes	yes	yes	yes	yes	yes	yes
greening (CAP reform 2013)	no	yes	yes	yes	yes	yes	yes	yes
CAP 2nd pillar								
volume mio Euro p.a.	1034	1090	1090	1090	1090	1090	1090	1090
agri-env. payments mio Eur p.a.	527	472	472	472	472	531	590	472
organic farming sheme mio Eur p.a.	89	112	112	112	150	150	150	112
other agri-environmental premia	438	330	330	330	330	330	330	330
organic premium grassland Eur/ha	110-240	70-225	70-225	70-225	80-250	80-250	80-250	70-225
organic premium cropland Eur/ha	110-285	230-450	230-450	230-450	250-500	250-500	250-500	230-450
organic premium perm. crops Eur/ha	< 600	< 700	< 700	< 700	< 770	< 770	< 770	< 700
ban of agri-chemicals	50	60	60	60	60	67.5	75	60
UBAG/UBB arable land Euro per ha	85	15-45	15-45	15-45	15-45	15-45	15-45	15-45
UBAG/UBB grassland Euro ja ha	50-100	15-45	15-45	15-45	15-45	15-45	15-45	15-45
index farmland hectares	100	98.4	97.1	94.5	98.4	97.1	94.5	100
index milk yield per cow	100	115	130	135	115	130	135	100
climate measure								
climate act measures 2013/2014	no	[1]	[1]	[1]	yes	yes	yes	yes
increase of lactations dairy cows					10.0%	20.0%	25.0%	no
increase efficieny of livestock (not milk)					2.5%	5.0%	7.5%	no
increase quality grassland/silage					2.5%	5.0%	7.5%	no
feeding efficiency increase (non-ruminants)					2.5%	5.0%	7.5%	no
reduction of losses manure nutrients					5.0%	20.0%	40.0%	
reduction of losses of fertilizer					5.0%	20.0%	40.0%	

Source: own construction
[1] implementation of measures of agri-environmental programme 2007-2013

7 Results and their sensitivity

7.1 Overview of the scenario results "with existing measures" WEM

The detailed results of the scenario analysis are provided in the tables in the appendix. The results partly deviate from previous analyses of the Austrian farm sector after the 2003 CAP-reform (Sinabell and Schmid, 2003; Schmid and Sinabell, 2004 and 2005; Sinabell, Schönhart and Schmid, 2011). An important reason is that in this scenario analysis a new set of policies is simulated that were not implemented previously (the CAP reform of 2013 will be introduced from 2015 onwards).

The changes between the CAP reform 2013relative to the changes of 2003 and 2008 are moderate, however still substantial. The agri-environmental program will be intact in the future and its generous support of organic farming has significant consequences. The fact that the payment scheme for farms in disadvantaged regions is maintained and even increasing in volume has the same consequences: livestock farming will be attractive in Austria. Organic farms need livestock in order to recycle nutrients and farms in mountain regions with grassland as the prevailing land use do not have many production options apart from ruminants.

An important aspect that has to be considered is the considerable loss of land over the period of four decades when observed data are compared to simulation results in 2050.

The most important results of scenarios which are close to a business as usual setting (WEM) compared to the **situation observed in recent years** are:

- The number of **cattle** is likely to increase slightly which is a result that would change a declining trend over decades.
- The reason is that milk production is likely to expand after the abolition of the milk quota (2015) and this would involve a substantial increase of the **dairy** herd. The large increase in 2050 is expected to come about because of very high relative prices and a Programme of Rural Development that promotes farming in mountain regions where milk production is the most profitable activity if sufficient labour is available.
- The number of **suckler cows** is expected to drop but their production will prevail at relatively high levels. The Programme of Rural Development and the coupled alpine farming premium are favourable for extensive cattle production and the availability of grassland and relatively high beef prices make this production attractive.
- The heads of heifers and other cattle are determined by relative price relationships and production costs; fluctuations in the stocking rate are in the range of rates previously observed and reflect the possibility of imports and exports.

- Slightly increasing prices for **pork** leads to an increasing number of pigs. The expansion of production is consistent with the overall outlook at European level (European Commission, 2014) but it is *not* consistent with the currently observed trend of declining numbers of pigs. An expansion of pork production is not unrealistic if the sector makes the same adjustment as the milk sector which gained significant market shares beyond the domestic market. Even if consumption per inhabitant stays constant (as observed in recent years), market volume in Austria will likely increase because population is projected to be more than 9 million by 2050 (see *Table 5*).
- According to the model results **poultry** production will likely decrease. This result is *not* consistent with the observed trend of increasing numbers of heads. Following international projections (European Commission, 2014) one would expect more poultry as well. The model result is the consequence of relative prices, production costs and coefficients of feed utilisation and observed production mixes among other factors. Looking at the assumed prices of poultry relative to pork is illuminative: while poultry prices increase by 5% until 2015, pork prices increase by more than 90% (see Table 4). An additional explanation for the results on poultry production is that poultry producers report about gloomy perspectives because tight animal welfare regulations relative to competitors imply that poultry and egg production in Austria has to cope with considerable higher costs than producers in other countries (aiz, 2015).
- The acreage of **agricultural land** will be reduced mainly due to the secular trend of competition for land from urbanisation and traffic infrastructure. This implies that crops with high yields and yield increases will become more competitive. Aspects like pests are not considered in the model but are not very likely to restrict the expansion of specific crops because the policies in place guarantee minimum crop rotations (which is an element of the CAP 2013 reform).
- The output of most **crops** will decline due to the limited area. The decline is smaller than the reduction of land due to the countervailing effect of(small) yield increases per hectare. The crop mix changes as well with a significant expansion of maize (corn and silage maize).The output of maize will increase mainly due to the demand for milk and pork production but also due to the relative higher yield increases compared to other crops.
- The acreage of **legumes** will be reduced as far as fodder crops are concerned. Given the low productivity and the given increasing energy costs this type of landuse will become less competitive. The CAP reform of 2013 made provisions that would make **protein crops** more attractive for farmers. This effect is not considered in the model, which may lead to an underestimation of future protein crop production. One has to consider in this context that prices for soy beans in Austria are considerable higher than on the world market. But according to the model results

the expected increases are not sufficiently high to make this crop competitive relative to maize.

- The sales of **mineral nutrients** are likely to decline. This result is consistent with the long term trend but not consistent with observations of more recent sales data. Given the relative increasing energy costs which determine the fertilizer costs (see Figure 2), the fact that agricultural land will decline (see Table 6), and the increasing production of manure from increasing livestock numbers this result seems to be plausible and needs no further explanation.

7.2 Results of the scenario “with additional measures” WAM

The major driving forces of the sector development are the prices on farm commodity markets, technological progress, and policy variables. In the scenario "**with measures**" organic farming and extensive management practices will be further stimulated by policy instruments (because the support of the agri-environmental program is higher).

In general, this scenario is similar to WEM but small technological improvements make production more efficient. This implies that nutrients from livestock will be better used that the need for mineral fertilizer is therefore reduced.

The reasoning of this scenario is that the promotion of human capital accumulation and the adoption of production innovations is gaining more momentum. In the model such improvements come at no further costs for the agricultural sector. Such a situation can be realistic if the cost are borne by the society, e.g. by financing agricultural research and education and further education and buy supporting the adoption of new environmentally friendly technology (which is actually done in the programme of rural development). Such a scenario is consistent with the EU-2020 strategy and the Austrian ambition to raise the share of R&D to 3% of GDP by 2020.

The major results of this scenario compared to the **situation observed in recent years**:

- The number of **cattle** is slightly increasing compared to the observed situation. The large growth of the number of **dairy** cows is responsible for this. The number of cattle is very similar in WAM to the number in WEM.
- The number of **suckler cows** is lower than observed recently. The reason is that the assumption was made that suckler cows are less competitive than dairy cows according to the price scenarios. According to our results suckler cow production will prevail in several regions even under such detrimental conditions. This is explained by the fact that sufficiently low cost grassland is available and that investments in more productive activities in these regions are likely not economical. The number of suckler cows in WAM is very similar to their number in WEM.

- Slightly increasing prices for **pork** lead to an increasing number of pigs. The expansion of production is consistent with the overall outlook at European level (European Commission, 2014) but it is not consistent with the currently observed trend. Pork production in Austria followed the trend of declining consumption. According to the model results in WAM this trend will change in the coming years.
- According to the model results **poultry** production will likely decrease in the WAM scenario. This result is also not consistent with the observed trend of increasing numbers of heads but much stronger. The expected prices (in particular relative to pork) and parameters determining the model results are obviously unfavourable for poultry production in Austria.
- Compared to the observed situation, the acreage of **arable land** will be reduced mainly due to the secular trend of competition for land from urbanisation and traffic infrastructure. Arable land acreage is rather similar in both scenarios WEM and WAM.
- The output of most **crops** will decline compared to the observed situation. This development is mainly due to the limited area. The decline is smaller than the reduction of land due to the countervailing effect of (small) yield increases. The crop mix changes as well with a significant expansion of maize (corn and silage maize). The difference of the crop harvest in the scenarios WAM and WEM is very similar.
- The acreage of **legumes** will be reduced relative to the observed period. Given the low productivity and the given increasing energy costs this type of landuse will become less competitive. **Protein crop** production will decline as well in this scenario but favourable regulations from greening are not considered.
- The sales of **mineral nutrients** are likely to decline dramatically relative to observed levels. This result is much stronger than the long term trend. The result reflects the consequences of more organic farming and more nutrient efficient practices. In addition one has to consider the significant amount of manure due to a strong livestock sector on a smaller acreage of agricultural land. Whereas there are only small differences between WAM and WEM in most indicators, the difference of mineral fertilizer use is significant. In WAM much less mineral fertilizers will be used in 2050 which is due to an expansion of extensive farming practices and more efficient use of manure.

7.3 Results of the sensitivity scenario "with existing measures - sensitivity" WEMsens

This scenario is a variant of WEM. There are two modifications compared to WEM: the loss of agricultural land is assumed to come to a halt and the assumption is made that Austrian cows stay as productive as they are with no further increases of annual milk yields per cow.

In this scenario the major drivers compared to WEM are the availability of additional resources but lower productivity increases in milk production:

- The results of the WEMsens scenario indicate that milk production will not dominate livestock production as is the case in the other scenarios. Rather it is pork production but only at a small margin when compared to the scenario WAM. In the absence of increasing annual milk yields per cow, the competitiveness of milk production is diminished. Given the attractive prices of pork the production expansion is strong enough to divert resources from crop production to livestock production.
- More land is available in WEMsens compared to all other scenarios. Consequently more arable land and more grassland are used for the production of agricultural commodities. It is mainly crop production that benefits from the additional resources. Not all this output is used in livestock production though. A significant share is sold directly on the market without further use in the agricultural sector.

8 Discussion of the model results

8.1 A comparison of results with those from the 2011 projection

The projection on the *business as usual scenario* (BAU) made in 2011 (Sinabell, Schönhart, Schmid, 2011) are in many aspects in line with the results on the scenario *with existing measures* (WEM) presented here:

- an increase of milk production and an increase in the number of dairy cows
- a decline of suckler cows;
- a decrease of crop output mainly due the loss of farm land for other uses;
- organic farming will not significantly expand production even if the market and policy environment is favourable.

The first major difference between the results from 2011 and those of this analysis is that it now seems likely that milk production will expand more than expected in 2011. This implies that the number of cows is likely to be significantly larger. This result is driven by the better prospects for milk production in the coming years.

The second major difference of the results of the scenario analysis in 2011 is that according to the recent outlook pork production will increase while poultry production will decline. The difference can be explained by the different price assumptions. The outlook of prices for livestock products is generally very favourable for livestock production and the model adjusts production accordingly.

Projections for the use of commercial fertilizer are very similar when the BAU scenario of 2011 is compared with the WEM scenario of this analysis. The difference in 2030 between the two projections is only 1.25% which is a surprisingly low number.

8.2 Discussion of the simulation results

An appraisal of the results of the scenarios requires accounting for the following aspects:

- the model is designed to evaluate in great detail a large number of changes that affect the decision making of Austrian farmers; one of the main advantages of this approach is a careful representation of production regions;
- the model is calibrated to an observed period and the parameters are reflecting the cost situation during this reference period; simulations based on these parameters reflect therefore an observed situation;
- the model optimizes gross margins but is not designed to simulate investment behaviour of farmers in a detailed manner and the model is not dynamic; therefore long term scenarios are analysed in a specific manner that has to be taken into account when results are compared;
- because most parameters are derived from observation during the calibration run, interventions to modify the model behaviour are limited and many results can only be explained by referring to the observed situation;
- the model is based on observed situations therefore completely new solutions not yet found in reality cannot be represented by the model; knowing this implies that the situation in 2050 will very likely be different from the situation captured by the model because many technologies available by then are not even know of by today.

For the purpose of comparing different scenarios the **situation for 2030** is chosen as a reference because it is more or less in the middle of the simulation period:

- The number of **cattle** is expected to be similar to observed levels in all scenarios. The number of heads of cattle in categories apart from dairy cows is diminishing. The differences are relatively small given the large differences in the assumptions of the scenarios.
- The number of **dairy** cows is expected to be larger in each of the scenarios analysed compared to the present situation. The largest number of cows is simulated for the scenario WEM. The smaller number of dairy cows in WAM can be explained by the higher efficiency in dairy production (e.g. more lactations per cow, smaller losses, etc.).
- The number of **suckler cows** is very similar in all two scenarios.
- As observed in the context of dairy cows, the number of other cattle is different between the scenarios. The model chooses an optimal cohort of animals of different ages by respecting constraints that are biologically determined. The number of animals is therefore reflecting relative price and cost situations and biological constraints.
- **Pork** production is expected to be highest in the scenario WAM. This can be explained by the relative high value of nutrients in the manure relative to the scenario WEM.
- **Discussion of poultry production WEM, WAM to be included**

- The output of **crops** is generally relatively stable or slightly increasing. Such a development is mainly due to the assumption of slightly increasing yields per hectare of arable crops. Price effects do not play an important role in this context. Output expansion is mainly due to higher yields of **maize**. Those assumptions seem to be plausible given that maize yields have been increasing steadily over the last six decades. It may be challenged that new pests (e.g. diabrotica virgifera) may impair production in future.
- The acreage of **legumes** is also smallest in the WEM scenario. The more limited area is the major reason for this result.
- The scenario results on soy bean production show an opposing direction to the observed trend. Whereas famers produced more soy beans in recent years, the projections indicate a decline. The most important reason is the relative superiority of maize production in economic terms. Soy prices are not high enough to compensate for the relatively weak yields of this crop. This situation might change if mark ups of prices between genetically modified soy (e.g. 405 €/t c.i.f. Rotterdam in 2013) and GMO free soy (418 €/t farm gate price as observed in Austria in 2013) increase in future.
- The sales of **mineral nutrients** are smallest in the scenario WAM. Given that the efficiency of nutrient management is assumed to be considerable higher in the WAM scenario compared to the WEM scenario it is plausible to observe a significant drop in fertilizer sales in WAM.
- The decline of **mineral fertilizer** at the sector level is only one facet of the very complex nutrient balance. The reduction of the sales of mineral fertilizer has to be seen in the context of nutrient use per hectare: *more* nutrients per hectare are available for crops in all future scenarios. The decline of agricultural land implies a smaller acreage where fertilizer can be used in an economical way. An explicit assumption of the model aggravates this effect: Nutrients from livestock manure can be allocated within regions very easily. An implicit assumption is that the necessary institutions like manure trading exist, another one is that technologies like manure separation are adopted when necessary. A further implicit assumption is the possibility to trade manure at no further costs (in particular no sales tax).
- Specific production intensity – as measured by **nutrients per hectare agricultural land** – is slightly increasing or relatively stable over the time in both scenarios WEM and WAM. In order to understand this result it is important to recall that nutrients come from two sources: manure and mineral fertilizer. Depending on the scenario, the amount of mineral fertilizer per hectare is declining more or less strongly. A deficit which would impair plant growth is offset by nutrients from manure. The total amount of nutrients declines a little less than agricultural land does - consequently nutrients per hectare increase a little more in WEM.

To summarize, **the most important driving forces** of the expected future of Austrian agriculture based on the assumptions made in this study are:

- The **milk quota** will be abolished as of April 1st 2015. Most relevant studies on the future of milk production in Europe agree that output of milk in Austria will increase. The scale of the increase is estimated to be around 20% in most studies.
- Our model results suggest that milk production will prevail in **grassland regions**. This favourable outlook from the perspective of producers is supported by active policy measures in the 1st and 2nd pillar of CAP: regions with a large share of grassland are likely to benefit from the adoption of the "regional model of direct payments" which will be fully implemented in 2020; the program of rural development supports investments in new, animal friendly barns and production facilities and farms in less favoured areas get a top-up. Favourable market perspectives combined with discretionary policies make agriculture in grassland regions (mainly mountain regions in Austria) more competitive than it would be under different market and policy settings. Investment behaviour is not explicitly modelled in the scenarios. Therefore the quantitative results can not reflect these aspects. The scenario results are plausible when they are considered with a view on this policy environment that is assumed to prevail throughout the period under consideration.
- The outlook of **prices is favourable for milk and other livestock products** relative to crop products. This will stimulate the production at the cost of crop production in Austria. The model results suggest that pork production will be expanded while poultry production will decline. These diverging results are due to the anticipated development of product prices in the future. Pork prices increase considerable compared to poultry prices.

8.3 Reflections on the uncertainties of the results

Finally it has to be stressed that projections into the future are exposed to a range of **uncertainties** which have to be kept in mind when the results of this analysis are considered:

- **Model uncertainty:** The first type of uncertainty is related to the type of model. The model is static by design and adjustments to future situations are calculated in discrete steps which are based on exogenous assumptions (prices, costs, technical coefficients) and model-endogenous coefficients (marginal costs) which are based on observations in the reference period. Investment costs are not considered in the model as it is based on gross margin calculations. The model assumes swift adaptation of land uses and management and efficient use of resources. In practice such adaptations may be overoptimistic because farmers are not able/willing to adjust as the model suggests. Such a situation may happen e.g. if the model allocates nutrients in a most cost-effective way in a region while actually there may be frictions that prevent this (e.g. blocked roads). In order to account for this type of uncertainty different scenarios are analysed in this study in which technical coefficients are set at different levels (e.g. loss of nutrients; efficiency of feeding; number of lactations).

- **Input-Data uncertainty:** Model input data are to some degree uncertain (e.g. actual amount of mineral fertilisers applied for various crops or the actual share of slurry and solid manure). Because most parameters of the model are based on observations derived from official statistics (average yields, land use etc.) or administrative sources (IACS) the scope of uncertainty is well defined. Given the large complexity of farm policy in Austria there are many administrative data available on land use and farm management which otherwise would not be observed Nevertheless, the lack of knowledge with respect to some important aspects (e.g. manure management or the actual application of mineral fertilzers) leads to model results with a range of uncertainty in the future. How sensitive results are due to input data uncertainty is a topic of future research.

- **Market uncertainty:** A review of past projections of OECD-FAO and the observed outcomes on the markets suggests that there is considerable deviation between those two. The range of such uncertainties can be accounted for and actually is discussed broadly in the most recent OECD-FAO report (2014). To account for this type of uncertainty in the analysis presented here would require to make hundreds of simulations which capture alternative price scenarios with various probabilities. The benefit would be a more realistic view on the range of potential future outcomes. The costs to achieve this would be considerable and probably not worth the efforts because the most likely scenario is the scenario chosen for this analysis. A value added of taking into consideration market uncertainty would be to attach a certain probability to the most likely scenario based on observations in the past. This would imply a significant expansion of the analysis.
- **Policy uncertainty**: Policies affect decisions of farmers and of other market participants in various ways. The range of policies is not limited to agricultural policies alone: energy policies affect energy prices and costs of other inputs; urban planning regimes affect the decisions to develop of residential and commercial areas which have an impact on the availability of agricultural land; climate protection policies are likely to take into consideration the results of studies like this one and induce incremental or significant adjustments. In order to account for such a type of uncertainty different scenarios are analysed in this study in which policy instruments are set at different levels (e.g. support for organic farms).

We may conclude that a range of uncertainties are directly addressed in this analysis. To analyse plausible scenarios is the way to account for the immanent problem that statements about the future are uncertain.

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10 Appendix: Model results

Table 7: Production in reference situations

		REF			REF bio
		2007-2009	2009-2011	2010-2012	2010-2012
arable land	ha	1,370,545	1,363,348	1,359,530	189,654
grassland (excl. alpine)	ha	1,028,422	984,702	972,531	239,229
peas	ha	21,862	13,482	11,994	3,899
soj beans	ha	21,308	32,607	36,542	6,898
horse beans	ha	3,664	4,334	5,678	4,279
clover, hey, lucerne	ha	100,633	103,984	105,229	36,715
meadows ploughed every four years	ha	59,218	58,671	58,166	12,232
cover crops	ha	317,754	305,423	301,966	42,124
corn	1000 t	5,184	5,184	5,095	174
wheat	1000 t	1,537	1,608	1,525	87
rye	1000 t	197	182	189	30
barley	1000 t	871	824	766	23
oats	1000 t	105	106	100	13
maize corn	1000 t	2,204	2,193	2,253	48
potato	1000 t	716	737	784	46
sugar beet	1000 t	2,971	3,224	3,234	59
fooder beet	1000 t	14	12	11	0
silomaize	1000 t	3,826	3,784	3,856	75
clover hey	1000 t	640	654	634	221
rape	1000 t	163	174	166	1
sunflower	1000 t	70	70	64	4
soja bean	1000 t	59	92	103	12
horse beans	1000 t	8	12	15	7
peas	1000 t	46	34	28	4
vegetables	1000 t	426	488	495	88
oilpumpkin	1000 t	9	13	15	2
dairy	head	529,235	531,035	527,832	94,527
non-dairy	head	1,478,653	1,474,321	1,453,976	286,641
suckl cows	head	267,442	260,754	255,384	84,884
young <1yr	head	638,000	633,619	628,710	123,946
breeding heifers <1-2 years	head	202,769	189,341	185,493	36,569
fattening heifers, bulls, oxen 1-2 year	head	235,319	250,507	247,001	48,695
other cattle >2yrs	head	135,123	140,101	137,388	27,085
swine	head	3,162,497	3,092,010	3,040,740	70,665
young & fattening pigs >20 kg	head	2,092,838	2,059,840	2,032,404	47,232
breeind sows > 50kg	head	303,360	284,822	274,588	6,381
piglets <20 kg	head	766,299	747,348	733,748	17,052
sheep	head	343,073	354,769	361,414	99,279
goats	head	63,722	70,771	72,446	37,418
poulty	head	13,835,779	14,105,324	14,644,413	1,336,919
chicken	head	13,136,586	13,397,328	13,918,813	1,270,677
layers	head	6,793,500	6,882,792	7,061,377	644,648
broilers	head	6,343,086	6,514,536	6,857,436	626,030
other poulty (total)	head	699,194	707,996	725,600	66,242
turkeys	head	582,942	593,899	615,813	56,219
outher poultry /ducks, etc.)	head	116,252	114,097	109,787	10,023
horses	head	84,355	83,449	81,637	11,511
deer	head	44,383	45,447	47,575	6,708
annual nutrient sales data	1000 t	108,000	97,893	101,700	n.a.
of which urea	t	13,156	13,922	11,367	n.a.
sewage sludge total	t	248,517	258,775	262,367	n.a.
sewage sludge applied agr.	t	39,968	42,187	42,368	n.a.

Source: own calculations after data from Statistic Austria.

Table 8: Production in the scenario WEM

		WEM				
		2020	2030	2035	2040	2050
arable land	ha	1,307,029	1,183,736	1,166,772	1,149,808	1,115,880
grassland (excl. alpine)	ha	956,764	900,475	886,136	871,796	843,117
peas	ha	17,162	19,983	19,671	19,358	18,733
soj beans	ha	27,533	19,387	19,265	19,143	18,898
horse beans	ha	4,242	2,885	2,893	2,902	2,919
clover, hey, lucerne	ha	101,568	92,266	90,456	88,647	85,028
meadows ploughed every four years	ha	57,386	50,349	49,472	48,596	46,843
cover crops	ha	304,589	276,666	272,702	268,737	260,807
corn	1000 t	5,160	5,145	5,191	5,237	5,329
wheat	1000 t	1,536	1,439	1,443	1,447	1,456
rye	1000 t	192	192	192	192	192
barley	1000 t	830	831	833	836	840
oats	1000 t	104	103	102	102	101
maize corn	1000 t	2,243	2,396	2,446	2,495	2,594
potato	1000 t	744	724	728	732	740
sugar beet	1000 t	3,045	2,677	2,685	2,693	2,710
fooder beet	1000 t	13	12	12	11	11
silomaize	1000 t	3,810	4,123	4,247	4,371	4,620
clover hey	1000 t	628	498	447	396	294
rape	1000 t	166	156	156	157	159
sunflower	1000 t	67	60	61	61	61
soja bean	1000 t	78	61	61	62	63
horse beans	1000 t	11	7	7	7	7
peas	1000 t	38	42	41	40	39
vegetables	1000 t	446	348	343	339	329
oilpumpkin	1000 t	12	9	8	8	8
dairy	head	531,432	562,453	586,581	610,708	658,964
non-dairy	head	1,417,856	1,273,909	1,301,356	1,328,803	1,383,696
suckl cows	head	253,424	226,874	226,038	225,202	223,531
young <1yr	head	590,630	465,737	475,601	485,465	505,192
breeding heifers <1-2 years	head	196,859	219,624	228,134	236,644	253,664
fattening heifers, bulls, oxen 1-2 year	head	242,029	233,978	240,399	246,820	259,661
other cattle >2yrs	head	134,913	127,696	131,184	134,672	141,648
swine	head	3,203,294	3,595,950	3,634,597	3,673,244	3,750,538
young & fattening pigs >20 kg	head	2,128,525	2,380,556	2,405,286	2,430,016	2,479,475
breeind sows > 50kg	head	299,810	344,051	348,618	353,185	362,319
piglets <20 kg	head	774,958	871,342	880,693	890,043	908,744
sheep	head	328,764	254,069	253,066	252,064	250,058
goats	head	64,598	49,261	47,758	46,255	43,248
poulty	head	13,436,181	9,407,910	8,726,141	8,044,372	6,680,835
chicken	head	12,695,943	8,740,310	8,150,844	7,561,379	6,382,449
layers	head	6,555,767	5,054,122	4,950,820	4,847,519	4,640,915
broilers	head	6,140,176	3,686,187	3,200,024	2,713,861	1,741,534
other poulty (total)	head	740,238	667,600	575,296	482,993	298,386
turkeys	head	631,819	588,713	502,090	415,466	242,219
outher poultry /ducks, etc.)	head	108,419	78,887	73,207	67,527	56,167
horses	head	81,195	73,623	74,011	74,399	75,175
deer	head	44,261	38,736	38,940	39,145	39,553
annual nutrient sales data	t	100,071	80,172	75,053	69,934	59,695
of which urea	t	12,434	9,766	9,143	8,519	7,272
sewage sludge total	t	262,956	262,956	262,956	262,956	262,956
sewage sludge applied agr.	t	40,489	40,489	40,489	40,489	40,489

Source: own calculations.

Table 9: Production in the scenarios WEM bio

		WEM bio				
		2020	2030	2035	2040	2050
arable land	ha	210,773	212,965	212,368	211,772	210,580
grassland (excl. alpine)	ha	255,165	250,916	233,895	216,873	182,831
peas	ha	4,179	4,318	4,332	4,347	4,376
soj beans	ha	7,398	7,430	7,331	7,231	7,033
horse beans	ha	4,586	4,738	4,754	4,770	4,802
clover, hey, lucerne	ha	39,161	38,509	35,896	33,284	28,060
meadows ploughed every four years	ha	13,046	12,829	11,959	11,089	9,348
cover crops	ha	46,815	47,302	47,169	47,037	46,772
corn	1000 t	193	195	195	194	193
wheat	1000 t	104	106	106	107	107
rye	1000 t	31	32	32	32	33
barley	1000 t	25	26	26	26	26
oats	1000 t	13	13	14	14	14
maize corn	1000 t	54	54	54	54	55
potato	1000 t	59	61	62	62	62
sugar beet	1000 t	70	73	74	74	75
fooder beet	1000 t	0	0	0	0	0
silomaize	1000 t	81	83	85	88	92
clover hey	1000 t	236	232	216	200	169
rape	1000 t	1	1	1	1	1
sunflower	1000 t	5	5	5	5	5
soja bean	1000 t	13	13	13	13	13
horse beans	1000 t	7	8	8	8	7
peas	1000 t	5	5	5	5	5
vegetables	1000 t	116	120	120	120	120
oilpumpkin	1000 t	1	1	1	1	1
dairy	head	89,381	96,750	97,853	98,956	101,163
non-dairy	head	228,010	232,292	230,936	229,579	226,866
suckl cows	head	50,274	49,888	49,115	48,342	46,796
young <1yr	head	76,366	73,771	72,696	71,621	69,471
breeding heifers <1-2 years	head	34,953	37,738	38,043	38,348	38,958
fattening heifers, bulls, oxen 1-2 year	head	41,604	45,010	45,575	46,139	47,268
other cattle >2yrs	head	24,814	25,885	25,507	25,129	24,372
swine	head	147,234	179,437	187,467	195,497	211,557
young & fattening pigs >20 kg	head	91,987	113,276	118,584	123,892	134,508
breeind sows > 50kg	head	13,805	16,537	17,253	17,968	19,399
piglets <20 kg	head	18,515	49,623	51,630	53,637	57,650
sheep	head	67,143	63,818	62,649	61,481	59,144
goats	head	25,300	24,151	22,344	20,538	16,924
poulty	head	851,098	753,667	681,480	609,293	464,919
chicken	head	637,804	603,562	564,188	524,815	446,068
layers	head	299,997	300,347	291,551	282,754	265,162
broilers	head	337,807	303,215	272,638	242,061	180,906
other poulty (total)	head	213,294	150,105	117,292	84,478	18,851
turkeys	head	208,263	145,344	112,841	80,338	15,333
outher poultry /ducks, etc.)	head	5,031	4,761	4,450	4,140	3,518
horses	head	8,251	7,912	7,654	7,395	6,878
deer	head	4,808	4,611	4,460	4,309	4,008
annual nutrient sales data	t	n.a.	n.a.	n.a.	n.a.	n.a.
of which urea	t	n.a.	n.a.	n.a.	n.a.	n.a.
sewage sludge total	t	n.a.	n.a.	n.a.	n.a.	n.a.
sewage sludge applied agr.	t	n.a.	n.a.	n.a.	n.a.	n.a.

Source: own calculations.

Table 10: Production in the scenarios WEM sens

		WEM sens				
		2020	2030	2035	2040	2050
arable land	ha	1,313,653	1,196,513	1,183,791	1,171,070	1,145,627
grassland (excl. alpine)	ha	964,717	917,059	907,119	897,179	877,300
peas	ha	17,215	20,327	20,008	19,688	19,049
soj beans	ha	27,619	19,738	19,665	19,591	19,445
horse beans	ha	4,251	2,917	2,944	2,972	3,027
clover, hey, lucerne	ha	102,125	93,994	92,872	91,750	89,505
meadows ploughed every four years	ha	57,561	51,089	50,435	49,781	48,473
cover crops	ha	302,824	269,209	260,583	251,958	234,706
corn	1000 t	5,172	5,201	5,272	5,343	5,486
wheat	1000 t	1,539	1,451	1,461	1,471	1,491
rye	1000 t	192	194	195	197	199
barley	1000 t	833	844	849	855	867
oats	1000 t	105	105	105	106	107
maize corn	1000 t	2,247	2,420	2,484	2,549	2,677
potato	1000 t	745	727	732	737	747
sugar beet	1000 t	3,051	2,705	2,721	2,737	2,770
fooder beet	1000 t	13	12	12	12	12
silomaize	1000 t	3,811	4,091	4,224	4,357	4,623
clover hey	1000 t	631	513	457	401	289
rape	1000 t	166	157	158	159	161
sunflower	1000 t	67	61	61	61	61
soja bean	1000 t	79	62	62	63	65
horse beans	1000 t	11	7	7	7	7
peas	1000 t	38	42	42	41	39
vegetables	1000 t	446	355	349	344	334
oilpumpkin	1000 t	12	8	8	8	8
dairy	head	528,938	531,341	550,185	569,029	606,718
non-dairy	head	1,417,059	1,281,519	1,297,988	1,314,458	1,347,397
suckl cows	head	253,745	234,180	232,962	231,745	229,309
young <1yr	head	590,125	474,596	480,104	485,613	496,631
breeding heifers <1-2 years	head	196,532	207,059	214,144	221,230	235,401
fattening heifers, bulls, oxen 1-2 year	head	241,360	235,356	238,414	241,473	247,589
other cattle >2yrs	head	135,297	130,328	132,363	134,398	138,468
swine	head	3,202,032	3,652,190	3,699,577	3,746,965	3,841,740
young & fattening pigs >20 kg	head	2,127,507	2,420,544	2,451,213	2,481,883	2,543,221
breeind sows > 50kg	head	299,875	346,630	351,877	357,125	367,619
piglets <20 kg	head	774,650	885,016	896,487	907,958	930,899
sheep	head	330,320	261,281	260,493	259,705	258,128
goats	head	64,641	51,250	49,939	48,629	46,008
poulty	head	13,529,954	10,381,401	9,477,440	8,573,478	6,765,556
chicken	head	12,787,349	9,655,491	8,837,206	8,018,920	6,382,350
layers	head	6,586,395	5,406,945	5,244,961	5,082,977	4,759,009
broilers	head	6,200,954	4,248,546	3,592,245	2,935,944	1,623,342
other poulty (total)	head	742,605	725,910	640,234	554,558	383,206
turkeys	head	633,396	638,851	560,737	482,623	326,395
outher poultry /ducks, etc.)	head	109,209	87,058	79,497	71,935	56,811
horses	head	81,481	76,749	76,559	76,369	75,989
deer	head	44,412	40,381	40,281	40,181	39,981
annual nutrient sales data	t	100,948	84,602	79,479	74,356	64,110
of which urea	t	12,541	10,306	9,682	9,058	7,810
sewage sludge total	t	262,956	262,956	262,956	262,956	262,956
sewage sludge applied agr.	t	40,489	40,489	40,489	40,489	40,489

Source: own calculations.

Table 11: Production in the scenarios WEM sens bio

		WEM sens bio				
		2020	2030	2035	2040	2050
arable land	ha	210,610	212,847	212,197	211,547	210,246
grassland (excl. alpine)	ha	253,961	250,952	230,116	209,281	167,610
peas	ha	4,173	4,282	4,312	4,341	4,400
soj beans	ha	7,600	7,348	7,298	7,247	7,146
horse beans	ha	4,579	4,699	4,731	4,764	4,829
clover, hey, lucerne	ha	38,976	38,514	35,317	32,119	25,724
meadows ploughed every four years	ha	12,985	12,831	11,766	10,700	8,570
cover crops	ha	46,779	47,276	47,131	46,987	46,698
corn	1000 t	193	195	195	194	193
wheat	1000 t	104	107	107	106	106
rye	1000 t	31	32	32	32	32
barley	1000 t	25	26	26	26	26
oats	1000 t	13	13	13	13	14
maize corn	1000 t	54	54	54	54	55
potato	1000 t	59	61	62	62	62
sugar beet	1000 t	69	73	73	73	73
fooder beet	1000 t	0	0	0	0	0
silomaize	1000 t	69	73	75	78	84
clover hey	1000 t	235	232	213	193	155
rape	1000 t	1	1	1	1	1
sunflower	1000 t	5	5	5	5	6
soja bean	1000 t	14	13	13	13	13
horse beans	1000 t	7	8	8	8	7
peas	1000 t	5	5	5	5	5
vegetables	1000 t	116	118	119	119	120
oilpumpkin	1000 t	1	1	1	1	1
dairy	head	86,108	90,035	90,242	90,449	90,864
non-dairy	head	225,719	233,547	228,900	224,254	214,962
suckl cows	head	50,427	51,771	50,306	48,841	45,910
young <1yr	head	76,394	77,053	73,854	70,655	64,258
breeding heifers <1-2 years	head	33,592	34,914	35,037	35,159	35,405
fattening heifers, bulls, oxen 1-2 year	head	40,163	42,785	42,838	42,891	42,997
other cattle >2yrs	head	25,143	27,024	26,866	26,708	26,392
swine	head	149,496	191,148	199,437	207,725	224,302
young & fattening pigs >20 kg	head	94,007	121,810	127,254	132,697	143,584
breeind sows > 50kg	head	13,889	17,226	17,964	18,702	20,178
piglets <20 kg	head	18,515	52,112	54,219	56,326	60,541
sheep	head	66,665	65,607	63,315	61,024	56,441
goats	head	25,058	24,213	22,765	21,317	18,421
poulty	head	899,944	887,831	833,724	779,616	671,401
chicken	head	656,583	672,998	634,357	595,716	518,433
layers	head	303,137	322,549	310,614	298,678	274,806
broilers	head	353,446	350,449	323,744	297,038	243,627
other poulty (total)	head	243,361	214,832	199,366	183,900	152,968
turkeys	head	238,182	209,524	194,363	179,202	148,879
outher poultry /ducks, etc.)	head	5,179	5,308	5,004	4,699	4,089
horses	head	8,393	8,367	7,974	7,580	6,794
deer	head	4,891	4,876	4,647	4,417	3,959
annual nutrient sales data	t	n.a.	n.a.	n.a.	n.a.	n.a.
of which urea	t	n.a.	n.a.	n.a.	n.a.	n.a.
sewage sludge total	t	n.a.	n.a.	n.a.	n.a.	n.a.
sewage sludge applied agr.	t	n.a.	n.a.	n.a.	n.a.	n.a.

Source: own calculations.

Table 12: Production in the scenario WAM

		WAM				
		2020	2030	2035	2040	2050
arable land	ha	1,307,429	1,185,130	1,168,640	1,152,150	1,119,170
grassland (excl. alpine)	ha	956,955	905,047	892,797	880,548	856,049
peas	ha	17,162	19,976	19,627	19,278	18,581
soj beans	ha	27,541	19,453	19,403	19,354	19,254
horse beans	ha	4,242	2,878	2,919	2,959	3,041
clover, hey, lucerne	ha	101,572	93,097	91,320	89,543	85,989
meadows ploughed every four years	ha	57,389	50,617	49,720	48,822	47,026
cover crops	ha	305,035	279,212	271,198	263,184	247,157
corn	1000 t	5,162	5,149	5,198	5,246	5,343
wheat	1000 t	1,536	1,437	1,442	1,446	1,456
rye	1000 t	192	193	193	193	193
barley	1000 t	830	830	832	834	838
oats	1000 t	104	103	102	102	101
maize corn	1000 t	2,244	2,406	2,457	2,508	2,610
potato	1000 t	744	725	729	734	743
sugar beet	1000 t	3,046	2,674	2,682	2,690	2,705
fooder beet	1000 t	13	12	12	11	11
silomaize	1000 t	3,810	4,045	4,181	4,316	4,586
clover hey	1000 t	628	517	466	416	316
rape	1000 t	166	156	157	158	160
sunflower	1000 t	67	61	61	61	61
soja bean	1000 t	78	61	62	63	64
horse beans	1000 t	11	7	7	7	7
peas	1000 t	38	42	41	40	39
vegetables	1000 t	446	349	344	339	329
oilpumpkin	1000 t	12	9	8	8	8
dairy	head	531,613	563,491	586,587	609,683	655,875
non-dairy	head	1,419,754	1,284,878	1,310,979	1,337,081	1,389,284
suckl cows	head	253,447	227,671	226,813	225,954	224,237
young <1yr	head	591,655	467,676	479,197	490,717	513,758
breeding heifers <1-2 years	head	196,848	219,642	227,409	235,176	250,710
fattening heifers, bulls, oxen 1-2 year	head	242,368	241,256	245,765	250,274	259,292
other cattle >2yrs	head	135,436	128,631	131,795	134,959	141,286
swine	head	3,212,272	3,661,724	3,701,292	3,740,860	3,819,996
young & fattening pigs >20 kg	head	2,134,753	2,423,945	2,449,787	2,475,630	2,527,314
breeind sows > 50kg	head	300,380	350,501	354,645	358,788	367,076
piglets <20 kg	head	777,139	887,278	896,860	906,442	925,605
sheep	head	328,513	255,010	254,453	253,897	252,784
goats	head	64,539	46,924	45,918	44,911	42,899
poulty	head	13,395,106	9,052,327	8,442,839	7,833,351	6,614,374
chicken	head	12,662,021	8,403,202	7,885,452	7,367,702	6,332,203
layers	head	6,551,922	5,050,869	4,951,069	4,851,268	4,651,666
broilers	head	6,110,098	3,352,332	2,934,384	2,516,435	1,680,537
other poulty (total)	head	733,085	649,126	557,387	465,648	282,171
turkeys	head	625,007	573,226	486,558	399,889	226,552
outher poultry /ducks, etc.)	head	108,078	75,899	70,829	65,759	55,619
horses	head	81,183	73,408	73,766	74,124	74,841
deer	head	44,255	38,623	38,811	39,000	39,377
annual nutrient sales data	t	99,514	73,090	66,876	60,663	48,236
of which urea	t	12,366	8,903	8,147	7,390	5,876
sewage sludge total	t	262,956	262,956	262,956	262,956	262,956
sewage sludge applied agr.	t	40,489	40,489	40,489	40,489	40,489

Source: own calculations.

Table 13: Production in the scenario WAM bio

		WAM bio				
		2020	2030	2035	2040	2050
arable land	ha	210,388	215,879	216,276	216,674	217,469
grassland (excl. alpine)	ha	254,738	262,319	245,934	229,549	196,779
peas	ha	4,174	4,381	4,426	4,472	4,563
soj beans	ha	7,406	7,549	7,465	7,381	7,212
horse beans	ha	4,580	4,807	4,857	4,907	5,008
clover, hey, lucerne	ha	39,095	40,259	37,744	35,230	30,200
meadows ploughed every four years	ha	13,025	13,412	12,575	11,737	10,061
cover crops	ha	46,729	47,949	48,037	48,126	48,302
corn	1000 t	193	198	198	199	199
wheat	1000 t	104	108	108	109	110
rye	1000 t	31	33	33	33	34
barley	1000 t	25	26	26	27	27
oats	1000 t	13	14	14	14	14
maize corn	1000 t	54	55	55	56	57
potato	1000 t	59	62	62	63	63
sugar beet	1000 t	70	74	75	76	77
fooder beet	1000 t	0	0	0	0	0
silomaize	1000 t	80	90	91	92	94
clover hey	1000 t	235	242	227	212	182
rape	1000 t	1	1	1	1	1
sunflower	1000 t	5	5	5	6	6
soja bean	1000 t	13	14	13	13	13
horse beans	1000 t	7	8	8	8	7
peas	1000 t	5	5	5	5	5
vegetables	1000 t	116	121	121	122	123
oilpumpkin	1000 t	1	1	1	1	1
dairy	head	89,836	99,059	100,426	101,794	104,529
non-dairy	head	226,949	240,795	239,970	239,145	237,494
suckl cows	head	49,818	52,025	51,308	50,591	49,156
young <1yr	head	74,969	75,832	75,055	74,278	72,724
breeding heifers <1-2 years	head	34,846	38,769	39,124	39,479	40,189
fattening heifers, bulls, oxen 1-2 year	head	41,874	46,565	47,278	47,992	49,419
other cattle >2yrs	head	25,443	27,605	27,205	26,805	26,005
swine	head	158,773	211,479	216,907	222,335	233,191
young & fattening pigs >20 kg	head	99,752	134,857	138,476	142,095	149,333
breeind sows > 50kg	head	14,711	19,158	19,626	20,094	21,029
piglets <20 kg	head	18,515	57,464	58,805	60,146	62,828
sheep	head	65,652	65,663	64,535	63,407	61,150
goats	head	24,850	21,198	20,147	19,097	16,996
poulty	head	856,336	803,816	729,363	654,910	506,005
chicken	head	644,108	654,177	611,970	569,763	485,348
layers	head	295,266	313,331	307,254	301,177	289,023
broilers	head	348,842	340,847	304,716	268,586	196,325
other poulty (total)	head	212,228	149,639	117,393	85,148	20,657
turkeys	head	207,148	144,479	112,566	80,653	16,828
outher poultry /ducks, etc.)	head	5,081	5,160	4,827	4,494	3,828
horses	head	8,083	7,964	7,721	7,478	6,992
deer	head	4,711	4,641	4,500	4,358	4,075
annual nutrient sales data	t	n.a.	n.a.	n.a.	n.a.	n.a.
of which urea	t	n.a.	n.a.	n.a.	n.a.	n.a.
sewage sludge total	t	n.a.	n.a.	n.a.	n.a.	n.a.
sewage sludge applied agr.	t	n.a.	n.a.	n.a.	n.a.	n.a.

Source: own calculations.