Final report

Development of models and tools
for assessing the environmental impact of agricultural policies

(ENV.B.2/ETU/2000/073)

Joint project of
LEI, IAP and IAM

The Hague, 27. April 2003

LEI, The Hague, Netherlands

IAP, Institute for Agricultural Policy, University of Bonn, Germany

IAM, Institute Agronomique Mediterranéen, Montpellier, France

Table of contents

Summary

Summary

The impacts of agriculture and agricultural policies on the environment are of major public concern, and play an increasingly important role in the context of agricultural policy reform, trade liberalisation and the achievement of sustainable agriculture. Therefore, the objective of the project "Development of models and tools for assessing the environmental impact of agricultural policies" (ENV.B.2/ETU/2000/073) is to investigate the links between agriculture and the environment. More specifically the objectives of the study are:

- To develop a *system of computer-based models* for assessing the environmental impact of agricultural policies, both at farm, regional (NUTS II) and EU wide level, which are consistently linked. A key asset is the existing CAPRI modelling system, which covers the whole EU at NUTS II. It will be systematically broken down to a series of farm models, reflecting Farm Accountancy Data Network (FADN) farming type models. The farm models will provide insights into farm income, environmental indicators per farm type and the variability of these indicators between farm types.

- To develop *databases* required for using the modelling system. Again, the databases are not built from scratch, but use existing frameworks.

- Using the system of models, to assess ex-ante and ex-post the *impact of selected changes in agricultural policies on the environment*;

CAPRI consists of a supply model of about 200 EU regions (NUTS 2, one model per region), 1050 farm type models (5 representative farms per region plus a residual one), and a world market model (11 world aggregates plus the EU). These models are all linked with each other, which enables endogenous price formation through the interplay of supply and demand. Taking into account the effect of changes in aggregated demand and supply on markets, improves the consistency and the reality of the analysis. Moreover, the mathematical programming approach offers the opportunity to include many regions and agricultural production activities. This in turn results in a rather detailed analysis of environmental effects, as these effects are different per agricultural production activity and region.

To reach the objectives of this report existing environmental indicators already embedded into the CAPRI system are improved and new environmental indicators are included. The most important environmental indicators are:

- N,P,K balances
- Ammonia output
- Water balances
- Global warming emissions (Carbon Dioxide, Methane and Nitrous Oxide) measured in global warming potentials.

The included environmental indicators in the CAPRI system are passive ones and can be seen as rather robust pressure indicators. In general, due to its concentration on agricultural markets and modelling of agricultural policies, the CAPRI modelling system is less developed in the field of detailed environmental modelling. In order to improve this, more refined approaches and models are developed. These models are linked to the overall CAPRI system as they use output from CAPRI, like e.g. cropping plan, number of animals, use of animal manure and mineral fertilisers and (possible) prices as an input. The case studies are related to:

- phytosanitary leaching to ground water in 'Nord Pas de Calais' and 'Midi-Pyrénnées',
- farm bio-economic modelling; case study for a specialised "Grandes Cultures" farm in French Midi-Pyrénnées,
- nitrate (NO_3) in upper ground water on Dutch dairy farms,
- Pesticide use in the Netherlands and in the EU.

The case studies mentioned above prove that the proposed system could be very useful in the future to link economic models with more detailed environmental models and reach more realistic results.

An important innovation of this project is the further breakdown of the CAPRI modelling system from NUTSII level to the level of farm types, by consistently including farm type programming models into the system. This way a major drawback of farm type models, namely exogenous prices of inputs and outputs, are overcome. The advantage of the farm type programming models is that detailed supply restrictions on farm level can be included, policies directed at different farm types can be included and the farm models will provide insights into farm income, environmental indicators per farm type and the variability of these indicators between farm types. Insofar, the project allows for a unique and powerful combination of different modelling approaches.

The farm type programming models in the system reflect Farm Accountancy Data Network (FADN) farming type models. For every NUTSII region the five dominant farm types are selected, a sixth farm type is included to take care of the rest. Analyses of dominant farm types per country in the base year 1998 show that farm type Dairy is the dominant farm type in north of Europe. An exception is Denmark where Specialised COP, Livestock and crops diversified and Specialised pigs and Poultry are the dominant farm types. Farm types Cattle fattening & rearing, Sheep and goats are the dominant farm types in Ireland and UK. In the south of Europe, Portugal, Spain, Italy and Greece, farm type Permanent crops and vegetables is the dominant farm type. Also in France and to a lesser extent in Belgium/Luxembourg and the Netherlands, this farm type is relatively important. The heterogeneity of farm types seems to be big in France (different farm types have about the same weight) and small in Ireland.

From the data it was found that at the level of the EU most farm types are rather heterogeneous with respect to agricultural activities. Hence, income and environmental effects are not only depending on market and policy changes related to their specialisation. Although the extent can be different, this heterogeneity is found at most farm types and should be taken into account when analysing effects at farm type level.

In close co-operation with DG-ENV, relevant policy scenarios are defined. The chosen relevant policy scenario is referred to as the **CAP Reform Proposal 2003** of the European Commission to reform the Common Agricultural Policy (CAP), Draft legal texts January 2003. The application of the full CAPRI modelling system compares developments of production, land use, demand, agricultural income and environmental indicators projected with the results of the so-called **Agenda reference run** (assuming full introduction of Agenda 2000) in 2009 to correct for future autonomous effects and focus on the effects of the policy switches.

Three important aspects of the **CAP Reform Proposal 2003** are decoupling of activity specific Agenda 2000 premiums from agricultural production, modulation of premiums and further reductions of administrative prices which are partially compensated. Under **CAP Reform Proposal 2003** premiums are decoupled from specific production activities and attributed to eligible hectares per farm type in NUTS II regions. In general this decreases competitiveness of activities with premiums under **Agenda reference run** (Agenda 2000) compared to activities with no premiums in the reference situation. Moreover, input costs savings could increase income because marginal activities, which are only kept into production because of the specific premiums, are abolished. The second important aspect of the **CAP Reform Proposal 2003** is that premiums are modulated until 2009 by –14% according to a three-tier system.

The report focuses on effects of supply and income on the level of the European Union, on the regional level and on the level of farm types. The main results of the **CAP Reform Proposal 2003** compared to the **Agenda reference run** in 2009 at EU level can be summarised as follows:

Agricultural production

- Hectares of cereals and oilseeds will decrease by respectively -8 % and -3 %.
- Fodder production increases in hectares by almost 3 %, mainly as a result of an increase in hectares of other fodder on arable land (+12 %) and a decrease of fodder maize (-7 %);
- Use of grassland switches from intensive grassland to extensive grassland;
- Other arable crops remain almost stable (-0.4%). This is mainly due to a decrease in hectares of pulses (-8 %) compensated by a small increase in root crops like potatoes and sugar beets (+3 and +4 % respectively). The increase in sugar beet relates to C-beet whose relative competitiveness increases compared to other Grandes Cultures receiving specific premiums under Agenda 2000. The increase in the supply of potatoes in the EU results into a price decrease of potatoes of about –2.4%.
- Hectare of fallow land plus set-aside increases with about 12 %;
- Due to abolishment of direct income payment the number of suckler cows drop by some –18 %. The number of fattening female calves decreases –16 % and male calves for

fattening increases about 12 %. All together the number of the cattle herd size decreases by -7 %. Due to the decreased supply, prices of beef and veal increases with about +2.4%;

- Effects of **CAP Reform Proposal 2003** for the EU as a whole are generally also found at the country, regional level and farm type level. Differences in supply effects from the European average are mainly explained by differences in the share of coupled premiums in total revenue in the reference situation. The higher this share is for a specific activity in a specific region and farm type, the larger the decrease in production and supply.

Environmental indicators

Nitrate (N):

For the EU as a whole the Nitrate surplus per hectare decreases by –3.5 % under the **CAP Reform Proposal 2003** run compared with the **Agenda reference run**. The changes in nitrate (N) surplus at regional level varies from about -6 % to -13 % in regions of Ireland, UK, France, Spain and Greece to more than 1% in the rest of Europe.

The highest nitrate surplus per hectare in the Base year (1998) is found at the following farm types: Dairy (69 kg N/ha), Cattle fattening and rearing (38 kg N/ha), Sheep & goats (20 kg N/ha), Specialised pigs (62 kg N/ha), Poultry (2292 kg N/ha), Livestock diversified (73 kg N/ha) and Livestock & crops diversified (25 kg N/ha). By far the largest contribution to total nitrate surplus in the EU is given by farm type Dairy.

The **CAP Reform Proposal 2003** compared to the **Agenda reference run** results into a large decrease of the nitrate (N) surplus per hectare at farm type Cattle fattening & rairing (-11.4%). This is explained by the decrease in the number of cattle fattening. The nitrate (N) surplus per hectare at farm types Specialist pigs and Poultry is rather stable. A small increase in nitrate (N) surplus is found at farm type Field crops diversified.

From a map with vulnerable zones (Nitrate Directive 91/676/EEC) it was concluded that reduction of nitrate (N) surplus is relatively low in regions with the highest percentage of sensitive areas, like France, East England, Germany, the Netherlands, Denmark and Finland.

Ammonia output:

In the 'CAP Reform Proposal 2003' [2009] compared to 'Agenda 2000' [2009] ammonia output decreases for all farm types. The decrease ranges from about -11 % for farm type Cattle fattening & rearing to -0.4 % for farm type Poultry. Due to the decreased production of manure and application of mineral fertilizer (reduced areas for cereals, oilseeds and intensive grassland) total ammonia output in the EU decreases by about -2 %.

Global Warming Potentials (GWP)

Global Warming Potentials (GWP) decrease under **CAP Reform Proposal 2003** (-4.2%) compared to **Agenda reference run**. At the regional level, the change in Global Warming Potentials (GWP) ranges from 0.4% in Sweden to –11.9% in regions in Spain, Greece and Ireland. The change in Carbon Dioxide Emissions ranges from about 3% in Sweden and Finland to about –10% in regions in Spain, Greece, Italy, United Kingdom and Ireland. Changes in methane from animals ranges from +4% in regions in Scandinavia to about –9% in regions in Ireland, United Kingdom, France and Spain.

Water balances

By the moment the model assign the water balances observed for the five most frequent crops in a region equally to all activities in this regions (rough average). It is observed that regions with a high proportion of vegetables and perennials have a higher water deficit than cereal specialist regions. All information attached to animal activities and mixed production is not included, due to the fact that water balances are not relevant for them. The '**CAP Reform Proposal 2003**' results for water follow the results of the supply model, as water is just a passive indicator.

Discussion points

The modelling results for the farm types basically mimics the results at the regional level. Differences in supply, income and environmental effects between farm types in specific regions, results from differences in agricultural output composition. Differences in behaviour or farm type specific restrictions are not yet included. This is mainly due to data limitations.

The modelling results presented in this report are based on assumptions concerning the implementation of the political instruments of the **CAP Reform Proposal 2003** in the model and some further assumptions related to market prospects. In the calculations it is assumed that eligible hectares receive an uniform premium per hectare (at a farm level). Clearly, a payment scheme deviating from the implementation system chosen here could drive to different results.

Some further issues concerning possible effects of the **CAP Reform Proposal 2003** are discussed. These relate to effects on land rents and barriers to newcomers and effects on irrigation. It is argued that decoupled premiums introduce a rigid price floor on land to lease. Compared to Agenda 2000 and coupled premiums, land rent is probably higher in regions with very low profitability. From the other hand, increases in fallow land in these regions are pronounced and interest in buying or leasing land for agricultural production in these regions will be low anyway. Other more productive regions are already facing high land prices.

With respect to irrigation, for crops receiving coupled premiums in Agenda 2000 the change to decoupled premiums leads to a decrease in areas. In the model, these crops are mostly replaced either by fallow land or extensive fodder production. The latter require less irrigation water and thus reduce the pressure on water balances. Countervailing are possible increases in vegetables and perennials as potential damaging candidates, which require typically higher irrigation quantities per ha compared to ‘Grandes Cultures’. Unfortunately, the effect on vegetables and perennials is not modelled in the current version of CAPRI. From the other hand, vegetables and perennials require specific machinery, a complete different marketing chain and changes in production quantities impact on regional prices, so that probable increases are restricted.

1. Introduction

The objective of the project "Development of models and tools for assessing the environmental impact of agricultural policies" (ENV.B.2/ETU/2000/073) is to investigate the links between agriculture and the environment. More specifically the objectives of the study are:

- To develop a *system of computer-based models* for assessing the environmental impact of agricultural policies, both at farm, regional (NUTS II) and EU wide level, which are consistently linked. A key asset is the existing CAPRI modelling system, which covers the whole EU at NUTS II. It will be systematically broken down to a series of farm models, reflecting Farm Accountancy Data Network (FADN) farming type models. The farm models will provide insights into farm income, environmental indicators per farm type and the variability of these indicators between farm types.

- To develop *databases* required for using the modelling system. Again, the databases will be not built from scratch, but use existing frameworks.

- Using the system of models, to assess ex-ante and ex-post the *impact of selected changes in agricultural policies on the environment*;

After a more detailed description of the project in chapter 2, this report will continue to describe data sources and models in chapter 3.[1] Paragraph 3.4 describes the implementation of the farm type programming models into the CAPRI system.

Chapters 4, 5,6 and 7 include scenario descriptions and results of the model applications. In principle the reader can concentrate on these chapters if he mainly wants to focus on scenarios and results. In close co-operation with DG-ENV, relevant policy scenarios are defined. Starting point is the so-called "**Agenda reference run**", which will simulate the most probably state of the agricultural system in the EU until 2009, based on technical process, economic development,

---

[1] Methodological issues are discussed in more detail in the different reports produced within the framework of this project (LEI, IAP, IAM, February 2001, December 2001, May 2002, December 2002).

population growth and taking into account the current policy setting. The **Agenda reference run** simulates the status quo policy for the simulation horizon, including the full introduction of the Agenda 2000 policy proposal. The **Agenda reference run** is described in chapter 4. The chosen relevant policy scenario is referred to as **CAP Reform Proposal 2003** (Draft legal texts January 2003) and is described in chapter 5. The application of the full CAPRI modelling system, including farm types, compares developments of production, land use, demand, agricultural income and environmental indicators projected for 2009 under the **CAP Reform Proposal 2003** to the results of the **Agenda reference run**. Results with respect to supply and income are described in chapter 6. Effects on environmental indicators are discussed in chapter 7. Environmental indicators include:

- N,P,K balances at farm type, regional and EU level.
- Ammonia output at farm type level
- Global warming emissions at farm type, regional and EU level
- Water balances

Chapter 7 and 8 are devoted to discussions on further improvements of the CAPRI system and possible effects of the '**CAP Reform Proposal 2003**' respectively. The latter effects concern effects on land rents and barriers to newcomers and effects on irrigation.

A weakness of the CAPRI system that is mentioned in the report is that the included environmental indicators are passive ones and can be seen as rather robust pressure indicators. In order to improve this, more refined approaches and models are developed. These models are linked to the overall CAPRI system as they use output from CAPRI, like e.g. cropping plan, number of animals, use of animal manure and mineral fertilisers and (possible) prices as an input. The case studies are related to:

- phytosanitary leaching to ground water in Nord Pas de Calais and Midi-Pyrénnées
- farm bio-economic modelling; case study for a specialised "Grandes Cultures" farm in French Midi-Pyrénnées;

- nitrate (NO_3) in upper ground water on Dutch dairy farms

- Pesticide use in the Netherlands and in the EU.

The report ends with conclusions and a description of possible other scenarios in chapter 10.

2. Description of the project

2.1. Problem statement

The impacts of agriculture and agricultural policies on the environment are of major public concern, and play an increasingly important role in the context of agricultural policy reform, trade liberalisation and the achievement of sustainable agriculture. This project aims to contribute to the understanding of the relationship between agriculture, environment, trade and sustainable development, both ex-post and ex-ante in scenario analysis.

The CAP '92 reform offered the chance to target EUs agricultural policy instruments from a rather strict orientation on market and income support towards environmental issues, too. Environmental goods and bads often lack features allowing for an effective market solution, lead to positive and negative external effects of agricultural production and hence call for a public choice solution. The set of agricultural policy instruments linked to price oriented support to farmers in the years before 1992 was hardly suitable to take into account environmental externalities. The direct payments introduced since then allow for modulation at regional or even farm level according to environmental issues. Cross-compliance between income support and a reduction of negative environmental effects were, for example, introduced in animal production by coupling stocking densities and premium levels.

The new paradigm required a switch from a uniform policy definition at EU level to higher responsibility at regional level, as both externalities and their evaluation by consumers show a high regional variation. Management at EU levels of such instruments provokes high control and data acquirement costs to define optimal regional policy instruments. Accordingly, the common agricultural policy now defines a consistent framework (directive 2078/92) in which member states and regional bodies can modulate direct aid.

The shift in agricultural policy instruments, not only in the EU and partly developed as a response to the Uruguay Round on Agriculture, will require innovative solution at international level, too. The discussing on de-coupled payments and multi-functionality clearly reflects not only growing awareness of externalities in agricultural production, but possible trade-offs between trade distorting and positive environmental effects of agricultural policy as well. The challenge consists in the definition of international rules for agricultural policy instruments where important externalities in agricultural production call for a solution in the political market, even if these provoke certain trade distorting effects.

The definition of such rules lies well beyond the scope of the study. The improvement and application of the CAPRI modelling system as proposed in the context of the study improves however the insight regarding the trade-off between trade distortion and the state of environment for certain policy instruments, and may contribute to a rational discussion of policy options and their evaluation.

The recent reform of the CAP, Agenda 2000, gives Member States for the first time the opportunity to take action on the environment in the framework of CAP instruments defined uniformly at European level, by allowing them to ascribe environmental conditions to some CAP payments to farmers (Regulation 1259/1999, article 3 on 'environmental protection requirements'). The opportunities brought about by this new instrument are very significant. However, as it is yet unknown how Member States will use these opportunities, their impact on the environment is not clear.

Although current agricultural policies have integrated to a certain degree environmental concerns, existing support systems for agricultural policy lack behind regarding the evaluation of environmental aspects, often due to a rather high regional aggregation level at Member state or even European level. Ex-ante and ex post evaluations of agricultural policies rarely include a thorough assessment of their environmental impacts. Analyses of the link between agriculture and the environment are often qualitative and case study based, but does not provide an overall view of the problem nor the possibility to effectively compare different policy options with regards to both their economic and environmental impact.

2.2. Objectives

The study will investigate the links between agriculture and the environment. More specifically, the objectives of the study are:

- To develop a *system of computer-based models* for assessing the environmental impact of agricultural policies, both at farm, regional (NUTS II) and EU wide level, which are consistently linked. A key asset is the existing CAPRI modelling system, which covers the whole EU at NUTS II. It will be systematically broken down to a series of farm models, reflecting existing models at LEI.

- To develop *databases* required for using the modelling system. Again, the databases will be not built from scratch, but use existing frameworks.

- Using the system of models, to assess ex-ante and ex-post the *impact of selected changes in agricultural policies on the environment*;

2.3. Policy coverage

The proposed conceptual framework will allow to evaluate a wide rage of market and policy parameters. Activity based agricultural sector models, as CAPRIs supply side are well suited to cover the major elements of CAP as direct payments and set-aside programs. Farm type models can easily incorporate the effect of premium ceilings per farm or coupling of premiums to stocking densities or other technological restrictions, and farm specific quotas. The CAPRI market model features 'ad valorem' and specific tariffs, administrative price floors and WTO restrictions on export subsidies as well as milk and sugar beet quotas. The following list of policy instruments gives a preliminary list of instruments integrated in the database and the proposed modelling system:

- traditional agricultural output price support by administrative prices and intervention schemes

- direct payments

- set-aside regimes

- agri-environmental measures (e.g. limits on stocking density, manure usage, premiums for environmentally friendly technologies), including modulation of direct payments

- taxes and subsidies on inputs (e.g. fertilisers, pesticides)

- water prices
- Tariffs and import/export restrictions
- Country, regional and farm type specific measurements

The final choice of policy variables integrated into the modelling system and the policy options that may be tested through modelling will be taken in agreement with the concerned commission services.

2.4. Environmental indicators

The first objective linked to the development of environmental indicators is to provide information to policy makers and the wider public on the current state and changes in the conditions of the environment affected by agriculture. The second objective is to better understand the linkage between the causes and impacts of agricultural production and agricultural or environmental policy measures on the environment. The third objective is to contribute to monitoring and evaluating the effectiveness of agri-environmental policies.

As the study is directed at application at EU wide scale, and resources are restricted, only a limited number of robust indicators can be employed, partly already embedded in the proposed modelling system. The project will built upon the existing framework of indicators from CAPRI (N,P,K-balances, emission of green house gases) and adds water balances to the set (see also Figure (1)).

The first set of indicators embedded in the CAPRI system relates to *nutrient balances* for N, P and K, as proposed by the OECD indicator system. These balances are linked to regional yield levels and characteristics of animal production.

Additionally insight regarding the environmental impact of agricultural production will be reached by applying the indicators to the farm models or farm type programming models as well, showing the variance of these indicators across farm types. The farm type models are especially important to check whether certain policy instruments are able to dampen negative externalities related to specific production system as pork fattening. Furthermore, the farm models will provide insights into farm income and the variability of this indicator between farm types.

The CAPRI system features already *output of gases related to global warming*. Taking climatic conditions into account, the indicator will be improved. Climatic influences are equally important for other reasons as well. Especially high variances in water availability in the late plant growth phase may increase negative externalities as chemical and fertilising applications are triggered by yield expectations, and a later drastic drop in the harvest level increases nutrient and chemical losses. So far, the CAPRI project had not yet investigated the effect of yield and weather variability on environmental indicators on large-scale.

Current research in the field of chemical use allows defining an *indicator system based on toxicity and degradability of active substances*. Appropriate input data are available for France and will be linked to the system, and it will be exploited if similar data can be derived for other member states as well.

The Nutrient Flow Model (NFM) in the Netherlands calculates very detailed mineral balances at farm level. Mineral balances are calculated using the farm gate approach, but can be decomposed into crop and animal balances. Extra components of the nitrogen (N) balance for crops in the NFM, compared to the corresponding balance in CAPRI, are denitrification, mutation soil storage and fixation. Resulting potential nitrogen (N) for leaching as nitrate (NO_3) is used as an input into an econometrically estimated equation, which estimates the nitrate (NO_3) in the upper ground water on Dutch dairy farms on sandy soils.

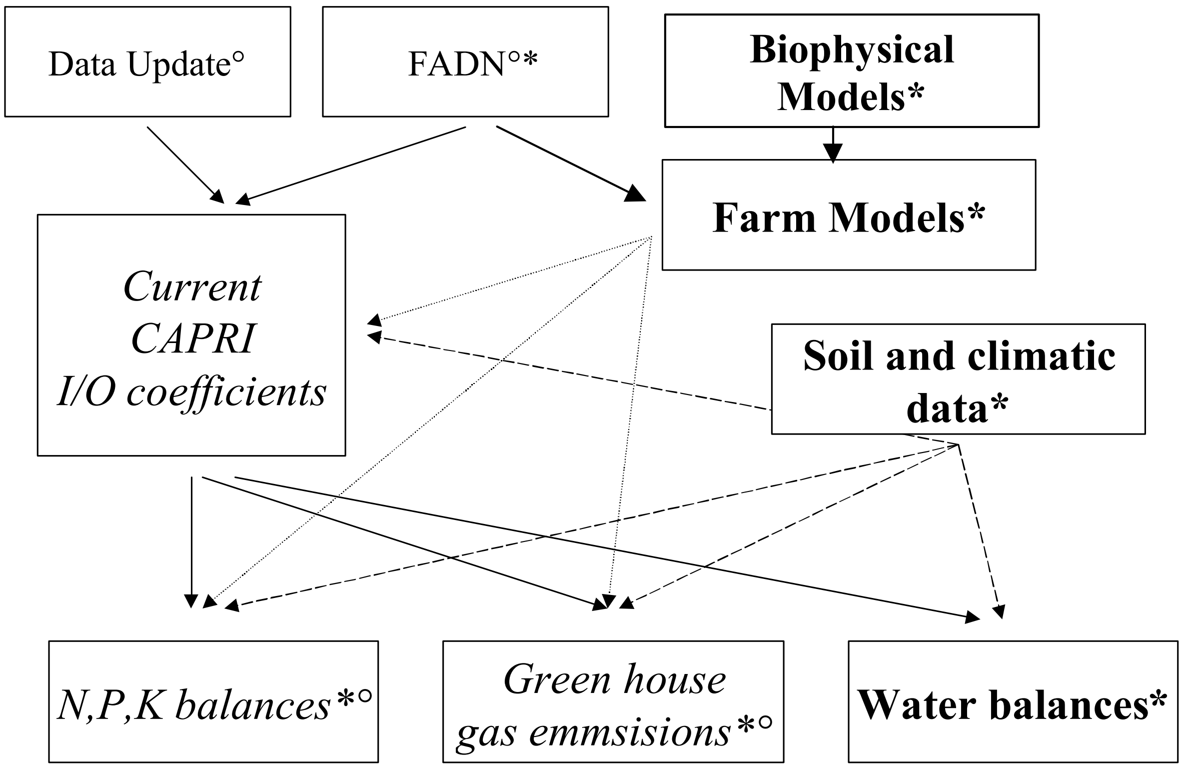
Water balances will be prepared for a group of important irrigated European regions (Spain, Southern France, Italy, and Greece) for the most important crops in each region. Using complex biophysical models can refine relationships between agricultural practices and their environmental impact. Therefore, a more detailed work on water balances will be initiated using CROPSYST for: Andalucía (Córdoba Province) in Spain, Cataluña (Lleida region) in Spain, Foggia (Puglia region) in Italy, Haute Garonne (Midi-Pyrénnées region) in France. Greece (region not yet defined)

The water balance will allow deriving from the nutrient balance the nutrient content of leaching water, too, in line with OECD indicators. In the cases of Foggia and Haute Garonne, we will present a case study integrating the result of the biophysical model on

- yields
- water balance
- nitrate losses

in a farm model. As said above, it will be investigated whether it will be possible to incorporate CROPSYST or EPIC results into the farming type models related to both regions. This could improve the biophysical relationships used in the NFM module.

Figure (1) Improvements of Environmental Indicators



* DG-Env project

° CAP-STRAT

3. Data sources and model description

3.1. History of the Model

The CAPRI modelling system was developed in the context of the Fourth Framework Project (FAIR3-CT96-1849)[2] from 1997 until end of 1999, building upon experiences with the RAUMIS, SPEL-EU MFSS and WATSIM modelling system. The Institute for Agricultural Policy, University of Bonn, co-ordinated a network of four main partners with sub-partners in almost all EU member states. The system was tested on an Agenda 2000 simulation run at the end of 1999, and the main results and concept were presented to DG-AGRI. In parallel, the German Agricultural Research Institute (FAL) employed the CAPRI modelling in the context of a research project (FAIR-CT96-1794) to analyse the effects of an increase in biological production systems. Results from both projects can be found in their respective final reports.

After a phase of consolidation, a new framework project titled CAP-STRAT (QLTR-2000-00394) started in March 2002, with a new set of objectives: data base update, implementation of methodological improvements, a thorough validation of the complete system, and a scenario analysis foreseen for 2004. The still intermediate outcome from this project feeds directly into this study for DG Environment (01/2001-12/2002).

3.2. Regional CAPRI data base

Analysing ex-post developments and building up a model for simulation purposes requires a solid and comprehensive database. This research builds up on the existing regionalised CAPRI database[3] whose main features are:

---

[2] Final consolidated report with a detailed model description is available on the project web site: http://www.agp.uni-bonn.de/agpo/rsrch/capri/finrep.pdf.

[3] The COCO (Completeness and Consistency) database was designed by the IAP team in 2000 to easily integrate additional sources apart from EUROSTAT (regio data), to fill gaps and to correct statistical data. Through an

- *Disaggregation* of the European Union into 200 regional units (mostly according to the NUTS II definition).

- *Production activity break-down of agricultural production and input use*

- *Consistency* between sectoral and regional aggregates. Data match official EUROSTAT statistics including Economic Accounts of Agriculture (EAA).

- *Economic Accounting Principles*. The model covers all outputs and inputs included in the national Economic Accounts of Agriculture (EAA) for the Member States.

- *Comprehensiveness:* complete coverage of product generation and input use, inclusion of activity levels, yields, input coefficients, prices, farm & market balances, economic performance, political instruments and environmental indicators

Table (1) gives an overview on the content of the CAPRI database at different regional levels. Generally, all information available at lower regional levels is available at higher levels as well, by consistent aggregation. Currently, the database covers the years 1990-2000 for all regions as well as a 3-year weighted average for 1998 which is used as "base year" for simulation runs of the modelling system. However, for many regions and Member States, data on earlier years are available as well. The CAPRI database[4] distinguishes between 58 outputs and 32 input categories, which cover agriculture according to the lists of products and inputs, defined by the EAA. As production activities are linked to the main outputs, CAPRI differentiates 38 crop and 16 animal production activities. Crop production activities are defined as main crop areas and hence completely cover the Utilisable Agricultural Area (UAA) of each region. Input and output coefficients are consistent to farm and market balances at national level, and income indicator and prices consistent to Economic Accounts for Agriculture.

econometric approach it puts a heavy weight on transparency and uniformness, so that manual corrections are currently restricted.

[4] Actual Stand November 2002

Based on FADN data, data on input coefficients and environmental and income indicators will be improved in the context of this research. Soil, climatic and CORINE land cover maps are available from GISCO, EUROSTAT.

Table (1) Overview on CAPRI database content

Regional level	Coverage	Items
EU **Norway** **12 World Regions (countries and aggregates)**	*Trade Policy instruments*	Specific and ad valorem tariffs, administrative prices, tariff rate quotas (TRQs), Export Subsidies (EU, Norway), bilateral import and exports streams, intervention purchases, PSE/CSE price wedges
15 Member States **Norway**	*Economic Accounts of Agriculture* *Prices* *Farm balances* *Market balances*	Valued output and input in current and constant prices Unit values consistent to EAA Consumer prices Sales, feed and seed use, losses and stock changes on farm, young animal flows Feed and seed use, human consumption, processing, loses and stock changes on market
50 Nuts I **200 Nuts II regions**	*Production related positions* *Policy instruments* *Environmental indicators*	Cropped areas and herd sizes, yields, input coefficients, income indicators Sales quotas, premiums, base areas, set-aside rates N, P, K balances, global warming emissions, water deficits and balances

3.3. The CAPRI modelling system: overall concept

The CAPRI modelling system is designed as a projection and simulation tool for the agricultural sector based on

- **A physical consistency framework**, covering balances for agricultural area, young animals and feed requirements for animals as well as nutrient requirement for crops, modelled as constraints in the regional supply models. The market model ensures that fat and protein content in the milk delivered to dairy is equal to the fat and protein content in the processed dairy products.

- **Economic accounting principles** according to the definition of the Economic Accounts for Agriculture (EAA). The models covers all outputs and inputs included in the national EAAs for the Member States, and the revenues and costs are broken down consistently to regions and production activities.

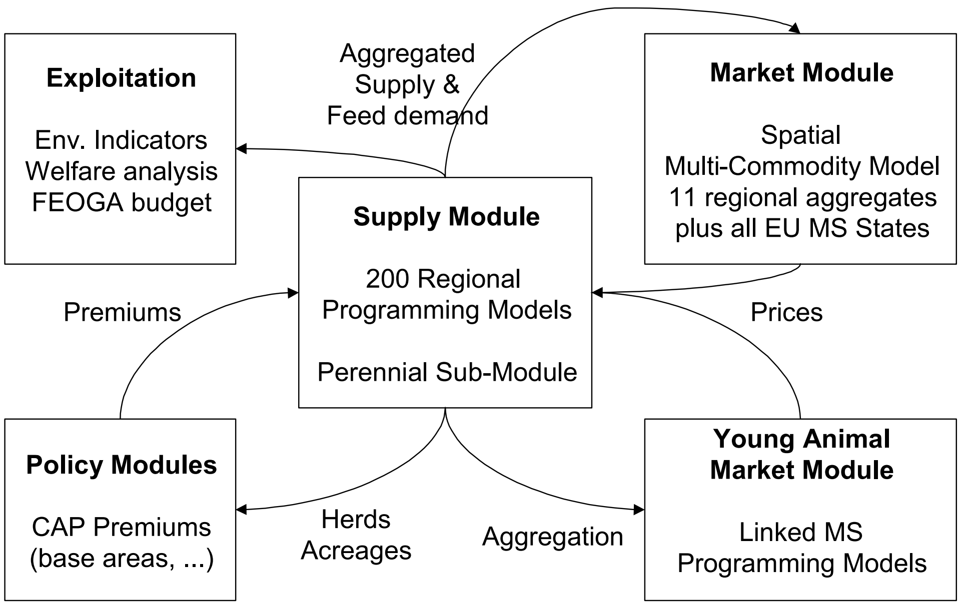
- **A detailed policy description**, on the supply side capturing all relevant payment schemes with their respective ceilings, on the market side covering tariffs, intervention purchases and subsidised exports. The policy of non-EU regions is based on OECD PSE/CSE database.

- **Behavioural functions** and allocation steering strictly in **line with micro-economic theory**. Functional forms are chosen to be globally well behaved, allowing for a consistent welfare analysis.

These fundamental principles are applied both for the reference run, as for counter factual runs against the reference.

The existing CAPRI framework consists of regional aggregate programming models at NUTS II level covering consistently the whole of Europe, and iteratively linked to market models for young animal and marketable agricultural outputs (Figure (2)). The young animal model builds upon aggregate national programming models calibrated by Positive Mathematical Programming techniques to the results of the NUTS II models with constraints ensuring market clearance for young animals.

Figure (2) Link of modules in the CAPRI modelling system



Supply Model[5]

Agricultural production of yearly crops and animal outputs in each region are modelled by an aggregated profit function approach under a limited number of explicit constraints – land, policy restrictions as sales quotas and set-aside obligations, and feeding restrictions.

The underlying methodology assumes a two-stage decision process. In the *first stage*, producers determine the optimal variable input coefficients per ha or head at given yields determined exogenous by trend analysis. The proceeding mimics the calculation of a gross margin in farm management. In the *second stage*, profit maximising cropping patterns and animal herds are determined simultaneously with cost minimising feed and fertiliser mix. Availability of grass and arable land as well as sales quotas restrict production possibilities, the mix of crops is further on influenced by set-aside obligations.

[5] A detailed description can be found in Thomas Heckelei & Wolfgang Britz (1999).

Market Model

The market model breaks down the world into 12 country aggregates in line with the WATSIM database - see Table (2) -, each featuring systems of supply, human consumption, feed and processing functions. The parameters of these functions are derived from exogenous elasticity's and calibrated to projected quantities and prices in the simulation year. It can be defined as a spatial multi-commodity model, which comprises a two stage Armington system (Armington, 1969). The *Armington assumption* drives the composition of demand from domestic sales and the different import origins depending on price relations and thus determines *bilateral trade streams*. On the top level, the composition of total demand from imports and domestic sales is determined, as a function of the relation between internal market price and the average import price. The lower stage determines the import shares from different origins.

Table (2) Regional disaggregation of the market module[6]

	Country aggregate	**Code**
1.	European Union, broken down into Member States	EU000
2.	East European Candidate Countries	CEE
3.	Mediterranean countries	MED
4.	United States of America	USA
5.	Canada	CAN
6.	Australia & New Zealand	ANZ
7.	Free trade developing (CAIRNS group)	CAD
8.	High tariff traders (Japan, Norway, Switzerland)	HIT
9.	China	CHN
10.	India	IND
11.	Asian, Caribbean, Pacific developing countries	ACP
12.	Rest of the world	ROW

[6] A detailed description can be found in C. Tritten, B. Henry de Frahan, W.Britz (2001).

Endogenous prices for intra-sectorally produced inputs (organic fertiliser, feeding stuff, young animals) and marketable outputs open up the unique chance to overcome a major drawback of many farm type approaches. Generally, farm type models take these prices as exogenously given. Accordingly, especially relating to intra-sectorally produced inputs, the production programs of the different farm types are not guaranteed to be mutually compatible. Further on, by enlarging the spatial scale of the analysis beyond regional and national level the assumption of given prices for outputs cannot longer be defended. Insofar, the project promises to allow for a unique and powerful combination of different modelling approaches.

Additional information

- *Yield development for the EU* are based on trend analysis, but subject to manual corrections if necessary.
- *Data relating to other world regions* are borrowed from the WATSIM modelling system and other studies, including shifters as population growth, income growth and changes in tastes. The resulting data set is carefully adjusted to fulfil consistency conditions, both in the base and the simulation year. A main data source for the shifters in supply and demand for non-EU regions is the @2030 framework of FAO’s global perspective unit.
- *Inflation* is set to 1.9 % p.a. and nominal GDP growth for the EU to 2.7 % p.a., both assumptions taken from DG-AGRI’s publication “Prospects for Agricultural market 2002-2009”.
- *Changes in demand behaviour* not linked to income or prices changes are trended using ex-post time series on per capita consumption, in most cases in line with data found in DG Agri’s market prospects.
- *Population growth* at Member States level is borrowed from EUROSTAT.
- *Total food consumption* for non-EU countries follows the assumptions underlying the @2030 framework, calibrated to domestic consumer prices derived from the price transmission functions of the model and world market developments borrowed from DG-Agri’s market outlook.

- The *price framework* is based on representative long-term time series for world market prices of major raw and processed agricultural product, which are trend forecasted.

3.4. The implementation of Farm Type Programming Models

The main aims linked to the introduction of farm types in the system was to ameliorate the analysis of agricultural policies linked to structural variables as farm size or stocking density, improve the reliability of environmental indicators and allows for income analysis at farm type level. In other words, the introduction of data for single farms from the FADN database reduces the aggregation bias of the model at regional level.

The farm group models could be defined by a number of indicators as economic importance, environmental impact and so forth. The standard grouping is proposed to use a typology based on specialisation. First of all, the resulting groups are already clearly defined according to official European documents, and results obtained can be easily compared to other studies. Secondly, the grouping is based on Standard Gross Margins, reducing the stochastic impact of weather or price changes on the grouping in single years. As a third point, it can be argued that environmental impacts are often linked to farm specialisation.

But even with the farm typology according to European standards is applied, a number of issues need to be addressed: (1) number of farm groups defined for each region, (2) level of typology, and (3) decision about the groups to include.

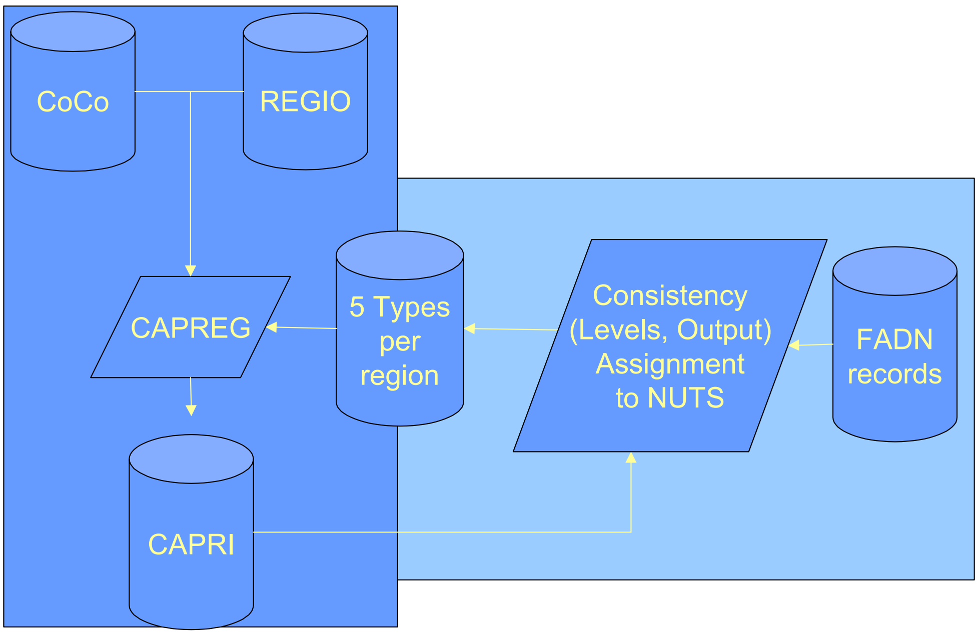
Regarding (1), *number of farm groups*. Clearly, the amount of detail increases with the number of farm types, in line with computing time and management cost to handle the additional information. Based on the experience that long response times reduce drastically the amount of validation runs, it was decided to choose not more then five types plus a mixed remaining group representing all other farms for the modelling system.

Regarding the level of typology: in order to keep the amount of different groups to the found in the system manageable, the three digit FADN typology was used, so that about 50 different type of specialisation can be found in the system.

It should be noted that farms are grouped "once forever" in a certain specialisation based on economic weights from the base period. In other words: applying the typology definition from FADN to the results would lead to shifts of the farms in between the groups. It was deemed more sensible to refrain from dynamic grouping.

The following diagram shows the relation between the FADN database and the elements of the CAPRI data processor. In a first step, ex post data on NUTS II level from the CAPRI database on activity levels and output were selected for the about 50 production activities were selected. Further on, an extraction program provided the necessary data from the FADN database.

Figure (3) Integration of farm types in the CAPRI data base



The second integration step consisted in a non-linear optimisation program, which ensured matching activity levels (hectares, herd sizes) and production quantities between CAPRI and FADN. A part of problem related to a different regional breakdown: where the CAPRI database refers to administrative NUTS regions, the FADN database has an own set of regions. In order to increase the number of farms available per type and region and thus preventing problems with confidentiality limits, the algorithm "distributed" the aggregation weights for each farm over several regions. A specific farm in the network may easily represent farms not only in the region where the farm is situated, but in other regions as well.

In order to match the CAPRI database – which is in major elements derived from the REGIO database at EuroStat – it was necessary to change the aggregation weights and activity data of single FADN records. Minimising squared differences ensured that the changes were not bigger then necessary. After that step, the single farm records were aggregated to specialised farms per region, see the following list, and the five most frequent farm types were selected, with the frequency relating to the aggregation weights.

That step was necessary only once for a given base year. Afterwards, further algorithm ensures that input use aggregated over the farm types matches the input use at NUTS II level. These algorithms are integrated in the so-called regionalisation step in CAPRI, which combines the so-called "CoCo" database (consistent and complete) with its time series at national level with information from REGIO and other sources at regional level.

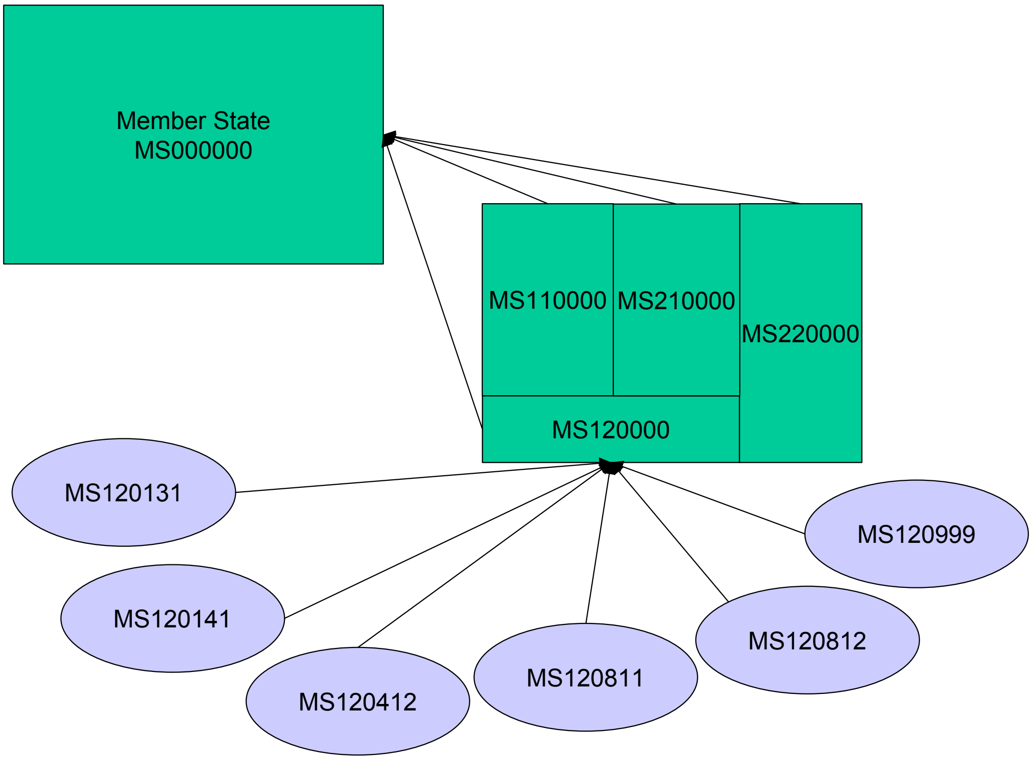
Table (3) Farm types found in the system

131	Specialist COP (other than rice)
132	Specialist rice
133	COP and rice combined
141	Specialist root crops
142	Cereals and root crops combined
143	Specialist field vegetables
144	Various field crops
201	Specialist market garden vegetables
202	Specialist flowers and ornamentals
203	General market garden cropping
311	Quality wine
312	Wine other than quality
313	Quality & other wine combined
314	Vineyards for various types of production
321	Specialist fruit (other than citrus)
322	Citrus fruits
323	Fruits & citrus fruits combined
330	Olives
340	Various permanent crops combined
411	Milk
412	Milk & cattle rearing
421	Cattle rearing
422	Cattle fattening
431	Dairying with rearing & fattening
432	Rearing & fattening with dairying
441	Sheep
442	Sheep & cattle combined
443	Goats
444	Various grazing livestock
501	Specialist pigs
502	Specialist poultry
503	Various garnitures combined
601	Market gardening & permanent crops
602	Field crops & market gardening
603	Field crops & vineyards
604	Field crops & permanent crops
605	Mixed cropping-mainly field crops
606	Mixed cropping-mainly market gardening or permanent crops
711	Mixed livestock-mainly dairying
712	Mixed livestock-mainly non-dairy grazing
721	Mixed livestock-granivores & dairying
722	Mixed livestock-granivores & non-dairy grazing
723	Mixed livestock-granivores with various livestock
811	Field crops & dairying
812	Dairying & field crops
813	Field crops & non-dairy grazing
814	Non-dairy grazing & field crops
821	Field crops & granivores
822	Permanent crops & grazing livestock
823	Various mixed crops and livestock
999	Rest

In the modelling system, the farm types are treated technically as a further breakdown inside the NUTS II regions: the activity levels in each farm type feature own input and output coefficients, and are independently optimised for maximal profits. After a model run, the farm type results are aggregated to NUTS II, Member State and EU.

It should be noted that the relation between NUTS II and Member States is a geographical one; the disaggregation thus provides localised effects in space. Farm type data however cannot be linked to specific locations in the NUTS II regions, even if they break down consistently output generation in physical and valued terms, activity levels and economic and environmental indicators. An improvement in that respect would require a complete link with Geographical Information System plus intensive economic analysis to create mapping algorithms between spatial specifics (soil types, local climate, slope, altitude.), production program and farm specialisation. Figure (4) shows as well the coding scheme. Member States are labelled with two character codes according to EUROSTAT standards (AT,BL,DK,DE ...). Regions inside a Member State receive a 3-digit code (first position: NUTS I level, second: NUTS II level, third: NUS III level) following the NUTS classification scheme. The farm types are labelled with alphanumerical three-digits code as well, where the “000” refers to the regional level.

Figure (4) Aggregation from farm types to NUTS II and Member State



Further on, the system aggregates across regions all farms of the same specialisation, allowing for e.g. the analysis of effects for farms of a certain specialisation across Europe. In order to add additional layer of information, the specialised farm type are aggregated further on to as shown in Table (4).

Table (4) Aggregated farm types used for impact assessment

Code	Description	Farm type included
A10	Specialist COP (other than rice) or various field crops	133,144
A13	Specialist Rice or Rice & COP	132,133
A14	Root crops	141,142
A23	Permanent crops & vegetables	143,201,202,203,311,312,313,314,321,322,323,330,340
A41	Dairy	411,412,431
A42	Cattle fattening & rairing	421,422,432
A44	Sheep & goats	441,442,443,444
501	Specialist pigs	501
A52	Specialist poultry	502,503
A60	Field crops diversified	601,602,603,604,605,606
A70	Livestock diversified	711,712,721,722,723
A80	Livestock & crops diversified	811,812,813,814,821,822,823
999	Various	

Figure (5) shows the relation between the farm types and other elements of the modelling system. Inside the system, the farm types are aggregated to NUTS II and Member States, to allow a link to the policy and market module. These aggregations allow as well to exploit the results from farm types in maps and tables relating to geographical units. All results are stored in the Database management system as well, and can be accessed by specialised tools as DAOUT, and any selection may then be exported via clipboard or text files to other applications as e.g. EXCEL.

Figure (5) Integration of farm types in the CAPRI modelling system

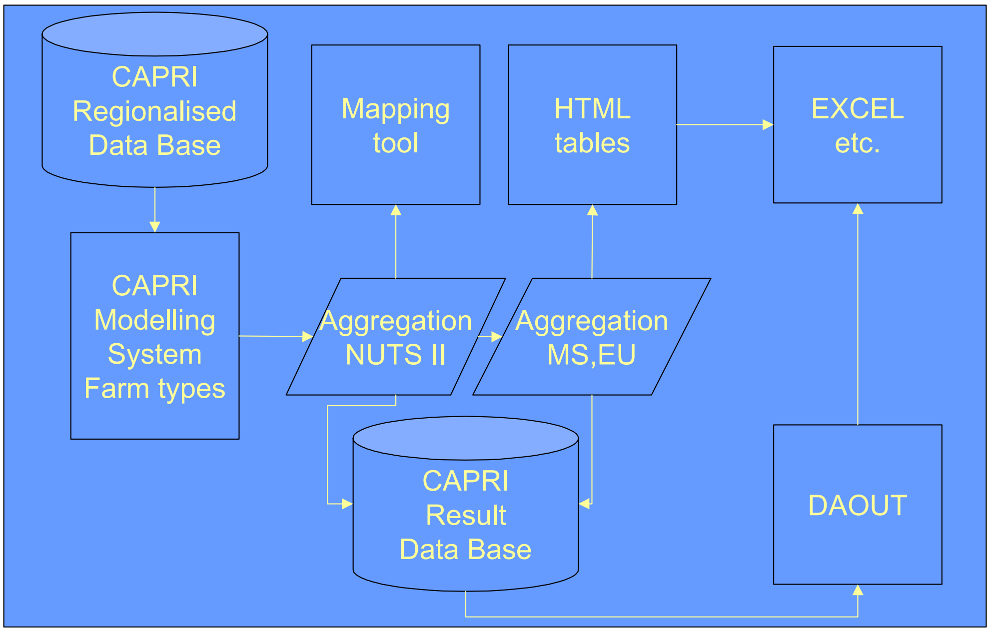


Figure (6) shows the dominant farm types per country. For reasons of survey research the farm types mentioned in Table (4) are further combined. It clearly shows that dairy is a dominant farm type in north of Europe. An exception is Denmark where specialised COP, livestock and crops diversified and specialised pigs and poultry are the dominant farm types. Cattle fattening, rearing, sheep and goats are the dominant farm types in Ireland and UK. In the south of Europe, Portugal, Spain, Italy and Greece, permanent crops and vegetables is the dominant farm type. Also in France and to a lesser extent in Belgium/Luxembourg and the Netherlands, this farm type is relatively important. The heterogeneity of farm types seems to be big in France (different farm types have about the same weight) and small in Ireland.

Figure (6) Farm types in EU countries

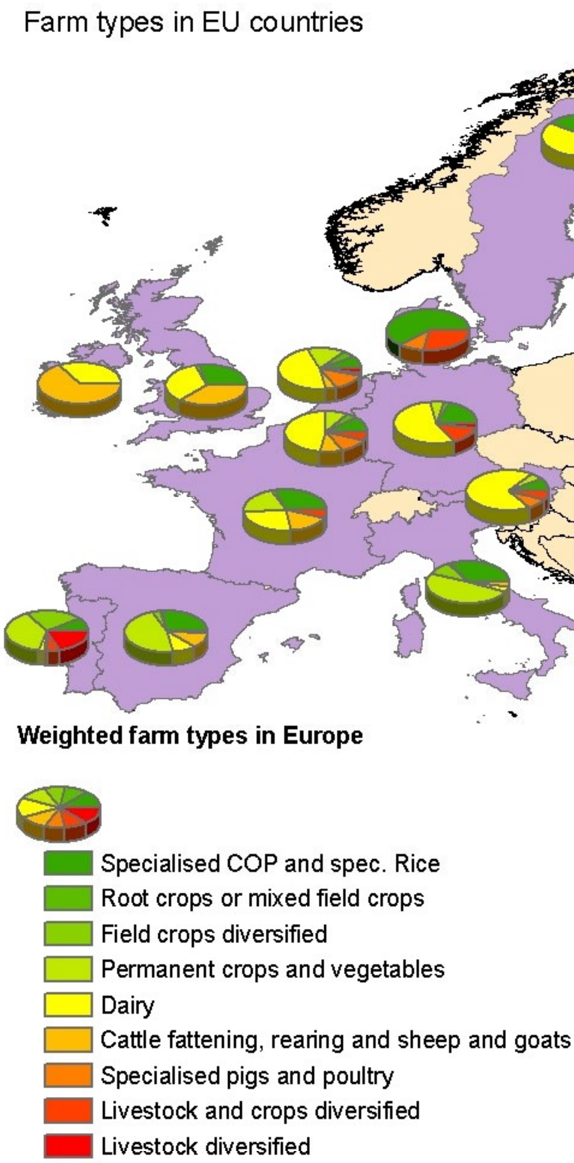


Table (5) is copied directly from the HTML-table exploitation tool. The first row relates to nutrient surpluses. The results are linked to a rather complex N-mass flow model. As gaseous losses of nitrate are accounted for, the surplus reflects the amount, which may run off, leach below the root zone or increase the nitrate (N) content in soils. It is well known from field experiments that agricultural soil features a certain buffer capacity for nitrate (N), so that even significant surpluses over longer period may not provoke nutrient leaching. However, once the buffer capacity is exceeded, almost all the nitrate leached out below the root zone will start to move downwards, and will earlier or later reach the ground water. Nitrate surpluses are hence a well-suited pressure indicator for water quality.

The P and K surpluses are calculated in a simpler way, by adding deliveries from manure and mineral fertiliser and subtracting exports of nutrient by harvested material. A description of the water pressure indicator can be found below.

Methane output is reported for two different sources: direct output from animals, and indirect output of methane during fertiliser production. Indirect gas outputs linked to fertiliser production are reported for CO2 and N2O as well. The fist columns present total surplus added over all farms of that specialisation (in 1000 tons), where as the second columns translate the gas quantities in 1000 tons CO2 equivalents or so called "Global Warming Potential”. The third columns reports the amounts in metric tons emitted per ha of utilisable agricultural area. The calculation of ammonia emissions is described in more detail in Annex 4; the results feed directly in the nitrate balance discussed in the next paragraph.

Table (5) Example table for environmental indicators at farm type/regional level

	Base year [1998]			Agenda reference run [2009]			CAP reform proposal 2003 [2009]		
Specialist COP (other than rice)	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*
Nitrate surplus	133.15		4.94	134.26 *0.83%*		4.98 *0.83%*	133.63 *-0.47%*		4.96 *-0.47%*
Phosphate surplus	57.32		2.13	59.29 *3.43%*		2.20 *3.43%*	57.36 *-3.25%*		2.13 *-3.25%*
Potassium surplus	104.39		3.87	104.51 *0.11%*		3.88 *0.10%*	99.57 *-4.73%*		3.69 *-4.73%*
Water deficit/surplus	7149.77		265.25	7006.67 *-2.00%*		259.93 *-2.01%*	6735.37 *-3.87%*		249.86 *-3.87%*
Methane output	103.63	2176.33	3.84	106.24 *2.52%*	2231.09 *2.52%*	3.94 *2.51%*	101.79 *-4.19%*	2137.69 *-4.19%*	3.78 *-4.19%*
Global warming potential	25678.31	25678.31	952.63	28038.89 *9.19%*	28038.89 *9.19%*	1040.15 *9.19%*	27061.33 *-3.49%*	27061.33 *-3.49%*	1003.89 *-3.49%*
Ammonium output	211.04		7.83	227.35 *7.72%*		8.43 *7.72%*	219.08 *-3.64%*		8.13 *-3.64%*
Methane from animals	78.51	1648.75	2.91	78.71 *0.25%*	1652.87 *0.25%*	2.92 *0.25%*	75.17 *-4.50%*	1578.57 *-4.50%*	2.79 *-4.50%*
Methane linked to fertiliser use	25.12	527.59	0.93	27.53 *9.60%*	578.22 *9.60%*	1.02 *9.59%*	26.62 *-3.30%*	559.12 *-3.30%*	0.99 *-3.30%*
CO2 linked to fertiliser use	10004.03	10004.03	371.13	10952.54 *9.48%*	10952.54 *9.48%*	406.30 *9.48%*	10597.23 *-3.24%*	10597.23 *-3.24%*	393.12 *-3.24%*
N20 linked to fertiliser use	43.54	13497.95	1.62	47.92 *10.06%*	14855.26 *10.06%*	1.78 *10.05%*	46.21 *-3.56%*	14326.41 *-3.56%*	1.71 *-3.56%*

A further table, Table (6), refers to the N-mass flow model, as shown in the following example. It should first be noted that the surplus shown in the last line could be found in Table (5) as well. The remaining positions are described in detail in earlier reports.

Table (6) Example table for a nitrate balance

	Base year [1998]		Agenda reference run [2009]	
Specialist COP (other than rice)	*Impact*	*Impact per ha UAA*	*Impact*	*Impact per ha UAA*
Import by mineral fertilizer	2877.54	106.75	3167.10 *10.06%*	117.49 *10.06%*
Export with harvest	1965.57	72.92	2112.83 *7.49%*	78.38 *7.49%*
Import by manure	297.29	11.03	307.09 *3.30%*	11.39 *3.29%*
Biological fixation	36.58	1.36	37.66 *2.95%*	1.40 *2.94%*
Releases from soil	680.71	25.25	678.79 *-0.28%*	25.18 *-0.29%*
Atmospheric deposition	352.03	13.06	352.03 *0.00%*	13.06 *0.00%*
Ammonia losses from organic fertiliser	79.49	2.95	82.13 *3.32%*	3.05 *3.32%*
Ammonia losses from mineral fertiliser	131.98	4.90	145.21 *10.03%*	5.39 *10.02%*
Ammonia losses from soil	190.18	7.06	192.97 *1.47%*	7.16 *1.46%*
Surplus	133.15	4.94	134.26 *0.83%*	4.98 *0.83%*

Last but not least, the environmental indicators had been where possible linked to individual production activities. An example table is shown below, Table (7), with only data for the base year. The number with brackets refers to the impact per activity level (ha or head). As an example, a hectare of cereals is linked to an indirect CO2 output of 505 kg. The number without brackets shows the impact of all farms in the aggregate at EU level, the multiplication with the impact per ha multiplied with total hectares. The [7248] in the same cell represent hence an output 7.248 Mio t of indirect CO2 output from cropping cereals in that farm type at EU level

(14.3 Mio ha). The table in the exploitation tool features many additional columns showing data relating to the individual activities as well.

Table (7) Example table for environmental indicators linked to production activities

	Base year [1998]					
Specialist COP (other than rice)	*Water surplus/ deficit*	*CO2 output indirect*	*Methane output*	*N2O output indirect*	*Global warming potential*	*Ammonia output*
Cereals	5653 *[394]*	7248 *[505]*	18 *[1]*	32 *[2]*	17678 *[1231]*	97 *[7]*
Oilseeds	830 *[303]*	1294 *[472]*	3 *[1]*	6 *[2]*	3086 *[1127]*	18 *[7]*
Other arable crops	379 *[215]*	752 *[426]*	2 *[1]*	3 *[2]*	1681 *[952]*	8 *[5]*
Permanent crops & vegetables	-169 *[-110]*	167 *[109]*	0 *[0]*	1 *[0]*	358 *[233]*	2 *[1]*
Fodder production	231 *[67]*	483 *[139]*	1 *[0]*	2 *[1]*	1078 *[311]*	5 *[2]*
Beef meat production			32 *[19]*		663 *[403]*	27 *[17]*
Set aside and fallow land	226 *[73]*	61 *[20]*	0 *[0]*	0 *[0]*	147 *[48]*	1 *[0]*
All cattle activities			56 *[18]*		1167 *[375]*	41 *[13]*
Other animals			23 *[2]*		482 *[40]*	38 *[3]*

The tool naturally presents standard economic results as well. Table (8) shows an example; similar results are presented for the individual products as well. Revenues represent quantities multiplied with farm gate prices (the latter consistent to the Economic Accounts for Agriculture); costs cover all non-primary factor costs. Taking into the account the premiums as well, the income is the sum available to remunerate labor, land and capital.

Table (8) Example table for economic indicators at farm type level

	Base year [1998]			
Specialist COP (other than rice)	***Revenues***	***Costs***	***Premiums***	***Income***
Cereals	11687.03 *[9413.04]*	8852.74 *[7130.23]*	4795.77 *[3862.64]*	7630.05 *[6145.44]*
Oilseeds	1721.27 *[1386.35]*	1892.88 *[1524.58]*	1545.26 *[1244.59]*	1373.64 *[1106.37]*
Other arable crops	4418.77 *[3559.00]*	1198.74 *[965.49]*	393.34 *[316.80]*	3613.37 *[2910.31]*
Permanent crops & vegetables	7740.47 *[6234.38]*	1217.22 *[980.38]*		6523.25 *[5254.00]*
Fodder production	722.72 *[582.10]*	773.59 *[623.07]*	47.99 *[38.65]*	-2.88 *[-2.32]*
Beef meat production	2543.95 *[2048.96]*	1343.83 *[1082.35]*	248.46 *[200.12]*	1448.58 *[1166.73]*
Set aside and fallow land	116.19 *[93.59]*	118.78 *[95.67]*	409.39 *[329.73]*	406.80 *[327.65]*
All cattle activities	3937.16 [3171.09]	2313.17 [1863.08]	248.46 [200.12]	1872.45 [1508.12]
Other animals	4412.48 [3553.93]	2279.10 [1835.64]	85.07 [68.52]	2218.45 [1786.80]
Sum	34756.09 [27993.47]	18646.23 [15018.16]	7525.27 [6061.05]	23635.13 [19036.36]

Table (9) shows the last type of information provided per farm type from the exploitation tool: economic information relating to the individual production activities or groups of activities. The number in brackets refers to the individual farm (total amount divided by aggregation weight). From table (9) but also from table (8) it can be seen that farm type Specialist COP (other than rice) includes much more activities than only COP crops. Hence, income effects are not only depending on the changes in COP markets. Although the extent can be different, this diversity is also found at other farm types.

Table (9) Example table for economic data linked to production activities at farm type level

	Base year [1998]				
Specialist COP (other than rice)	***Premium per ha or head***	***Income per ha or head***	***Hectares or herd size***	***Yield***	***Supply***
Cereals	334	531	14356.24 *[11.56]*	5671	81416 *[66]*
Oilseeds	564	501	2739.57 *[2.21]*	2842	7785 *[6]*
Other arable crops	223	2047	1765.36 *[1.42]*	26096	46068 *[37]*
Permanent crops & vegetables		4247	1536.12 *[1.24]*	6287	9658 *[8]*
Fodder production	14	-1	3468.96 *[2.79]*	5833	20234 *[16]*
Beef meat production	151	881	1645.15 *[1.33]*	335	551 *[0]*
Set aside and fallow land	133	132	3089.04 *[2.49]*	116	357 *[0]*
All cattle activities	80	602	3110.21 *[2.51]*	878	2731 *[2]*
Other animals	7	185	12004.13 *[9.67]*	1243	14925 *[12]*

3.5. Environmental indicators in CAPRI

In the following section, the existing environmental indicators in CAPRI, planned and already achieved improvements in the current project and possible further extensions are briefly discussed. It should be noted that CAPRI is basically a regionalised agricultural sector model, thus concentrating on modelling aggregated reactions of agricultural producers and consumers to changes in long term shifters as technical progress, income changes and CAP programs. Most of the environmental indicators are “passive” and do not develop a feedback in the modelling system itself, but are appended as independent modules after a simulation. Further on, most indicators are rather robust pressure indicators.

That structure has clearly its disadvantages, as economic (dis)-incentives can be neither directly linked to the environmental externality nor to the pressure indicators. On the other hand, further passive indicators can be introduced or the current ones changed easily.

The project aims at four different fields (1) improvement of the current state indicators – especially ammonia output and nitrate leaching, (2) introduction of new ones as a water balance and chemical indicators (3) feasibility studies for the application of the Nutrient Flow Model for the Netherlands and the bio-physical model CropSyst for regions in France (4) improving the interpretation of the indicators by contrasting them with soil and land-use maps.

Table (10) shows an overview of the indicators embedded in the CAPRI system when the project is finalised.

Table (10) Indicators in the CAPRI system

Indicator	Linked to	Fixed at	Source/Comment
N,P,K output at tail	Regional animal population and yields (final weights, milk yield, length of production period)	Animal type	Farm management literature, operationally embedded in system
Ammonia emissions (see annex 4)	Animal population, housing & storage type, crop level & yields	Member state level	IASSA, prototype embedded
N,P,K losses by leaching and soil storage	N,P,K output at tail and ammonia emission, N-crop need	EU level	Operational, currently with old emission factors
Output of greenhouse gases (carbon dioxide, nitrous oxide, methane)	Animal herds, mineral fertiliser	Uniform coefficients per animal type and pure mineral nutrient for EU	Counter-check with EAA
Water balances	Meteorology, management, irrigation, soil	Regional coefficients per crop activity	CropWat model, partial counter-check with CropSyst model -To be implemented-
Nitrate concentrations in ground water	soil type, ground water level, nitrate (N) surplus	Region, crops and farm types	Case studies for the Netherlands and France
Chemical emissions	crop production	Regional coefficients per crop activity	Case studies for the Netherlands and France
Energy balances			-To be implemented-
Carbon sinks			-To be implemented-

3.6. Strengths and weaknesses of the CAPRI modelling system for environmental modelling

3.6.1 Strengths

Several strengths of the approach used in this project can be mentioned. Firstly, its consistent and detailed break down of agricultural production at farm type and NUTS 2 level in Europe. Regions and farm types not only differ by soil type, which affects yields in crop production, but they also differ by agricultural specialisation. Related to this are different environmental issues relevant for agriculture in different regions and at different farm types. For example, use of pesticides is mainly a problem in regions specialising in arable crops, whereas oversupply of organic fertilisers could be a problem in regions with high animal densities. Secondly, the mathematical programming approach makes it possible to include on the one side many regions, farm types, agricultural production activities and environmental indicators and on the other side it offers the opportunity to include alternative technologies fairly easily. Third, the CAPRI model features endogenous prices for many inputs e.g. feed, fertilisers, young animals and outputs e.g. cereals, beef, milk. This is reached either through internal balances of demand and supply or through the linkage of the CAPRI supply model with a world market model. This way behaviour of farmers is modelled more realistic as the aggregated effect of changes in demand and supply on market prices is taken into account. Fourth, because the CAPRI database and modelling system covers the whole agricultural sector the trade off between different environmental themes can be assessed e.g. between oversupply of organic fertilisers and use of pesticides.

3.6.2 Weaknesses

Weaknesses are related to the aggregation error stemming from the regional and farm type programming approach. Variation in behavior between farms only comes from differences in output composition. This could be improved if the necessary data would be available. Moreover, the aggregation to NUTS 2 and farm type level, does still not allow to asses local environmental effects.

A further weakness of the current modelling system is that the included environmental indicators are passive ones and can be seen as rather robust pressure indicators. In order to improve the understanding between pressure indicators in CAPRI, more refined approaches had been linked to the results for selected indicators. A module for the Netherlands has been developed which calculates nitrate in the upper ground water (mg N/liter), which is linked to the CAPRIs nitrate (N-) balance. Very detailed regional farm models for two French regions allow looking in more detail at water balances and pesticide use.

4. The reference run

In general, the reference run is the reference for the interpretation and analysis of different policy simulations. In this run, the *status quo* policy is simulated for the simulation horizon and policy changes can therefore be analysed *against* this status quo situation. It is necessary to reflect carefully policy representation, assumptions and exogenous shifters for this run as well as the most important results for different activity and commodity groups. The policy for the status quo scenario of the reference run is the Agenda 2000 policy proposal extended to the year 2009.

4.1. Policy representation

4.1.1 Administrative prices and quotas

As explained above, behavioural functions for intervention stocks and subsidised exports are calibrated to the observed quantities and price relations between domestic, export and administrative prices for a three-year average around 1998. Table (11) lists the price floors used in the base situation to calibrate these functions, as well as the price floor used in the reference run.

Table (11) Prices triggering intervention and subsidised exports in the reference / simulation runs

Product (group)	Price floor in the base year (1998)	Price floor in Agenda 2000 (in 2009)	Price floor in CAP Reform 2003 (in 2009)	Explanation
Cereals	119 €/t	101.5 €/t	92.3 €/t	Used as effective intervention price, 5.8 % cut in CAP Reform 2003, monthly increments considered
Beef	2780 €/t	2224 €/t	2224 €/t	Basic price (private storage possible at 103% of that price), used as trigger for intervention
Butter	3282 €/t	2790 €/t	2133 €/t	Intervention price
Skim milk powder	2055€/t	1747€/t	1695 €/t	Intervention price
Cheese	5515 €/t	5139 €/t	4967	Constructed from butter and skim milk powder intervention prices, using fat and protein content and reflecting processing margins
Rice	333 €/t	298 €/t	150 €/t	Safety net for paddy rice

Milk ***quotas*** are supposed to increase in average over all Member States by 2.4% against the base year. Percentages of under- and over-utilisation of quotas at regional level are kept constant as observed in the base year. Sugar quotas are kept at base year levels.

4.1.2 Compensation payments

Due to its activity-based layout, the CAPRI supply model is well suited to deal with activity based payment scheme. A rather detailed modelling component, developed in co-operation between Torbjörn Jansson and Anders Bäckstrand -SLI, Lund- and the team in Bonn, allows the definition of payment schemes linked to outputs or activity levels in combination with ceilings in physical and/or valued terms. Table (12) shows the payments included in the reference run. Many of the premiums have ceilings defined at national or even regional level, and premiums are cut if ceilings are exceeded.

The premiums are either defined per ha/head, slaughtered head, historic yield or main output coefficients. Ceilings are either defined in value terms or in eligible hectares or heads. Table (12) shows the premium programs covered in the reference run.

Table (12) Premium schemes included in the reference run

Premium	Linked to the following activities
Direct payment to Grandes Cultures	Cereals, Oilseeds, Set-Aside, Non-Food crops on Set aside
Traditional durum wheat premium	Durum Wheat
Established payment to durum wheat	Durum Wheat
Rice premiums	Paddy Rice
Suckler cow premium	Suckler Cows
Special premium to bulls and steers where all are assumed to be bulls	Bulls low and high yield
Direct income support to dairy cows	Dairy cows low and high yield
Direct payment for sheep and goat	Sheep and Goats for Milk
National envelope for sheep and goat	Sheep and Goats for Milk
National envelope dairy cows	Dairy cows low and high yield
National envelope bovine meat cattle	Suckler Cows, Dairy cows low and high yield, Bulls low and high yield, Heifers low and high yield
Slaughter premium for adult cattle	Suckler Cows, Dairy cows low and high yield, Bulls low and high yield, Heifers low and high yield
Slaughter premium for calves	Calved for Fattening
National premium to dairy cows in northern Sweden and Finland	Dairy cows low and high yield

5. The ‘CAP Reform Proposal 2003’ (Draft legal texts January 2003)

5.1. Introduction

The ‘**CAP Reform Proposal 2003**’ aims at (1) economic viability, (2) social balance, (3) environmental integration and animal health and welfare concerns as well as (4) rural development. The following quantitative analysis based on the CAPRI modelling system compares developments of production, land use, demand, agricultural income and some environmental indicators projected for 2009 under the policy set of the ‘**CAP Reform Proposal 2003**’ to the results of the reference run shown above, which represent the full implementation of the Agenda 2000 proposal in the year 2009.

Critical points in the analysis are:

(1) Decoupled payments were attributed to eligible hectares per farm type in NUTS II regions. This corresponds to the standard implementation scheme proposed in the draft legal text. However, exception as premiums uniform at regional level are mentioned, and any payment scheme deviating from the implementation system chosen in the modelling exercise could provoke different results.

(2) The uniform premium was calculated based on historical land use and herd patterns from a three year average around 1998. Shifts in production for the now foreseen period 2001-2002 as historical base would somehow affect premiums values at eligible hectares.

(3) Dynamic modulation was based on data provided by Commission services on latest available Farm Accounting Data Network results.

(4) As for the reference run, deviation in income growth, inflation and € to US$ exchange rate could change results relating to domestic and world market prices and market interventions as well as subsidised exports.

(5) Some elements of the proposal, as compulsory farm audits cannot be modelled with the CAPRI system, but the effect on the results discussed below is deemed neglectable.

5.2. Calculation of compensation payments and set-aside obligations in the 'CAP Reform Proposal 2003' run

First of all, the premiums from Agenda 2000 were modified according to the '**CAP Reform Proposal 2003**':

- 50% compensation of the cut in intervention prices by an increase of Grandes Cultures premiums, i.e. an increase by 3 €/t of historic yield to 66 €/ton.

- A reduction of the supplementary payment in durum wheat to 250 €/ha in "traditional areas" bundled with an abolishment of the supplement in "established areas". Introduction of quality top-up of 40 €/ha in "traditional areas" where certain varieties are used.

- Introduction of a compensation payment of 102 €/t in rice (177 €/t – 75 €/t remaining as a crop specific premium).

- Introduction of a premium of 45 €/ha for energy crops (coupled to non-food production activities), a contract with processor required, under a MGA of 1.4 mio ha at EU level.

- Dairy cow premiums were based on an quota expansion beyond the Agenda 2009 level by 2%.

- All other premiums were kept unchanged. Support to Nuts is not included in the runs, as well as direct payments for dehydrated or sun dried fodder.

Table (13) Premium schemes included in the 'CAP Reform Proposal 2003' runs

Text	Activities	Status
Direct payment to Grandes Cultures	Cereals, Oilseeds, Set-Aside, Non-Food on Set-Aside	Amount of payment revised and decoupled
Traditional durum wheat premium	Durum wheat	Amount of payment revised and partly decoupled
Established payment to durum wheat	Durum wheat	Abolished
Rice premium	Paddy rice	Amount of payment revised partly decoupled
Suckler cow premium	Suckler Cows	Decoupled
Special premium to bulls and steers where all are assumed to be bulls	Bulls low and high yield	Decoupled
Direct income support to dairy cows	Dairy cows low and high yield	Decoupled
Direct payment for sheep and goat	Sheep and Goats for Milk	Decoupled
National envelope for sheep and goat	Sheep and Goats for Milk	Decoupled
National envelope dairy cows	Dairy cows low and high yield	Decoupled
National envelope bovine meat cattle	Suckler Cows, Dairy cows low and high yield, Bulls low and high yield, Heifers low and high yield	Decoupled
Slaughter premium for adult cattle	Suckler Cows, Dairy cows low and high yield, Bulls low and high yield, Heifers low and high yield	Decoupled
Slaughter premium for calves	Calves for fattening	Decoupled
National premium to dairy cows in northern Sweden and Finland	Dairy cows low and high yield	Unaffected

The partially redefined premiums falling under the new uniform per farm premium and category, labelled "decoupled", were applied to the three-year average 1998 areas or herd sizes, and cut if respective ceilings were overshot.

The premiums were "modulated" until 2009 by -14% (-19% at the end of 2012 set in the legal text) according to a "three-tier system" (and not "dynamic", as proposed on the first MTR

Proposal). The two top layers will be used to create a budget for the reforms of the dairy and sugar beet sectors. Transfers to the second pillar start in 2006 and rise from 1% until 3% in 2009 (6% at the end of the period in 2012). All payments will be subject to modulation but only above a certain ceiling – 50.000 € per farm- was the full rate of reduction applied. We included the percentages of the groups of payments, which fall under modulation. The information regarding the percentage of direct payments exempt from modulation was provided by Commission Services and is based on a model working on the European Farm Accounting Data Network. Further on, the proposed capping at 300.000€ per farm in the MTR Proposal (July 2002) is abolished.

Afterwards, all received premiums for every farm type are distributed over its eligible hectares (SWHE, DWHE, BARL, RYEM, OATS, OCER, MAIZ, PARI, RAPE, SUNF, SOYA, PULS, SETA, NONF, MAIF, POTA, SUGB, TEXT, TOBA, OIND, OOIL, ROOF, OFAR, GRAE, GRAI, FALL, TOMA, OVEG)[7], and converted into a farm uniform premium per ha in the '**CAP Reform Proposal 2003**' run. The resulting sum is introduced as a premium ceiling, so that direct payments per eligible hectare would be cut if this value were overshot. Durum wheat receives an additional premium of 40 €/ha in "traditional areas", within the MGA limit, provided that certain quantities of seed are used, and rice of 75 €/t of historic yield. According to this proposal (January 2003), vegetables and fruits are also eligible.

Set-aside obligations are defined as "***continuation of the individual historic set-aside obligation***". As in the case of the premiums, we applied the proposed set-aside rate of 10%, corrected by national or regional small producer shares are applied to base year levels (3-year average around 1998) to calculate the necessary set-aside obligation at regional level. The supply models were then not allowed to reduce set-aside below these regional ceilings.

The costs of the ***farm advisory system*** on all relevant material flows and on-farm processes for all farm receiving more than 5000 € are not included in the study. The error is deemed not important, especially as financial support covering operation costs is eligible under Rural Development, and the dynamic modulation will increase budgets available under the second pillar. It can be

[7] See Annex 2 and 3 for the complete code list of production activities and outputs.

expected that regional government will at least partially redirect the budgetary funds into new agri-environmental programs, especially the proposed “temporary and digressive aid (max 200 €/ha) to farms to help them implementing statuary standards”.

6. Main Results: 'CAP Reform Proposal 2003' and Agenda 2000

In this chapter the policy scenarios **Agenda 2000** and **CAP Reform Proposal 2003** are analysed. First of all, the results at EU level will be presented. The main indicators for the supply part of the model are shown in different tables. In the second section, the results at a regional level (NUTS II disaggregation) are explained by using the CAPRI mapping tool. This section is needed in order to get a better picture of the different interactions between activities and products in the model within each country. Lastly, a short analysis is introduced for a set of farm types (see Section 3.4). Aggregated or geographically localised supply responses can hide several impacts for a specific type of farming activity.

6.1. General overview of results: EU level

Table (14) Supply details for the main crop aggregates, premium and income (nominal € 2009/ha), acreage (1000ha), yield (kg/ha) and supply (1000t)[8]

	Base year [1998]					Agenda reference run [2009]					CAP reform proposal 2003 [2009]				
European Union	*Premium per ha*	*Income per ha*	*Hectars*	*Yield*	*Supply*	*Premium per ha*	*Income per ha*	*Hectars*	*Yield*	*Supply*	*Premium per ha*	*Income per ha*	*Hectars*	*Yield*	*Supply*
Cereals	**346**	527	**37694.09**	**5617**	211746	**338** *-2.24%*	356 *-32.45%*	**37163.06** *-1.41%*	**6310** *12.33%*	234495 *10.74%*	**241** *-28.57%*	263 *-26.23%*	**34183.81** *-8.02%*	**6457** *2.33%*	220724 *-5.87%*
Oilseeds	**545**	461	**5573.27**	**3072**	17121	**268** *-50.84%*	99 *-78.54%*	**4585.48** *-17.72%*	**3397** *10.58%*	15576 *-9.02%*	**238** *-11.42%*	77 *-22.71%*	**4432.98** *-3.33%*	**3439** *1.24%*	15245 *-2.13%*
Other arable crops	**100**	2512	**8028.22**	**32934**	264398	**84** *-16.58%*	2538 *1.05%*	**7367.67** *-8.23%*	**37862** *14.97%*	278956 *5.51%*	**190** *127.42%*	2650 *4.41%*	**7341.62** *-0.35%*	**38927** *2.81%*	285786 *2.45%*
Permanent crops & vegetables		4911	**12873.06**	**8746**	112590		5176 *5.40%*	**13069.46** *1.53%*	**8951** *2.35%*	116989 *3.91%*	24	5200 *0.47%*	**13069.46** *0.00%*	**8951** *0.00%*	116989 *0.00%*
Fodder production	**20**	0	**65565.48**	**9018**	591247	**16** *-16.69%*	9 *6890.66%*	**66122.18** *0.85%*	**9206** *2.08%*	608693 *2.95%*	**179** *997.20%*	180 *1836.70%*	**68024.16** *2.88%*	**8888** *-3.44%*	604631 *-0.67%*

The main results for **Agenda 2000 (reference run)** show an increase in total *cereal production* by 10.7 % with respect to base year 1998 as a result of the combined effect of yield growth (12.3 %) and a drop in cultivated area of -1.4 %. The latter is partly due to an increase in set aside

[8] Note that all monetary values for the base year are inflated to the simulation year 2009 for comparison purposes.

obligations, which reduce the amount of land dedicated to cereal production and falling domestic prices. The price decline in **Agenda 2000** is provoked by increasing cereals surpluses compared to the base year policy situation (5.4 MM tons cereals intervened), putting pressure on internal market prices. With falling world market prices in real terms and parallel drop of administrative prices in **Agenda 2000**, cereals producer prices cannot hold to the previous level. Average cereal market prices drop from 142 €/ton to 111 €/ton in 2009 in real terms (closer to the 101.5 €/ton new administrative price).

The other important activity to consider is *oilseeds.* Supply and cultivated area drop by -9 % and -17 % respectively, with yields increasing (10 %) as in the case of cereals (assumed technological improvements). The overall effect is mainly due to a shortening of premiums (-50 %), which are now identical to cereals.

Interaction between the activities is at the one hand due to the competition between crops for arable land. With the uniform premium for oilseeds and cereals, oilseeds loose a comparative advantage and hence lead to substitution from oilseeds to cereals. A second chain of interactions is linked to fodder production on arable land and will be discussed later in the context of animal activities.

In the **'CAP Reform Proposal 2003' (simulation run)** hectares of *cereals* (-8.0 %) and *oilseeds* (-3.3 %) are reduced against the reference run as their premiums are now decoupled and distributed for other activities which previously did not receive any premium (e.g. vegetables, grass production). Compared to the **Agenda 2000** situation, revenues of Grandes cultures including the premiums drop as the premiums are removed, whereas revenues of other arable crops without any specific premiums under **Agenda 2000** are not touched. Relative competitiveness of Grandes Cultures is hence reduced.

The sharper drop for cereals compared to oilseeds is due to the shortening and further decoupling of durum wheat premiums in traditional areas (from 344 €/ha to 250 €/ha), provoking a reduction of supply of *durum wheat* by 27 % in the EU.

Fodder production increases in hectares by 2.9 %, with supply remaining more or less constant. The model keeps grassland fixed – in line with the proposal which prevents conversion of grass into arable land. Within this sector, *fodder maize* (-7.8 %) is replaced by other fodder on arable land (11.5 %). As for cereals and oilseeds, fodder maize revenues drop with the premiums removed, whereas fodder from arable land is untouched. That in turn decreases the relative competitiveness of fodder maize, which is partly replace by fodder production on arable land. The increase in fodder on arable land with constant output quantities explains an extensification of fodder production as shown by a drop in fodder yields by –3.4 %.

Permanent crops and vegetables do not change in the simulation run vs. the reference run because they are not endogenously considered in the current version of the model but trended to 2009 in both scenarios, according to the EU Medium Term Prospects.

Table (15) Supply details for set aside and fallow land, premium and income (nominal € 2009/ha), acreage (1000ha), yield (kg/ha) and supply (1000t)

	Base year [1998]					**Agenda reference run [2009]**					**CAP reform proposal 2003 [2009]**				
European Union	*Premium per ha*	*Income per ha*	*Hectars*	*Yield*	*Supply*	*Premium per ha*	*Income per ha*	*Hectars*	*Yield*	*Supply*	*Premium per ha*	*Income per ha*	*Hectars*	*Yield*	*Supply*
Set aside and fallow land	**154**	157	**9163.11**		1524	**149** *-3.45%*	139 *-10.99%*	**10608.59** *15.78%*		1663 *9.13%*	**176** *18.50%*	168 *20.63%*	**11864.41** *11.84%*		1632 *-1.86%*
Set-aside	**293**	**214**	**4049.41**			**287** *-2.06%*	**206** *-3.70%*	**4742.25** *17.11%*			**223** *-22.28%*	**141** *-31.51%*	**4711.2** *-0.65%*		
Non food on set-aside	**362**	**912**	**623.62**	**2444**	**1524**	**346** *-4.48%*	**798** *-12.54%*	**629.34** *0.92%*	**2642** *8.13%*	**1663** *9.13%*	**311** *-9.94%*	**776** *-2.73%*	**620.77** *-1.36%*	**2629** *-0.51%*	**1632** *-1.86%*
Fallow land			**4490.08**					**5237** *16.63%*			**130**	**130**	**6532.44** *24.74%*		

For **Agenda 2000** the growth in set-aside reflects partially increased set aside obligations from 6.7 % in average 1997-1999 to 10 % assumed in 2009, combined with a loss of profitability of oilseeds. Non-food on set-aside also profits from increased set-aside obligations with a slight increase in hectares of 1%. The drop in gross margins for Grandes cultures provoked by price and premium reduction in real terms combined with increased set-aside obligations leads to an increase of fallow land (excluding set-aside) by about 17%.

For the **'CAP Reform Proposal 2003'** fallow and set-aside areas increase by 11.8 % compared to Agenda 2000. This is under the assumption that all fallow land would be claimed for the decoupled premium, as costs of keeping fallow land in "good agricultural conditions" are far below the uniform premium –in average 50 €-. Acreage of energy crops drops slightly (-1.5 %). Hectares of perennials and vegetables are fixed to the results from the reference run. With respect to other arable crops it is expected that there will be a decrease in hectares of pulses (-7.8%) and an increase in hectares of root crops as potatoes (3.2%) and sugar beets (4.3%) –this is C-sugar because the quota does not change. The total change in area for other arable crops is expected to be very limited. Supply for other arable crops is slightly increased (2.4%) mainly due to potatoes and sugar beet production increases. The increase in sugar beet relates to C-beet whose relative competitiveness increases compared to other Grandes Cultures receiving specific premiums under **Agenda 2000**. It should however be noted that the version of the model applied in here features a somewhat simplified allocation mechanism for sugar beet which probably slightly overestimates the reaction in C-beet.

Table (16) Supply details for cattle activities, premium and income (nominal € 2009/ha), acreage (1000ha), yield (kg/ha) and supply (1000t)

	Base year [1998]					Agenda reference run [2009]					CAP reform proposal 2003 [2009]				
European Union	*Premium per head*	*Income per head*	*Herd Size*	*Yield*	*Supply*	*Premium perhead*	*Income per head*	*Herd Size*	*Yield*	*Supply*	*Premium perhead*	*Income per head*	*Herd Size*	*Yield*	*Supply*
All cattle activities	**45**	459	**84589.56**	**1914**	161945	**122** *170.88%*	400 *-12.87%*	**80299.39** *-5.07%*	**2042** *6.64%*	163943 *1.23%*	**3** *-97.54%*	249 *-37.83%*	**74474.67** *-7.25%*	**2183** *6.93%*	162594 *-0.82%*
Other Cows	**194**	**189**	**11783.36**	**417**	**4908**	**188** *-3.17%*	**214** *12.80%*	**13145.21** *11.56%*	**417** *0.11%*	**5481** *11.68%*	*-100.00%*	**20** *-90.48%*	**10764.12** *-18.11%*	**417** *-0.05%*	**4486** *-18.16%*
Heifers breeding		**290**	**7290.49**	**1000**	**7290**		**157** *-46.00%*	**6745.27** *-7.48%*	**1000** *0.00%*	**6745** *-7.48%*		**81** *-48.58%*	**6316.95** *-6.35%*	**1000** *0.00%*	**6317** *-6.35%*
Fattening male calves		**116**	**3809.93**	**120**	**459**	**47**	**-59** *-150.84%*	**2941.61** *-22.79%*	**126** *4.27%*	**369** *-19.50%*	*-100.00%*	**-24** *59.08%*	**3307.73** *12.45%*	**123** *-1.85%*	**408** *10.36%*
Fattening female calves		**191**	**2227.33**	**148**	**329**	**48**	**47** *-75.26%*	**2048.98** *-8.01%*	**149** *0.72%*	**305** *-7.35%*	*-100.00%*	**0** *-99.25%*	**1720.23** *-16.04%*	**157** *5.87%*	**271** *-11.12%*
Raising male calves		**194**	**10652.18**	**1000**	**10652**		**170** *-12.15%*	**10645.39** *-0.06%*	**1000** *0.00%*	**10645** *-0.06%*		**79** *-53.59%*	**9360.73** *-12.07%*	**1000** *0.00%*	**9361** *-12.07%*
Raising female Calves		**140**	**11593.67**	**1000**	**11594**		**86** *-38.16%*	**10929.34** *-5.73%*	**1000** *0.00%*	**10929** *-5.73%*		**46** *-46.82%*	**10387.14** *-4.96%*	**1000** *0.00%*	**10387** *-4.96%*
Dairy Cows low yield		**541**	**10745.68**	**3404**	**36582**	**159**	**730** *34.88%*	**9536.79** *-11.25%*	**4189** *23.05%*	**39952** *9.21%*	**7** *-95.37%*	**402** *-44.95%*	**9494.38** *-0.44%*	**4192** *0.07%*	**39801** *-0.38%*
Dairy Cows high yield		**1712**	**10745.68**	**7944**	**85359**	**262**	**1941** *13.38%*	**8689.6** *-19.13%*	**9777** *23.08%*	**84956** *-0.47%*	**17** *-93.44%*	**1310** *-32.52%*	**8906.09** *2.49%*	**9782** *0.05%*	**87115** *2.54%*
Male adult cattle low weight	**137**	**35**	**5508.5**	**189**	**1040**	**260** *90.26%*	**-119** *-435.62%*	**5532.63** *0.44%*	**181** *-4.20%*	**1001** *-3.78%*	*-100.00%*	**-173** *-46.25%*	**4834.95** *-12.61%*	**197** *8.93%*	**953** *-4.80%*
Male adult cattle heigh weight	**137**	**318**	**5508.5**	**292**	**1606**	**260** *90.41%*	**60** *-81.03%*	**5479.58** *-0.52%*	**279** *-4.45%*	**1527** *-4.95%*	*-100.00%*	**31** *-48.75%*	**4891.09** *-10.74%*	**304** *9.12%*	**1487** *-2.60%*
Heifers fattening low weight		**501**	**2362.13**	**364**	**861**	**86**	**239** *-52.36%*	**2337.28** *-1.05%*	**359** *-1.38%*	**840** *-2.41%*	*-100.00%*	**195** *-18.47%*	**2264.79** *-3.10%*	**364** *1.29%*	**824** *-1.86%*
Heifers fattening high weight		**1092**	**2362.13**	**536**	**1265**	**86**	**662** *-39.40%*	**2267.72** *-4.00%*	**526** *-1.80%*	**1193** *-5.72%*	*-100.00%*	**635** *-4.09%*	**2226.47** *-1.82%*	**532** *1.16%*	**1184** *-0.68%*

For **Agenda 2000** dairy ***cow*** yields for low and high yielding cows are estimated to increase by 23 % from 1998 to 2009, reflecting technical progress. In the reference run the model predicts that the process of shifting supply to more efficient cows will slow down – the number of high yield milk cows drops by –19 % compared to about –11 % for low yield milk cows. This shift is due to the reduction in milk prices combined with the pressure over the young animal markets.

The total dairy cow herd is simulated to decrease by –15.2 % to an inventory of 18.2 Mio dairy cows in 2009. The trend of growing suckler cow herds observed in the last year continues up to a herd size of 13 Mio heads (11.6 %) in 2009. The aggregated number of cattle activities thus decreases by 5 %. The number of male adult cattle for fattening is rather stable, on the other hand male and female calves for fattening will decrease with about respectively –22% and –8%.

In the **'CAP Reform Proposal 2003'** the assignment of premiums to land, previously attached to animals, leads formally to a drastic drop in income per activity unit, both for milk cows and cattle fattening processes. However, the biggest part of this shift will be offset by direct income payments to grass land used for cattle production (grass activity eligible for decoupled payments). Inside of the cattle chain, activities, which draw a higher part of their income from direct payments, are affected most. Accordingly, suckler cows herd drops by some –7.3 %, and milk production is intensified by a shift to high yield cows. These developments interact with reduced herd sizes in the fattening chain, as well as with an increase of average slaughter weights. The latter is due to the fact that, in the reference run, animals with low final weights draw a higher percentage of income from direct payments in. The number of cattle is reduced by -7.2 %.

Farm specific premiums do change the picture, as a higher part of the direct support paid to cattle is redirected to grass land within the same farm, compared to uniform regional payments at NUTS II level (previous version of the model). This means that there is a slight smoother effect on activity levels since direct support does not move from cattle production specialised farm types to other farm types. The results are coupled to the assumption that grassland cannot be converted to set-aside.

Dairy cows are still competitive after removal of direct payments, increasing milk output parallel to quota (1.6%). A reduction of sheep and goat milk by about –6.2 % leads to no changes in output of processed dairy products produced both from cow and sheep and goat milk. Slight changes occur for human consumption as well, partly due to cross price effects from changes in meat and crop prices. Net trade of processed dairy products is slightly reduced.

Table (17) Product balances for meat (1000t)

European Union	*Supply*	*Intervention*	*Net trade*	*Demand*	*Supply*	*Intervention*	*Net trade*	*Demand*	*Supply*	*Intervention*	*Net trade*	*Demand*
Meat	35011		2302	32708	36859		2074	34786	36588		1769	34819
					5.28%		*-9.93%*	*6.35%*	*-0.74%*		*-14.70%*	*0.10%*
Beef	7020		452	6568	6627		254	6373	6397		43	6354
					-5.60%		*-43.86%*	*-2.97%*	*-3.47%*		*-82.98%*	*-0.30%*
Veal	788		59	728	674		-37	711	679		-30	708
					-14.42%		*-161.45%*	*-2.43%*	*0.65%*		*18.94%*	*-0.36%*
Pork meat	17318		1335	15983	18922		1564	17358	18939		1559	17380
					9.26%		*17.12%*	*8.60%*	*0.09%*		*-0.34%*	*0.13%*
Sheep and goat meat	1138		-255	1393	1120		-274	1394	1045		-358	1403
					-1.65%		*-7.49%*	*0.02%*	*-6.66%*		*-30.67%*	*0.69%*
Poultry meat	8746		710	8036	9517		566	8951	9528		555	8973
					8.81%		*-20.24%*	*11.38%*	*0.11%*		*-2.04%*	*0.25%*

Mainly by using the assumption of EU's Medium Term Prospects regarding the development of per capita consumption for the different meat products, total meat demand is forecasted to grow by 6 % from 1998 to 2009. This is reflected in the reference run results (trend going from 1998 to 2009). The sharpest increase is forecasted for **poultry meat** with 11 %, which combined with a production growing by around 9 % reduces somewhat EU's position as a net exporter. The increase in production is calibrated to the expectations of DG-AGRI by assuming that input saving technical progress for capital and labour was –2 % per annum. The decrease in beef production (-5.6%) is due to several factors, (1) negative demand trend according to EU's Medium Term Prospects, (2) the changes observed in Table (16) for the cattle activities, outweighing the drop of fattening activities (suckler cows increases) in terms of meat production, and (3) positive demand trends for poultry and pork production, making these activities more attractive.

In the **'CAP Reform Proposal 2003'** supply of beef (-3.8 %) and sheep and goat meat (-6.6 %) is expected to drop, whereas veal, pork and poultry meat remain stable. Meat consumption increases slightly (0.1 %) with consumer prices remaining almost constant in average (0.4%). Whereas pork and poultry meat consumer prices are stable, sheep and goat meat prices increase (3.4%). Reduced supply from the cattle chain raises farm gate prices for beef by 2.4 % and consumer prices by 0.9 %.

Table (18) Supply details for fodder and grass production activities, premium and income (nominal € 2009/ha), acreage (1000ha), yield (kg/ha) and supply (1000t)

	Base year [1998]					Agenda reference run [2009]					CAP reform proposal 2003 [2009]				
European Union	*Premium per ha*	*Income per ha*	*Hectares*	*Yield*	*Supply*	*Premium per ha*	*Income per ha*	*Hectares*	*Yield*	*Supply*	*Premium per ha*	*Income per ha*	*Hectares*	*Yield*	*Supply*
Fodder production	20	0	65565.48	9018	591247	16 -16.69%	9 6890.66%	66122.18 0.85%	9206 2.08%	608693 2.95%	179 997.20%	180 1836.70%	68024.16 2.88%	8888 -3.44%	604631 -0.67%
Fodder maize	311	368	3843	42070	161674	294 -5.45%	365 -0.59%	3675.93 -4.35%	44033 4.67%	161864 0.12%	285 -3.04%	364 -0.29%	3334.85 -9.28%	44752 1.63%	149240 -7.80%
Fodder root crops		2590	113.02	70883	8011		3087 19.19%	108.93 -3.62%	79508 12.17%	8661 8.11%	316	3316 7.40%	114.32 4.95%	78728 -0.98%	9001 3.92%
Fodder other on arable land	8	264	11834.15	9175	108579	-100.00%	261 -1.12%	12562.01 6.15%	9059 -1.27%	113794 4.80%	207	456 74.40%	14799.68 17.81%	8570 -5.39%	126839 11.46%
Gras and grazings extensive		-73	24887.66	3773	93895		-68 7.10%	26184.32 5.21%	4055 7.47%	106171 13.07%	164	97 243.06%	26949.58 2.92%	4074 0.47%	109787 3.41%
Gras and grazings intensive		-121	24887.66	8803	219088		-109 10.31%	23590.99 -5.21%	9249 5.07%	218204 -0.40%	164	56 151.82%	22825.73 -3.24%	9190 -0.64%	209766 -3.87%

In **Agenda 2000** a shift from intensive grass to extensive grass production is observed. The total amount of hectares does not change due to a restriction, which fix grass production area in the model. Although fewer premiums are paid to fodder maize (-5.4%), supply remains stable (0.1 %) due to increases in yield because of technical progress. On the other hand, and as already mentioned before for other activities like cereals or other arable crops, fodder root crops increase due to substitution effects. For the **'CAP Reform Proposal 2003'** simulation run, these mentioned shifts are further on observed. Extensive grass production is increased and the inclusion of decoupled premiums drives all fodder crops but fodder maize to increases in area and supply because of its more competitive position.

The next table shows the agricultural income effect for the European Union as a whole. In the Base year something less than 30% of Agricultural income in the European Union comes from permanent crops and vegetables, about 25% comes from cattle activities and another 25% comes from cereals, oilseeds and other arable crops, other animals account for the rest.

Under **Agenda 2000** agricultural income in the European Union decreases with about –11.6%. Income from all activities decreases except permanent crops and vegetables and fodder production activities. The share of permanent crops and vegetables in agricultural income increases to about 50%.

For the **CAP Reform proposal 2003**, agricultural income in the European Union decreases with about –3.8%. The decrease mainly results from a decrease in income from cereals, oilseeds and all cattle activities.

Table (19) Agricultural income in European Union (1000 Euro of 2009)

	Base year [1998]				Agenda reference run [2009]				CAP reform proposal 2003 [2009]			
European Union	*Revenues*	*Costs*	*Premiums*	*Income*	*Revenues*	*Costs*	*Premiums*	*Income*	*Revenues*	*Costs*	*Premiums*	*Income*
Cereals	**30642**	**23793**	**13027.5**	**19876**	**26581.2** *-13.25%*	**25900** *8.86%*	**12556.9** *-3.61%*	**13237.9** *-33.40%*	**25051.4** *-5.76%*	**24320** *-6.10%*	**8250.34** *-34.30%*	**8982.2** *-32.15%*
Oilseeds	**3354.8**	**3823.7**	**3040.17**	**2571.2**	**2476.55** *-26.18%*	**3252.3** *-14.94%*	**1229.69** *-59.55%*	**453.92** *-82.35%*	**2443.08** *-1.35%*	**3156.9** *-2.93%*	**1053.02** *-14.37%*	**339.19** *-25.28%*
Other arable crops	**27193**	**7832.4**	**804.88**	**20166**	**25958.4** *-4.54%*	**7874.1** *0.53%*	**616.18** *-23.44%*	**18700.5** *-7.27%*	**26082.4** *0.48%*	**8022.8** *1.89%*	**1396.34** *126.61%*	**19456** *4.04%*
Permanent crops & vegetables	**80221**	**17006**		**63214**	**85675.4** *6.80%*	**18028** *6.01%*		**67647** *7.01%*	**85675.4** *0.00%*	**18028** *0.00%*	**315.25**	**67963** *0.47%*
Fodder production	**19987**	**21281**	**1285.42**	**-8.97**	**21169.6** *5.92%*	**21635** *1.66%*	**1079.92** *-15.99%*	**614.58** *6948.32%*	**21708.5** *2.55%*	**21653** *0.09%*	**12189.7** *1028.76%*	**12245** *1892.40%*
Beef meat production	**23917**	**19773**	**3796.53**	**7940.7**	**19858.7** *-16.97%*	**21053** *6.47%*	**5734.96** *51.06%*	**4540.76** *-42.82%*	**18404.2** *-7.32%*	**17019** *-19.16%*	*-100.00%*	**1385.3** *-69.49%*
Set aside and fallow land	**460.62**	**439.14**	**1412.66**	**1434.1**	**412.06** *-10.54%*	**513.11** *16.85%*	**1579.02** *11.78%*	**1477.97** *3.06%*	**413.61** *0.38%*	**512.25** *-0.17%*	**2092.58** *32.52%*	**1993.9** *34.91%*
All cattle activities	**106548**	**71516**	**3796.53**	**38829**	**93170.5** *-12.56%*	**70819** *-0.97%*	**9762.62** *157.15%*	**32114.5** *-17.29%*	**83333.8** *-10.56%*	**65039** *-8.16%*	**222.77** *-97.72%*	**18518** *-42.34%*
Other animals	**67016**	**47767**	**2490.01**	**21738**	**58329.9** *-12.96%*	**45619** *-4.50%*	**1438.84** *-42.22%*	**14149.5** *-34.91%*	**59071.2** *1.27%*	**45871** *0.55%*	*-100.00%*	**13201** *-6.71%*
Sum	**335422**	**193459**	**25857.2**	**167820**	**313774** *-6.45%*	**193641** *0.09%*	**28263.2** *9.30%*	**148396** *-11.57%*	**303779** *-3.19%*	**186602** *-3.63%*	**25520** *-9.71%*	**142697** *-3.84%*

6.2. Analysis of country results

In the next subchapter the main results for the member states are presented.

Table (20) Supply details for cereals at a member state level, premium and income (nominal € 2009/ha), acreage (1000ha), yield (kg/ha) and supply (1000t)

	Base year [1998]					Agenda reference run [2009]					CAP reform proposal 2003 [2009]				
SUPPLY CEREALS	*Premium per ha*	*Income per ha*	*Hectares*	*Yield*	*Supply*	*Premium per ha*	*Income per ha*	*Hectares*	*Yield*	*Supply*	*Premium per ha*	*Income per ha*	*Hectares*	*Yield*	*Supply*
BELGIQUE	**368**	196	**329.7**	**7205**	2375	**356** *-3.22%*	-73 *-137.24%*	**319.6** *-3.06%*	**8360** *16.03%*	2672 *12.48%*	**306** *-14.15%*	-116 *-58.80%*	**306.23** *-4.18%*	**8389** *0.35%*	2569 *-3.85%*
DENMARK	**349**	718	**1522**	**6253**	9517	**329** *-5.74%*	523 *-27.16%*	**1510.34** *-0.77%*	**6811** *8.93%*	10287 *8.09%*	**292** *-11.26%*	490 *-6.35%*	**1453.81** *-3.74%*	**6838** *0.39%*	9941 *-3.36%*
GERMANY	**375**	520	**6892.11**	**6642**	45776	**353** *-5.79%*	305 *-41.33%*	**6763.21** *-1.87%*	**7550** *13.67%*	51063 *11.55%*	**288** *-18.26%*	246 *-19.31%*	**6411.26** *-5.20%*	**7593** *0.57%*	48680 *-4.67%*
GREECE	**398**	615	**1290.51**	**3602**	4648	**407** *2.15%*	508 *-17.49%*	**1379.06** *6.86%*	**3689** *2.42%*	5087 *9.44%*	**143** *-64.85%*	242 *-52.37%*	**1191.37** *-13.61%*	**3773** *2.27%*	4495 *-11.65%*
SPAIN	**198**	352	**6773.39**	**3043**	20612	**205** *3.36%*	270 *-23.30%*	**6459.86** *-4.63%*	**3420** *12.38%*	22091 *7.18%*	**129** *-36.82%*	188 *-30.44%*	**5762.44** *-10.80%*	**3520** *2.92%*	20282 *-8.19%*
FRANCE	**392**	597	**9092.31**	**7251**	65926	**379** *-3.25%*	383 *-35.82%*	**8962.61** *-1.43%*	**8308** *14.58%*	74462 *12.95%*	**279** *-26.45%*	294 *-23.20%*	**8442.13** *-5.81%*	**8397** *1.07%*	70886 *-4.80%*
IRELAND	**406**	637	**300.04**	**6603**	1981	**383** *-5.74%*	454 *-28.80%*	**263.61** *-12.14%*	**7311** *10.71%*	1927 *-2.73%*	**240** *-37.41%*	307 *-32.37%*	**190.5** *-27.73%*	**7456** *1.98%*	1420 *-26.30%*
ITALIA	**445**	869	**4145.72**	**4990**	20687	**455** *2.27%*	721 *-17.12%*	**4278.51** *3.20%*	**5359** *7.40%*	22929 *10.84%*	**258** *-43.39%*	531 *-26.37%*	**3834.18** *-10.39%*	**5534** *3.27%*	21219 *-7.46%*
HOLLAND	**382**	327	**202.38**	**7243**	1466	**358** *-6.20%*	97 *-70.42%*	**213.76** *5.62%*	**7839** *8.23%*	1676 *14.32%*	**294** *-17.96%*	42 *-56.54%*	**200.19** *-6.35%*	**7862** *0.29%*	1574 *-6.08%*
AUSTRIA	**357**	495	**832.46**	**5877**	4893	**337** *-5.60%*	326 *-34.10%*	**830.86** *-0.19%*	**6299** *7.18%*	5234 *6.98%*	**268** *-20.38%*	264 *-18.98%*	**775.06** *-6.72%*	**6401** *1.61%*	4961 *-5.21%*
PORTUGAL	**266**	202	**604.54**	**2724**	1647	**267** *0.28%*	101 *-49.84%*	**545.71** *-9.73%*	**3030** *11.24%*	1654 *0.42%*	**208** *-22.20%*	2 *-97.69%*	**369.3** *-32.33%*	**3566** *17.67%*	1317 *-20.37%*
SWEDEN	**272**	174	**1234.66**	**4653**	5745	**246** *-9.57%*	14 *-91.95%*	**1263.13** *2.31%*	**5101** *9.63%*	6443 *12.16%*	**199** *-19.22%*	-33 *-333.77%*	**1189.19** *-5.85%*	**5157** *1.10%*	6133 *-4.82%*
FINLAND	**200**	111	**1116.03**	**3052**	3406	**188** *-6.01%*	-1 *-100.75%*	**1111.09** *-0.44%*	**3220** *5.50%*	3577 *5.03%*	**139** *-26.20%*	-52 *-6134.20%*	**982.5** *-11.57%*	**3230** *0.31%*	3173 *-11.30%*
UNITED KINGDOM	**392**	534	**3358.23**	**6869**	23066	**371** *-5.31%*	296 *-44.62%*	**3261.71** *-2.87%*	**7785** *13.34%*	25393 *10.09%*	**281** *-24.19%*	213 *-27.88%*	**3075.66** *-5.70%*	**7827** *0.54%*	24074 *-5.19%*

Having in mind the data for the EU presented in the previous subchapter, Table (20) shows that *cereals* follow a similar pattern in all member states: for **Agenda 2000** yields and supply increase and income per hectare drops; for the **'CAP Reform 2003'** supply decreases and premiums per hectare are shortened drastically. Interesting is though to see how certain countries react to the policy changes implemented in the model.

Changes from the base year to **Agenda 2000** are mainly due to changes in market prices and premiums in real terms. The small change in administrative prices in nominal terms (-14.9%) is not fully mapped into changes in market prices, but taking into account inflation (1.9% per annum), leads to a loss in market revenues (-13.25%) at EU level. The reduction in administrative prices is only partially compensated by increases in premiums in nominal terms from 54 to 63

Euro per ton of historical yield. The compensation effect is further reduced as actual yields increase (technological change) whereas the premiums are based on the historical yields from the early nineties. In real terms, the premiums per hectare are lower than in the base year (-2.24%) despite the mentioned nominal increase per ton. Accordingly, in all regions the sum of revenues and premiums drops in real terms with input costs almost increasing with inflation. Resulting from this is a reduction of the gross margins (revenues minus costs) in real terms.

The relative reduction of the gross margin is high in regions where the difference between revenues and costs is small, typically found in regions with low yields and/or high production costs per ton. *Portugal* represents this case with low cereal production (1.6 MMt) and very low yields (2.7 t/ha). This is translated into high relative input costs and low gross margins in the base year situation, being premiums necessary to maintain production. On the other side, *France* is a typical example of a favourable production site; in the base year it is the highest cereal producer (65.9 MMt) and has very high yields (7.2 t/ha). Accordingly relative small changes of gross margins in real terms provoke only minor changes in the cropping pattern and cereal production is relatively very competitive, covering revenues production costs, without "having to make use" of premiums. Therefore, is not surprising that in **Agenda 2000** *Portugal* is further affected than *France*. Cereal production remains almost unchanged in the former, not getting much from the technological change, and increases rapidly in the latter (13%).

For the simulation scenario **'CAP Reform 2003'** cereals drop generally. The results differ though in the different countries according to the proportion of durum wheat production in the cereals aggregate (activity most affected by less received premiums), the relative importance of cereals in the country, and its relative competitiveness. In Portugal cereal hectares decrease higher than in the rest of the countries (-32.33%) due to a high percentage of durum wheat production in cereals (it falls by 64%). In Ireland cereals acreage experiences also a strong decrease, due to the general presence in Irish farms of fodder production with some cereal production. Additionally fodder maize is not grown in Ireland, activity that received previously a specific payment. Premiums are therefore shifted within the same farm to fodder activities by the decoupling mechanism. The rest of the countries experience also drops in cereal areas, but not far away from the European average, which was previously explained.

Table (21) Supply details for male adult cattle low weight at a member state level, premium and income (nominal € 2009/ha), acreage (1000ha), yield (kg/ha) and supply (1000t)

	Base year [1998]					Agenda reference run [2009]					CAP reform proposal 2003 [2009]				
	Premium per ha	Income per ha	Hectars	Yield	Supply	Premium per ha	Income per ha	Hectars	Yield	Supply	Premium per ha	Income per ha	Hectars	Yield	Supply
						318	60	144.75	237	34		-6	120.86	268	32
BELGIQUE	166	287	140.22	254	36	91.61%	-79.28%	3.23%	-7.04%	-4.03%	-100.00%	-110.25%	-16.51%	13.11%	-5.56%
						285	-208	150.08	127	19		-283	114.92	174	20
DENMARK	164	-132	140.45	136	19	74.18%	-56.85%	6.86%	-6.88%	-0.50%	-100.00%	-36.38%	-23.43%	36.73%	4.70%
						272	-80	1042.07	197	205		-143	861.07	223	192
GERMANY	146	58	1011.77	208	210	85.70%	-237.87%	2.99%	-5.42%	-2.59%	-100.00%	-78.59%	-17.37%	13.41%	-6.29%
						299	4	53.22	214	11		-51	44.13	236	10
GREECE	166	236	54.36	222	12	80.12%	-98.26%	-2.09%	-3.47%	-5.49%	-100.00%	-1349.17%	-17.07%	10.16%	-8.65%
						205	-171	580.95	180	105		-182	562.41	185	104
SPAIN	98	11	605.88	186	113	109.64%	-1613.63%	-4.11%	-3.10%	-7.08%	-100.00%	-5.93%	-3.19%	2.50%	-0.77%
						268	-189	978.3	188	184		-258	880.08	197	174
FRANCE	145	0	1002.16	193	193	84.29%	-43249.31%	-2.38%	-2.35%	-4.67%	-100.00%	-36.30%	-10.04%	4.87%	-5.66%
						292	-11	515.5	187	96		-95	417.31	200	83
IRELAND	166	98	520.75	190	99	75.56%	-110.69%	-1.01%	-1.57%	-2.56%	-100.00%	-807.67%	-19.05%	6.86%	-13.50%
						179	-195	753.56	185	139		-175	753.62	192	145
ITALIA	66	9	753.34	195	147	171.66%	-2279.51%	0.03%	-5.11%	-5.08%	-100.00%	9.85%	0.01%	3.92%	3.93%
						259	217	101.3	319	32		183	91.79	340	31
HOLLAND	130	447	100.85	328	33	99.34%	-51.38%	0.44%	-2.58%	-2.15%	-100.00%	-15.81%	-9.39%	6.43%	-3.56%
						291	-113	168.36	160	27		-172	132.59	190	25
AUSTRIA	166	7	162.2	173	28	75.07%	-1756.49%	3.80%	-7.68%	-4.18%	-100.00%	-52.19%	-21.25%	19.17%	-6.15%
						297	75	87.05	216	19		53	69.95	255	18
PORTUGAL	166	281	84.64	229	19	79.07%	-73.39%	2.86%	-5.98%	-3.29%	-100.00%	-29.46%	-19.65%	18.34%	-4.92%
						299	-197	126.19	196	25		-309	107.04	213	23
SWEDEN	166	-66	124.6	199	25	80.32%	-200.32%	1.28%	-1.36%	-0.10%	-100.00%	-56.75%	-15.18%	8.35%	-8.09%
						300	-259	103.48	160	17		-378	81.47	189	15
FINLAND	166	-184	97.27	166	16	80.65%	-41.27%	6.39%	-3.60%	2.55%	-100.00%	-45.70%	-21.27%	17.84%	-7.22%
UNITED						295	-195	727.81	121	88		-279	597.71	135	81
KINGDOM	166	-95	710	128	91	78.01%	-105.54%	2.51%	-5.17%	-2.79%	-100.00%	-43.31%	-17.88%	11.37%	-8.54%

Table 21 shows the supply details for activity male adult cattle low weight. It was decided to show effects for this activity in more detail because of the important changes in the beef market both in the **Agenda 2000** reference run and in the '**CAP reform proposal 2003**'. CAPRI features many activities producing beef (dairy activities with beef as a secondary product, fattening activities and raising activities). The activity male adult cattle are split in male adult cattle low weight and male adult cattle high weight. In the base year it is assumed that fifty percent of the total number of male adult cattle belongs to the category low weight and fifty percent belongs to the category high weight. Hence, table 20 only shows fifty percent of the total number of male adult cattle in the Base year.

Having in mind the data for the EU presented in the previous subchapter, Table 20 shows that activity *male adult cattle low weight* follows a similar pattern in all member states: for **Agenda 2000** yields and supply decrease and income per head drops; for the **'CAP Reform 2003'** supply decreases and premiums per head are shortened drastically, being the slaughtering premium of 80 €/head introduced in **Agenda 2000** decoupled and distributed over hectares.

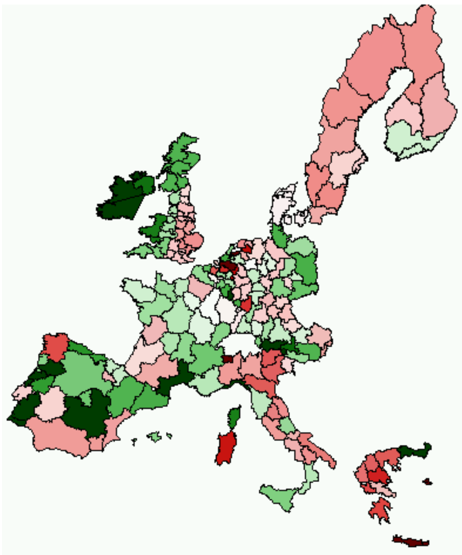
In all regions the sum of revenues and premiums drops in real terms with input costs almost increasing with inflation. As for cereals income changes from the base year to **Agenda 2000** are mainly due to changes in market prices in real terms (drop of administrative prices drive producer price decreases). Contrary to cereals, the share of the premiums in total revenues increases drastically, due to the fact that male adult cattle gets the new slaughtering premium. Since income losses are mainly determined by lower market prices, not being compensated by the new premium, income effects are biggest in countries with relative low share of premium in total revenue and a high share of income from the market. The most affected countries are: Germany, France, Spain and Italy. The overall effect is negative for supply due to almost no increases in number of heads and a decrease in yield per head.

The drop in beef prices and lower heard sizes in suckler and dairy cows puts also some pressure in the young animal market. On the one side beef output prices decrease, and therefore are cattle activities less competitive and on the other side input costs for male adult cattle increase (young male bulls) because of less mother cows in the market.

For the simulation scenario **‘CAP Reform 2003’** the number of male adult cattle low weight drops generally. The large decrease in number of heads is explained by the decoupling of premiums. The higher the share of premiums in income in the reference period, the bigger the income effects and the decrease in number of heads. In terms of income the most affected countries are Belgium, Greece and Ireland. Supply is less affected for this activity, because of shifts from high weight cattle activities to low weight ones.

6.3. Analysis of regional results: NUTS II level

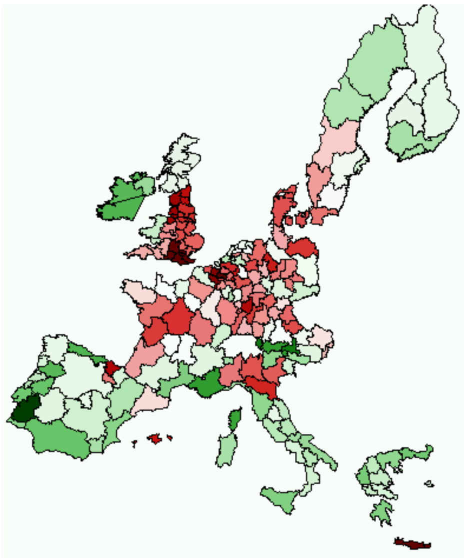
Map (1) Changes in cereal acreages (1000ha): Agenda 2000 vs. base year



Note: From dark green to light green: between –23 % and –5 %, white around –1 % and from light red to dark red between -4 % and 34 %.

The previous map pictures the changes in hectares of cereals for the **Agenda 2000** run. The map underlines the results discussed above for the Member States: the slight average reduction at EU level of –1.4% results from partially diverse effects at regional level. Increases in **Agenda 2000** compared to the base year can be observed in some mediterranean regions. For Greece, the main reason is the reduction in flax and hemp area, which in combination with a reduction of oilseeds by around a third due to the now uniform premium for cereals and oilseeds. For Italy, the expansion is mainly due to a reduction again in oilseeds combined with the continued long-term trend in reduction of areas of sugar beet – increases in yields with fixed quotas drive production down – as well as of potatoes and tobacco. In Sweden, the main reason for the expansion is continued reduction in other crop area, which allows for an expansion of cereals. The changes in the Netherlands relate to rather small shares of cereals and are provoked by changes in perennial crops and vegetables. In opposite to these effects, the important production regions in France, Spain and Germany where the increased set-aside obligations and reduced competitiveness with prices and premiums in real terms provoke a shift towards set-aside dominate the EU average.

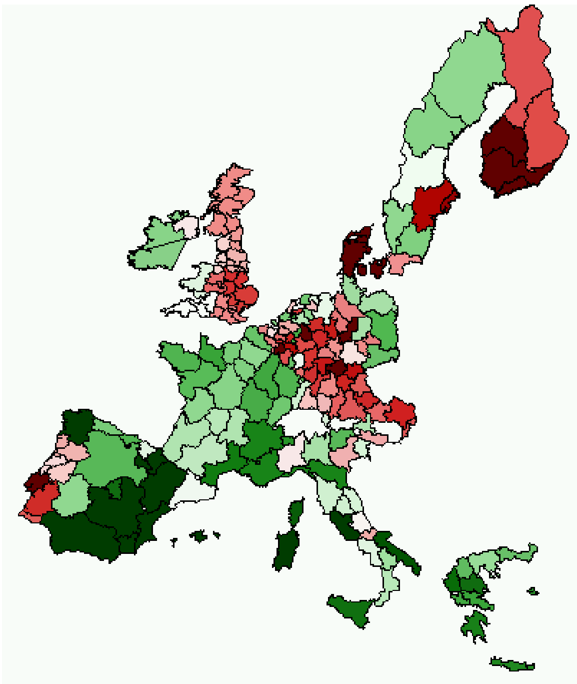
Map (2) Cereals regional acreages (1000ha): 'CAP Reform 2003' vs. Agenda 2000



Note: From dark green to light green: between –46 % and –10 %, white around –6 % and from light red to dark red between -4 % and -2 %.

For the **'CAP Reform 2003'** all regions experience drops in cereals (see previous map) because of the decoupling of premiums. As already explained for the EU case, the distribution of premiums makes other activities relatively more competitive. The main regional changes are due to the competitiveness of the sector. Regions in East England, Central Europe, Denmark and North Italy show changes under the European average, whereas North Sweden, Ireland and the Southern regions are most affected.

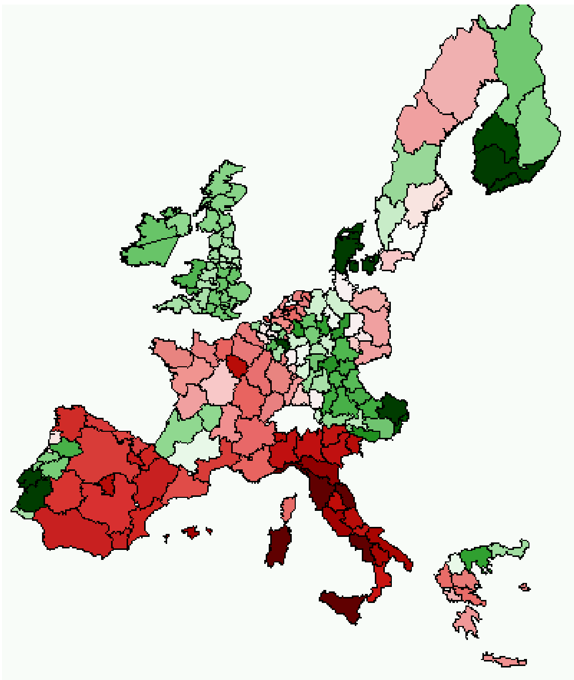
Map (3) Male adult cattle low weight activity level (1000heads): Agenda 2000 vs. base year



Note: From dark green to light green: between –6 % and +1 %, white around 1.6 % and from light red to dark red between 1 % and +6 %.

The previous map pictures the changes in number of male adult cattle low weight for the **Agenda 2000** run. The map underlines the results discussed above for the Member States: the changes at EU level results from partially diverse effects at regional level. Decreases in **Agenda 2000** compared to the base year can be observed in most regions of Germany, France, Italy and Spain. The regions most affected are characterised by a relative high share of total revenue coming from the market and a relative small share coming from premiums. Especially in Germany and in the Netherlands there are large differences between regions.

Map (4) Male adult cattle low weight activity levels (1000heads): 'CAP Reform 2003' vs. Agenda 2000



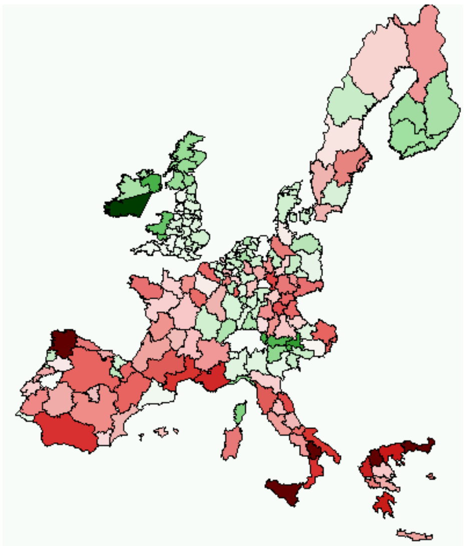
Note: From dark green to light green: between –24 % and –15.5 %, white around –16 % and from light red to dark red between -14 % and +0 %.

For the simulation scenario **'CAP Reform 2003'** the number of male adult cattle low weight drop generally. The map presented above shows that the effects are about the opposite of the effects of **Agenda 2000**. Under the **CAP Reform proposal 2003**, regions with a relative high share of premium in total revenue are affected most, especially Ireland, United Kingdom, Portugal and some regions in Germany.

The following map shows the change in the aggregate "fallow land and set-aside" in the '**CAP Reform Proposal 2003**' compared to the reference run. As the map reveals, the 'CAP Reform Proposal 2003' does not dramatically change the overall picture. On EU level, there is an increase of fallow land plus set-aside of about 11 %. Reductions are observed in Southern Finland and Ireland, where fallow arable land is now converted into low productive fodder production.

Increases occur mostly in Southern Member States, but the absolute share on agricultural land is increasing by not more than 1-2 %.

Map (5) Percentage of the aggregate "set-aside and fallow land" in total utilizable agricultural area: 'CAP Reform Proposal 2003' simulation run versus Agenda 2000



Note: From dark green to light green: between -64 % and -14 %, white around -11 % and from light red to dark red between 7 % and 56 %.

A technical Note on the modelling specialities of the aggregate set-aside/fallow land.

The modelling system distinguishes set-aside and fallow land, in order to allow for modelling of compulsory set-aside obligations and voluntary set-aside programs. By the introduction of a uniform premium paid to both activities, the model technically moves areas from set-aside to fallow land. The results for the '**CAP Reform Proposal 2003**' should hence be interpreted for the aggregate of both.

6.4. Analysis of results at a farm level: farm types

In this section the income effects of the **Agenda reference run** and the CAP Reform Proposal scenarios are discussed at farm type level. Broadly speaking the changes in agricultural production at the regional farm type level mostly mimics the changes in agricultural production for the region as a whole. For example, an increase in number of other cows or male adult cattle low weight at the regional level for **Agenda 2000 reference run**, is the result of the increase in these activities at all farm types included for the region. Differences in income changes between farm types within the region, mainly results from differences in composition of agricultural production or differences in output composition.

Table (22) shows economic information relating to the individual production activities or groups of activities per farm type. The number without brackets gives the impact of all farms belonging to a specific farm type. The number in brackets refers to the individual farm (total amount divided by aggregation weight).

For **Agenda 2000** the income effects ranges from +6.7% for farm type Permanent crops and vegetables to –60% for farm type Sheep and goats. The latter results from a decrease in revenues (-12.8%) and premiums (-27.5%). Other farm types, which experience large income effects under the Agenda 2000 reference run compared to the base, are Specialist pigs and other farm types with relative large shares of income from pigs and poultry. Income for farm type Dairy and Cattle fattening & rairing are relative to other farm types less affected.

Under **CAP reform proposal 2003** the largest decrease in income was found for farm type Dairy. Income decreases because of the decrease of producer price of milk of about –12.4% and the decrease in premiums of about –4.4%. These effects are only partially compensated by a switch from low producing dairy cows to high producing dairy cows and other technology switches resulting in lower input costs. Remarkably enough income at farm type Cattle fattening & rairing increases under **CAP reform proposal 2003**. This mainly results form the costs decreasing effect of decoupled premiums.

Table (22) Economic indicators per farm type.[1]

	Base year [1998]				Agenda reference run [2009]				CAP reform proposal 2003 [2009]			
	Revenues	*Costs*	*Premiums*	*Income*	*Revenues*	*Costs*	*Premiums*	*Income*	*Revenues*	*Costs*	*Premiums*	*Income*
Specialist COP other than rice or various	**58766**	**28886.7**	**9745.91**	**39625**	**54720.2**	**29923.9**	**8622.98**	**33419**	**54147.2**	**29127.2**	**7354.16**	**32374**
	[28299.85]	[13910.94]	[4693.33]	[19082.23]	[26351.54]	[14410.39]	[4152.56]	[16093.70]	[26075.57]	[14026.73]	[3541.53]	[15590.38]
					-6.88%	3.59%	-11.52%	-15.66%	-1.05%	-2.66%	-14.71%	-3.13%
Rice or rice & COP	**66.42**	**19.51**	**4.62**	**51.53**	**67.02**	**22.33**	**5.7**	**50.39**	**61.14**	**21.88**	**18.16**	**57.42**
	[8823.70]	[2591.58]	[613.93]	[6846.05]	[8903.69]	[2966.09]	[757.01]	[6694.61]	[8123.15]	[2907.48]	[2412.96]	[7628.64]
					0.91%	14.45%	23.31%	-2.21%	-8.77%	-1.98%	218.75%	13.95%
Root crops	**5635.83**	**2928.39**	**623.99**	**3331.4**	**4900.27**	**3048.18**	**600.47**	**2452.6**	**4882.34**	**3028.31**	**533.33**	**2387.4**
	[72760.56]	[37806.63]	[8055.94]	[43009.87]	[63264.33]	[39353.10]	[7752.34]	[31663.57]	[63032.75]	[39096.62]	[6885.48]	[30821.61]
					-13.05%	4.09%	-3.77%	-26.38%	-0.37%	-0.65%	-11.18%	-2.66%
Permanent crops and vegetable	**25340.5**	**6036.87**	**619.37**	**19923**	**26996.4**	**6376.51**	**629.67**	**21250**	**26778.3**	**6214.5**	**462.47**	**21026**
	[11569.56]	[2756.22]	[282.78]	[9096.12]	[12325.59]	[2911.29]	[287.49]	[9701.79]	[12226.02]	[2837.32]	[211.15]	[9599.85]
					6.53%	5.63%	1.66%	6.66%	-0.81%	-2.54%	-26.55%	-1.05%
Dairy	**63988.7**	**43765.4**	**2352.74**	**22576**	**57677.9**	**42277.6**	**5018.87**	**20419**	**53297.9**	**40665.9**	**4797**	**17429**
	[51527.82]	[35242.73]	[1894.57]	[18179.66]	[46445.93]	[34044.65]	[4041.52]	[16442.80]	[42918.86]	[32746.83]	[3862.86]	[14034.89]
					-9.86%	-3.40%	113.32%	-9.55%	-7.59%	-3.81%	-4.42%	-14.64%
Cattle fattening & rairing	**10817.3**	**8364.53**	**1094.97**	**3547.7**	**10666.3**	**8664.37**	**1313.33**	**3315.3**	**9888.74**	**7706.38**	**1237.95**	**3420.3**
	[33242.67]	[25705.06]	[3364.95]	[10902.56]	[32778.74]	[26626.51]	[4035.99]	[10188.22]	[30389.12]	[23682.51]	[3804.35]	[10510.96]
					-1.40%	3.58%	19.94%	-6.55%	-7.29%	-11.06%	-5.74%	3.17%
Sheep & goats	**7901.62**	**7720.12**	**1303.64**	**1485.2**	**6892.79**	**7238.9**	**944.73**	**598.63**	**6910.15**	**7048.3**	**881.58**	**743.43**
	[30005.93]	[29316.68]	[4950.51]	[5639.76]	[26174.97]	[27489.27]	[3587.57]	[2273.26]	[26240.88]	[26765.51]	[3347.76]	[2823.13]
					-12.77%	-6.23%	-27.53%	-59.69%	0.25%	-2.63%	-6.68%	24.19%
Specialist pigs	**7520.49**	**5924.64**	**359.4**	**1955.3**	**6454.04**	**5741.59**	**325.78**	**1038.2**	**6448.53**	**5726.92**	**312.6**	**1034.2**
	[75702.06]	[59638.07]	[3617.79]	[19681.78]	[64967.10]	[57795.47]	[3279.35]	[10450.99]	[64911.59]	[57647.79]	[3146.63]	[10410.43]
					-14.18%	-3.09%	-9.35%	-46.90%	-0.09%	-0.26%	-4.05%	-0.39%
Poultry	**257.1**	**171.41**	**0.37**	**86.06**	**239.56**	**170.8**	**0.7**	**69.46**	**239.05**	**171.16**	**0.68**	**68.57**
	[168151.31]	[112107.92]	[241.53]	[56284.92]	[156680.33]	[111709.62]	[456.21]	[45426.92]	[156344.24]	[111943.53]	[442.99]	[44843.70]
					-6.82%	-0.36%	88.89%	-19.29%	-0.21%	0.21%	-2.90%	-1.28%
Field crops diversified	**7179.74**	**1989.75**	**469.56**	**5659.6**	**7468.35**	**2210.85**	**455.56**	**5713.1**	**7424.03**	**2163.66**	**344.89**	**5605.3**
	[13925.06]	[3859.10]	[910.71]	[10976.67]	[14484.81]	[4287.93]	[883.56]	[11080.44]	[14398.85]	[4196.40]	[668.91]	[10871.36]
					4.02%	11.11%	-2.98%	0.95%	-0.59%	-2.13%	-24.29%	-1.89%
Livestock diversified	**2657.63**	**1929.28**	**123.4**	**851.75**	**2326.39**	**1904.48**	**168.29**	**590.2**	**2246.2**	**1855.3**	**162.68**	**553.58**
	[26180.84]	[19005.70]	[1215.64]	[8390.78]	[22917.71]	[18761.38]	[1657.89]	[5814.21]	[22127.72]	[18276.96]	[1602.63]	[5453.39]
					-12.46%	-1.29%	36.38%	-30.71%	-3.45%	-2.58%	-3.33%	-6.21%
Livestock & crops diversified	**17308.8**	**12001.5**	**2010.43**	**7317.7**	**15321.2**	**11990.9**	**1981.55**	**5311.8**	**14861.1**	**11700**	**1850.8**	**5011.9**
	[65983.47]	[45751.30]	[7664.04]	[27896.21]	[58406.46]	[45710.98]	[7553.94]	[20249.43]	[56652.48]	[44602.07]	[7055.52]	[19105.94]
					-11.48%	-0.09%	-1.44%	-27.41%	-3.00%	-2.43%	-6.60%	-5.65%
Various	**127974**	**73720.6**	**7148.79**	**61402**	**120035**	**74070.5**	**8195.54**	**54160**	**116587**	**71172.5**	**7563.73**	**52978**
	[36885.19]	[21248.13]	[2060.46]	[17697.52]	[34597.17]	[21348.97]	[2362.16]	[15610.35]	[33603.26]	[20513.70]	[2180.06]	[15269.61]
					-6.20%	0.47%	14.64%	-11.79%	-2.87%	-3.91%	-7.71%	-2.18%

1.The number without brackets gives the impact of all farms belonging to a specific farm type in 1000 Euro of 2009. The number in brackets refer to the individual farm (total amount divided by aggregation weight) in Euro per farm in 2009

The next table shows the income effects for farm type Dairy. The table shows that in the Base year (1998) about three-quarter of the total income comes all cattle activities (especially dairy cows), also about twenty percent comes from cereals, root crops and permanent crops and vegetables. The table below shows that income under the **Agenda reference run** decreases with about 10% compared to the base. Lower prices for milk products in real terms are partly compensated by the expansion of the milk quota.

Under the **CAP Reform Proposal 2003** income decreases with about –15% compared to the Agenda reference run. The table shows that this is mainly the result of the strong decrease in income from all cattle activities, especially through the further decline of the milk price (-12.4%) under the **CAP Reform Proposal 2003**. This decrease is only partially offset by an increase in income from fodder production. The latter results from a re-allocation of premiums from all cattle activities to fodder production.

Table (23) Economic indicators for farm type 'Dairy'

	Base year [1998]				Agenda reference run [2009]				CAP reform proposal 2003 [2009]			
Dairy	*Revenues*	*Costs*	*Premiums*	*Income*	*Revenues*	*Costs*	*Premiums*	*Income*	*Revenues*	*Costs*	*Premiums*	*Income*
	1796.6	1581.54	833.98	1049.05	1479.84	1658.03	755.01	576.82	1355.02	1511.67	531.93	375.28
	[1446.74]	*[1273.55]*	*[671.57]*	*[844.76]*	*[1191.66]*	*[1335.15]*	*[607.98]*	*[464.49]*	*[1091.15]*	*[1217.29]*	*[428.34]*	*[302.20]*
Cereals					*-17.63%*	*4.84%*	*-9.47%*	*-45.01%*	*-8.43%*	*-8.83%*	*-29.55%*	*-34.94%*
	65.1	77.26	62.33	50.16	46.05	60.97	22.83	7.91	41.46	53.17	19.52	7.82
	[52.42]	*[62.22]*	*[50.19]*	*[40.39]*	*[37.08]*	*[49.10]*	*[18.38]*	*[6.37]*	*[33.39]*	*[42.81]*	*[15.72]*	*[6.30]*
Oilseeds					*-29.26%*	*-21.08%*	*-63.37%*	*-84.24%*	*-9.96%*	*-12.80%*	*-14.49%*	*-1.11%*
Other	811.68	315.59	11.33	507.41	857.64	324.03	8.76	542.36	854.21	324.85	39.87	569.24
arable	*[653.62]*	*[254.14]*	*[9.12]*	*[408.60]*	*[690.63]*	*[260.93]*	*[7.05]*	*[436.74]*	*[687.87]*	*[261.59]*	*[32.11]*	*[458.39]*
crops					*5.66%*	*2.67%*	*-22.71%*	*6.89%*	*-0.40%*	*0.25%*	*355.37%*	*4.96%*
Permanen												
t crops &	1888.71	514.66		1374.05	1968.1	546.25		1421.86	1968.1	546.28	2.3	1424.12
vegetable	*[1520.91]*	*[414.44]*		*[1106.47]*	*[1584.84]*	*[439.87]*		*[1144.97]*	*[1584.84]*	*[439.90]*	*[1.85]*	*[1146.79]*
s					*4.20%*	*6.14%*		*3.48%*	*0.00%*	*0.01%*		*0.16%*
	7703.94	6929.55	593.26	1367.65	8182.2	7120.27	495.97	1557.9	8319.98	7139.83	3874.26	5054.41
Fodder	*[6203.70]*	*[5580.12]*	*[477.73]*	*[1101.32]*	*[6588.84]*	*[5733.70]*	*[399.38]*	*[1254.52]*	*[6699.78]*	*[5749.45]*	*[3119.80]*	*[4070.13]*
production					*6.21%*	*2.75%*	*-16.40%*	*13.91%*	*1.68%*	*0.27%*	*681.16%*	*224.44%*
	6006.9	4798.79	667.7	1875.81	4659.63	4971.4	1173.04	861.27	4352.78	4063.93		288.85
Beef meat	*[4837.14]*	*[3864.29]*	*[537.67]*	*[1510.52]*	*[3752.23]*	*[4003.29]*	*[944.61]*	*[693.55]*	*[3505.14]*	*[3272.54]*	*-100.00%*	*[232.60]*
production					*-22.43%*	*3.60%*	*75.68%*	*-54.09%*	*-6.59%*	*-18.25%*		*-66.46%*
Set aside	24.07	43.26	125.94	106.75	21.11	50.38	138.82	109.54	19.51	46.72	136.61	109.39
and fallow	*[19.39]*	*[34.84]*	*[101.41]*	*[85.96]*	*[17.00]*	*[40.57]*	*[111.79]*	*[88.21]*	*[15.71]*	*[37.62]*	*[110.00]*	*[88.09]*
land					*-12.33%*	*16.45%*	*10.23%*	*2.62%*	*-7.58%*	*-7.26%*	*-1.60%*	*-0.14%*
	47931	32232.8	667.7	16365.86	41719.9	30520.2	3561.09	14760.8	37318.1	29047.6	192.52	8462.98
All cattle	*[38597.10]*	*[25955.93]*	*[537.67]*	*[13178.84]*	*[33595.54]*	*[24576.78]*	*[2867.62]*	*[11886.37]*	*[30050.89]*	*[23390.98]*	*[155.03]*	*[6814.93]*
activities					*-12.96%*	*-5.31%*	*433.34%*	*-9.81%*	*-10.55%*	*-4.82%*	*-94.59%*	*-42.67%*
	3767.63	2070.74	58.21	1755.1	3403.05	1997.54	36.4	1441.91	3421.53	1995.84		1425.69
Other	*[3033.94]*	*[1667.49]*	*[46.87]*	*[1413.32]*	*[2740.35]*	*[1608.54]*	*[29.31]*	*[1161.12]*	*[2755.24]*	*[1607.18]*	*-100.00%*	*[1148.06]*
animals					*-9.68%*	*-3.54%*	*-37.46%*	*-17.84%*	*0.54%*	*-0.08%*		*-1.13%*
	63988.7	43765.4	2352.74	22576.02	57677.9	42277.6	5018.87	20419.1	53297.9	40665.9	4797	17428.9
	[51527.82]	*[35242.73]*	*[1894.57]*	*[18179.66]*	*[46445.93]*	*[34044.65]*	*[4041.52]*	*[16442.80]*	*[42918.86]*	*[32746.83]*	*[3862.86]*	*[14034.89]*
Sum					*-9.86%*	*-3.40%*	*113.32%*	*-9.55%*	*-7.59%*	*-3.81%*	*-4.42%*	*-14.64%*

The next table shows the income effects for farm type Specialist pigs. The table shows that in the Base year (1998) about half of the total income comes other animals (especially pigs). Moreover, about one-third of the total income comes from cereals and permanent crops and vegetables.

The table below shows that income under the **Agenda reference run** (2009) decreases with almost 50% compared to the Base year (1998). Again this shows the decrease in output prices in real terms. Input prices are about stable in real terms.

Under the **CAP Reform Proposal 2003** income at farm type Specialist Pigs is about constant compared to Agenda reference run. An increase in income from fodder production and other animals compensate the decrease in income from cereals and all cattle activities. The increase in income from fodder production mainly results from a re-allocation of premiums from cereals and all cattle activities to fodder production.

Table (24) Economic indicators for farm type 'specialist pigs'

	Base year [1998]				Agenda reference run [2009]				CAP reform proposal 2003 [2009]			
Specialist pigs	*Revenues*	*Costs*	*Premiums*	*Income*	*Revenues*	*Costs*	*Premiums*	*Income*	*Revenues*	*Costs*	*Premiums*	*Income*
Cereals	640.68	505.72	258.99	393.95	532.2	529.02	239.4	242.57	509.78	499.71	184.68	194.75
	[6449.14]	*[5090.63]*	*[2606.99]*	*[3965.50]*	*[5357.14]*	*[5325.17]*	*[2409.79]*	*[2441.76]*	*[5131.46]*	*[5030.14]*	*[1859.01]*	*[1960.33]*
					-16.93%	*4.61%*	*-7.56%*	*-38.42%*	*-4.21%*	*-5.54%*	*-22.86%*	*-19.72%*
Oilseeds	40.75	31.74	31.61	40.62	35	29.7	13.84	19.15	34.84	28.79	11.87	17.93
	[410.24]	*[319.51]*	*[318.15]*	*[408.87]*	*[352.35]*	*[298.96]*	*[139.36]*	*[192.75]*	*[350.72]*	*[289.80]*	*[119.51]*	*[180.44]*
					-14.11%	*-6.43%*	*-56.20%*	*-52.86%*	*-0.46%*	*-3.07%*	*-14.24%*	*-6.39%*
Other arable crops	178.43	94.05	12.43	96.82	175.64	86.21	9.08	98.51	176.02	86.64	12.42	101.81
	[1796.13]	*[946.68]*	*[125.15]*	*[974.60]*	*[1767.96]*	*[867.76]*	*[91.37]*	*[991.57]*	*[1771.86]*	*[872.11]*	*[125.06]*	*[1024.80]*
					-1.57%	*-8.34%*	*-26.99%*	*1.74%*	*0.22%*	*0.50%*	*36.87%*	*3.35%*
Permanent crops & vegetables	502.13	250.85		251.27	431.57	209.68		221.89	431.57	209.81	0.8	222.57
	[5054.46]	*[2525.12]*		*[2529.34]*	*[4344.26]*	*[2110.70]*		*[2233.55]*	*[4344.25]*	*[2111.93]*	*[8.08]*	*[2240.40]*
					-14.05%	*-16.41%*		*-11.69%*	*0.00%*	*0.06%*		*0.31%*
Fodder production	49.3	49.86	20.31	19.76	53.87	52.26	13.16	14.77	58.26	55.51	71.25	74
	[496.29]	*[501.89]*	*[204.46]*	*[198.86]*	*[542.31]*	*[526.07]*	*[132.47]*	*[148.71]*	*[586.49]*	*[558.73]*	*[717.17]*	*[744.93]*
					9.27%	*4.82%*	*-35.21%*	*-25.22%*	*8.15%*	*6.21%*	*441.40%*	*400.94%*
Beef meat production	153.05	65.57	9.77	97.25	115.94	68.73	14.52	61.73	119.61	66.46		53.16
	[1540.60]	*[660.02]*	*[98.36]*	*[978.94]*	*[1167.04]*	*[691.85]*	*[146.15]*	*[621.34]*	*[1204.03]*	*[668.97]*	*-100.00%*	*[535.07]*
					-24.25%	*4.82%*	*48.58%*	*-36.53%*	*3.17%*	*-3.31%*		*-13.89%*
Set aside and fallow land	5.35	8.25	25.53	22.62	5.41	10.32	30.45	25.54	5.55	9.06	31.57	28.06
	[53.80]	*[83.05]*	*[256.95]*	*[227.70]*	*[54.50]*	*[103.93]*	*[306.51]*	*[257.08]*	*[55.89]*	*[91.19]*	*[317.80]*	*[282.50]*
					1.29%	*25.14%*	*19.29%*	*12.90%*	*2.56%*	*-12.26%*	*3.68%*	*9.89%*
All cattle activities	279.24	147.89	9.77	141.13	231.28	149.26	19.25	101.26	221.03	146	0	75.03
	[2810.89]	*[1488.66]*	*[98.36]*	*[1420.59]*	*[2328.04]*	*[1502.49]*	*[193.76]*	*[1019.32]*	*[2224.96]*	*[1469.68]*	*[0.00]*	*[755.27]*
					-17.18%	*0.93%*	*96.98%*	*-28.25%*	*-4.43%*	*-2.18%*	*-100.00%*	*-25.90%*
Other animals	5824.61	4836.28	0.77	989.09	4989.07	4675.13	0.61	314.55	5011.47	4691.41		320.06
	[58631.11]	*[48682.53]*	*[7.73]*	*[9956.31]*	*[50220.54]*	*[47060.38]*	*[6.10]*	*[3166.26]*	*[50445.96]*	*[47224.20]*	*-100.00%*	*[3221.76]*
					-14.34%	*-3.33%*	*-21.16%*	*-68.20%*	*0.45%*	*0.35%*		*1.75%*
Sum	7520.49	5924.64	359.4	1955.25	6454.04	5741.59	325.78	1038.24	6448.53	5726.92	312.6	1034.21
	[75702.06]	*[59638.07]*	*[3617.79]*	*[19681.78]*	*[64967.10]*	*[57795.47]*	*[3279.35]*	*[10450.99]*	*[64911.59]*	*[57647.79]*	*[3146.63]*	*[10410.43]*
					-14.18%	*-3.09%*	*-9.35%*	*-46.90%*	*-0.09%*	*-0.26%*	*-4.05%*	*-0.39%*

The next table shows the income effects for farm type Specialist COP. The table shows that in the Base year (1998) about 25 percent of the total income comes from cereals, less than 5 percent comes from oil seeds and about 50 percent comes from other arable crops, permanent crops and vegetables. Something less than 10 percent of the total income comes from all cattle activities.

Income under the **Agenda reference run** decreases with almost 16%. This is explained by an increase in income from cereals, oilseeds and all cattle activities. From the other hand there is an increase in income from permanent crops and vegetables and from set-aside.

Under the **CAP Reform Proposal 2003** income at farm type Specialist COP decreases with more than 3%. This is explained by a further decrease in income from cereals, oilseeds and all cattle activities. Income from other arable crops, permanent crops and vegetables and from fodder production increases because of the re-allocation of premiums and the increased production.

Table (25) Economic indicators for farm type 'Specialist COP other than rice or various field crops'

	Base year [1998]				Agenda reference run [2009]				CAP reform proposal 2003 [2009]			
	Revenues	*Costs*	*Premiums*	*Income*	*Revenues*	*Costs*	*Premiums*	*Income*	*Revenues*	*Costs*	*Premiums*	*Income*
Cereals	15224.7 *[7331.72]*	11532 *[5553.44]*	6238.31 *[3004.18]*	9930.99 *[4782.45]*	13362.2 *[6434.84]* *-12.23%*	12684 *[6108.27]* *9.99%*	6052.22 *[2914.56]* *-2.98%*	6730.4 *[3241.13]* *-32.23%*	12875.04 *[6200.21]* *-3.65%*	12148 *[5850.10]* *-4.23%*	3904.34 *[1880.21]* *-35.49%*	4631.4 *[2230.32]* *-31.19%*
Oilseeds	2042.49 *[983.60]*	2266.56 *[1091.50]*	1821.91 *[877.38]*	1597.84 *[769.47]*	1503.98 *[724.27]* *-26.37%*	1938.5 *[933.51]* *-14.48%*	742.91 *[357.76]* *-59.22%*	308.41 *[148.52]* *-80.70%*	1509.44 *[726.90]* *0.36%*	1915.5 *[922.44]* *-1.19%*	643.91 *[310.09]* *-13.33%*	237.85 *[114.54]* *-22.88%*
Other arable crops	9918.52 *[4776.45]*	2707.34 *[1303.77]*	495.33 *[238.54]*	7706.51 *[3711.21]*	9527.71 *[4588.25]* *-3.94%*	2733.5 *[1316.35]* *0.97%*	382.32 *[184.11]* *-22.82%*	7176.6 *[3456.01]* *-6.88%*	9590.69 *[4618.58]* *0.66%*	2782.05 *[1339.75]* *1.78%*	605.14 *[291.42]* *58.28%*	7413.8 *[3570.25]* *3.31%*
Permanent crops & vegetables	16424.1 *[7909.34]*	3151.66 *[1517.74]*		13272.5 *[6391.59]*	16767.8 *[8074.83]* *2.09%*	3139.2 *[1511.74]* *-0.40%*		13629 *[6563.09]* *2.68%*	16767.77 *[8074.83]* *0.00%*	3138.62 *[1511.46]* *-0.02%*	88.78 *[42.75]*	13718 *[6606.12]* *0.66%*
Fodder production	1288.46 *[620.48]*	1236.57 *[595.49]*	100.05 *[48.18]*	151.93 *[73.17]*	1408.85 *[678.46]* *9.34%*	1286.7 *[619.64]* *4.06%*	79.42 *[38.25]* *-20.62%*	201.55 *[97.06]* *32.66%*	1502.65 *[723.63]* *6.66%*	1322.13 *[636.69]* *2.75%*	1186.34 *[571.31]* *1393.75%*	1366.9 *[658.24]* *578.17%*
Beef meat production	3876.52 *[1866.81]*	1989.55 *[958.10]*	356.38 *[171.62]*	2243.34 *[1080.32]*	3065.97 *[1476.47]* *-20.91%*	2126.2 *[1023.93]* *6.87%*	517.63 *[249.28]* *45.25%*	1457.4 *[701.82]* *-35.04%*	3024.14 *[1456.33]* *-1.36%*	1827.81 *[880.22]* *-14.04%*	*-100.00%*	1196.3 *[576.12]* *-17.91%*
Set aside and fallow land	177.27 *[85.37]*	178.46 *[85.94]*	613.68 *[295.53]*	612.49 *[294.96]*	160.24 *[77.17]* *-9.61%*	214.54 *[103.32]* *20.22%*	710.27 *[342.04]* *15.74%*	655.96 *[315.89]* *7.10%*	166.36 *[80.12]* *3.82%*	213.51 *[102.82]* *-0.48%*	925.64 *[445.76]* *30.32%*	878.49 *[423.05]* *33.92%*
All cattle activities	6494.73 *[3127.66]*	3765.16 *[1813.18]*	356.38 *[171.62]*	3085.95 *[1486.10]*	5468.14 *[2633.28]* *-15.81%*	3960.3 *[1907.17]* *5.18%*	585.21 *[281.82]* *64.21%*	2093 *[1007.93]* *-32.18%*	5137.1 *[2473.87]* *-6.05%*	3579.67 *[1723.85]* *-9.61%*	*-100.00%*	1557.4 *[750.01]* *-25.59%*
Other animals	7195.73 *[3465.24]*	4048.99 *[1949.87]*	120.26 *[57.91]*	3267 *[1573.28]*	6521.29 *[3140.45]* *-9.37%*	3967 *[1910.39]* *-2.02%*	70.64 *[34.02]* *-41.26%*	2624.9 *[1264.07]* *-19.65%*	6598.11 *[3177.44]* *1.18%*	4027.68 *[1939.61]* *1.53%*	*-100.00%*	2570.4 *[1237.84]* *-2.08%*
Sum	58766 *[28299.85]*	28886.7 *[13910.94]*	9745.91 *[4693.33]*	39625.2 *[19082.23]*	54720.2 *[26351.54]* *-6.88%*	29924 *[14410.39]* *3.59%*	8622.98 *[4152.56]* *-11.52%*	33419 *[16093.70]* *-15.66%*	54147.16 *[26075.57]* *-1.05%*	29127.2 *[14026.73]* *-2.66%*	7354.16 *[3541.53]* *-14.71%*	32374 *[15590.38]* *-3.13%*

The next table shows the income effects for farm type Specialist rice or Rice & COP. The table shows that in the Base year (1998) about half of the total income comes cereals. Moreover, almost another 50% comes from other arable crops and permanent crops & vegetables.

Contrary to other farm types discussed above, income under the **Agenda reference run** is about constant in real terms compared to the Base year (1998). This is explained by an increase in income from other arable crops and permanent crops and vegetables.

Under the **CAP Reform Proposal 2003** income at farm type Specialist rice or Rice & COP increases. This is also different from the farm types discussed above. This is explained by an increase in income from all activities, with the exception of income from all cattle activities and other animals. However, the share in total income of the latter activities is very low at farm type Specialist rice or Rice & COP. As a result income increase under **CAP Reform Proposal 2003** with almost 14%.

Table (26) Economic indicators for farm type 'specialist rice or Rice & COP'

	Base year [1998]				Agenda reference run [2009]				CAP reform proposal 2003 [2009]			
Specialist Rice or Rice & COP	*Revenues*	*Costs*	*Premiums*	*Income*	*Revenues*	*Costs*	*Premiums*	*Income*	*Revenues*	*Costs*	*Premiums*	*Income*
Cereals	35.02 *[4652.44]*	12.22 *[1624.14]*	4.52 *[600.21]*	27.31 *[3628.52]*	30.79 *[4090.42]* *-12.08%*	13.77 *[1829.08]* *12.62%*	5.44 *[722.24]* *20.33%*	22.46 *[2983.57]* *-17.77%*	25.13 *[3338.49]* *-18.38%*	13.41 *[1781.16]* *-2.62%*	13.78 *[1831.28]* *153.56%*	25.51 *[3388.61]* *13.58%*
Oilseeds	0.01 *[1.36]*	0.01 *[1.67]*	0.03 *[4.28]*	0.03 *[3.97]*	0.01 *[1.01]* *-25.72%*	0.01 *[1.38]* *-17.62%*	0.01 *[1.94]* *-54.78%*	0.01 *[1.57]* *-60.47%*	0 *[0.38]* *-62.48%*	0 *[0.51]* *-62.72%*	0.01 *[1.80]* *-6.86%*	0.01 *[1.67]* *6.36%*
Other arable crops	14.24 *[1892.40]*	2.92 *[388.58]*		11.32 *[1503.82]*	17.75 *[2358.79]* *24.65%*	3.83 *[508.27]* *30.80%*		13.93 *[1850.52]* *23.06%*	17.74 *[2356.89]* *-0.08%*	3.82 *[508.02]* *-0.05%*	1.31 *[174.53]*	15.23 *[2023.39]* *9.34%*
Permanent crops & vegetables	7.54 *[1001.76]*	0.96 *[127.55]*		6.58 *[874.21]*	9.7 *[1288.35]* *28.61%*	1.19 *[158.75]* *24.46%*		8.5 *[1129.60]* *29.21%*	9.7 *[1288.35]* *0.00%*	1.19 *[158.75]* *0.00%*	0.07 *[9.93]*	8.58 *[1139.53]* *0.88%*
Fodder production	0.64 *[85.46]*	0.5 *[66.68]*	0 *[0.21]*	0.14 *[18.99]*	0.65 *[86.43]* *1.14%*	0.5 *[66.66]* *-0.04%*	0 *[0.15]* *-30.59%*	0.15 *[19.92]* *4.91%*	0.66 *[87.92]* *1.72%*	0.51 *[67.46]* *1.21%*	1.43 *[190.12]* *129040.40%*	1.59 *[210.58]* *957.18%*
Beef meat production	1.79 *[237.29]*	0.52 *[68.48]*	0.04 *[5.75]*	1.31 *[174.56]*	1.24 *[164.21]* *-30.80%*	0.5 *[65.92]* *-3.73%*	0.08 *[10.25]* *78.26%*	0.82 *[108.54]* *-37.82%*	1.26 *[168.05]* *2.34%*	0.45 *[60.24]* *-8.62%*	*-100.00%*	0.81 *[107.81]* *-0.67%*
Set aside and fallow land		0 *[0.18]*	0.01 *[1.40]*	0.01 *[1.22]*		0 *[0.20]* *13.69%*	0.01 *[1.45]* *3.46%*	0.01 *[1.25]* *1.97%*		0 *[0.27]* *33.38%*	1.55 *[205.31]* *14059.59%*	1.54 *[205.04]* *16324.40%*
All cattle activities	6.69 *[888.27]*	2.02 *[268.93]*	0.04 *[5.75]*	4.71 *[625.10]*	5.69 *[755.87]* *-14.91%*	2.07 *[274.71]* *2.15%*	0.22 *[29.08]* *405.64%*	3.84 *[510.24]* *-18.37%*	5.48 *[727.73]* *-3.72%*	1.99 *[264.07]* *-3.87%*	*-100.00%*	3.49 *[463.66]* *-9.13%*
Other animals	2.27 *[302.01]*	0.86 *[113.85]*	0.02 *[2.07]*	1.43 *[190.23]*	2.43 *[322.83]* *6.89%*	0.96 *[127.05]* *11.60%*	0.02 *[2.16]* *4.57%*	1.49 *[197.94]* *4.05%*	2.43 *[323.41]* *0.18%*	0.96 *[127.24]* *0.15%*	*-100.00%*	1.48 *[196.16]* *-0.90%*
Sum	66.42 *[8823.70]*	19.51 *[2591.58]*	4.62 *[613.93]*	51.53 *[6846.05]*	67.02 *[8903.69]* *0.91%*	22.33 *[2966.09]* *14.45%*	5.7 *[757.01]* *23.31%*	50.39 *[6694.61]* *-2.21%*	61.14 *[8123.15]* *-8.77%*	21.88 *[2907.48]* *-1.98%*	18.16 *[2412.96]* *218.75%*	57.42 *[7628.64]* *13.95%*

The next table shows the income effects for farm type Field crops diversified. The table shows that in the Base year (1998) about 60 percent of the total income comes from permanent crops and vegetables and about 10 percent comes from cereals and oilseeds.

Income under the **Agenda reference run** increases with about 1%. The decrease in income from cereals, oilseeds and all cattle activities is more than offset by an increase in income from permanent crops and vegetables.

Under the **CAP Reform Proposal 2003** income at farm type Field crops diversified decreases with almost 2%. Again, this is explained by a further decrease in income from cereals, oilseeds and all cattle activities, which is not fully offset by an increase income from other arable crops, permanent crops and vegetables and from fodder production. The latter increase mainly results from re-allocation of premiums and increased production.

Table (27) Economic indicators for farm type 'Field crops diversified'

	Base year [1998]				Agenda reference run [2009]				CAP reform proposal 2003 [2009]			
	Revenues	*Costs*	*Premiums*	*Income*	*Revenues*	*Costs*	*Premiums*	*Income*	*Revenues*	*Costs*	*Premiums*	*Income*
Cereals	725.78	512.39	338.09	551.47	653.73	566.91	355.99	442.8	612.03	532.28	168.37	248.12
	[1407.64]	[993.78]	[655.72]	[1069.57]	[1267.90]	[1099.52]	[690.44]	[858.82]	[1187.03]	[1032.35]	[326.54]	[481.22]
					-9.93%	10.64%	5.30%	-19.70%	-6.38%	-6.11%	-52.71%	-43.97%
Oilseeds	46.6	48.8	55.03	52.83	32.55	39.02	18.22	11.75	32.57	38.81	14.86	8.63
	[90.38]	[94.64]	[106.73]	[102.47]	[63.14]	[75.69]	[35.33]	[22.78]	[63.17]	[75.26]	[28.83]	[16.73]
					-30.14%	-20.03%	-66.90%	-77.77%	0.04%	-0.56%	-18.41%	-26.57%
Other arable crops	1161.2	184.04	12.73	989.89	1253.67	191.28	9.41	1071.8	1256.69	194.33	36.07	1098.43
	[2252.13]	[356.95]	[24.69]	[1919.88]	[2431.49]	[370.98]	[18.25]	[2078.76]	[2437.34]	[376.91]	[69.97]	[2130.40]
					7.96%	3.93%	-26.08%	8.28%	0.24%	1.60%	283.33%	2.48%
Permanent crops & vegetables	4172.9	683.66		3489.2	4565.34	836		3729.34	4565.34	836.02	9.54	3738.86
	[8093.23]	[1325.94]		[6767.28]	[8854.45]	[1621.42]		[7233.03]	[8854.45]	[1621.45]	[18.50]	[7251.49]
					9.41%	22.28%		6.88%	0.00%	0.00%		0.26%
Fodder production	56.33	54.22	4.42	6.52	61.44	56.06	4.3	9.68	65.97	58.07	71.33	79.22
	[109.25]	[105.16]	[8.57]	[12.65]	[119.17]	[108.73]	[8.34]	[18.78]	[127.94]	[112.63]	[138.34]	[153.64]
					9.08%	3.39%	-2.63%	48.43%	7.36%	3.59%	1558.77%	718.14%
Beef meat production	250.83	97.37	17.52	170.98	189.42	104.87	25.56	110.11	189.04	91.6		97.44
	[486.49]	[188.86]	[33.98]	[331.62]	[367.39]	[203.40]	[49.58]	[213.57]	[366.64]	[177.65]	-100.00%	[188.99]
					-24.48%	7.70%	45.90%	-35.60%	-0.20%	-12.66%		-11.51%
Set aside and fallow land	5.25	7.25	31.62	29.63	4.58	7.52	31.18	28.24	4.62	7.43	44.72	41.91
	[10.19]	[14.05]	[61.32]	[57.46]	[8.89]	[14.59]	[60.47]	[54.77]	[8.96]	[14.41]	[86.74]	[81.28]
					-12.74%	3.82%	-1.39%	-4.68%	0.75%	-1.23%	43.44%	48.41%
All cattle activities	395.71	170.73	17.52	242.5	322.58	182.68	29.75	169.66	307.61	164.38		143.23
	[767.48]	[331.14]	[33.98]	[470.33]	[625.65]	[354.31]	[57.70]	[329.04]	[596.61]	[318.81]	-100.00%	[277.80]
					-18.48%	7.00%	69.81%	-30.04%	-4.64%	-10.02%		-15.57%
Other animals	616.01	328.65	10.16	297.51	574.45	331.37	6.71	249.79	579.21	332.34		246.86
	[1194.75]	[637.42]	[19.70]	[577.03]	[1114.14]	[642.70]	[13.02]	[484.46]	[1123.37]	[644.58]	-100.00%	[478.79]
					-6.75%	0.83%	-33.92%	-16.04%	0.83%	0.29%		-1.17%
Sum	7179.7	1989.8	469.56	5659.6	7468.35	2210.9	455.56	5713.06	7424.03	2163.66	344.89	5605.26
	[13925.06]	[3859.10]	[910.71]	[10976.67]	[14484.81]	[4287.93]	[883.56]	[11080.44]	[14398.85]	[4196.40]	[668.91]	[10871.36]
					4.02%	11.11%	-2.98%	0.95%	-0.59%	-2.13%	-24.29%	-1.89%

The next table shows the income effects for farm type Root crops. The table shows that in the Base year (1998) more than half of the total income comes from other arable crops. About 25% comes from cereals and permanent crops and vegetables.

Under the **Agenda reference run** income decreases with more than 26% compared to the Base year (1998). This is modest compared to e.g. farm type Specialist pigs. An explanation is the rather stable income from permanent crops and vegetables.

Under the **CAP Reform Proposal 2003** income at farm type Root crops decreases with about –2.7%. The decrease in income from cereals is almost fully offset by an increase in income from other arable crops and fodder production.

Table (28) Economic indicators for farm type 'root crops'

	Base year [1998]				Agenda reference run [2009]				CAP reform proposal 2003 [2009]			
Root crops	*Revenues*	*Costs*	*Premiums*	*Income*	*Revenues*	*Costs*	*Premiums*	*Income*	*Revenues*	*Costs*	*Premiums*	*Income*
Cereals	1187.67 *[15333.22]*	1001.98 *[12935.88]*	454.76 *[5871.14]*	640.45 *[8268.49]*	1075.37 *[13883.45]* *-9.46%*	1148.31 *[14825.10]* *14.60%*	445.45 *[5750.98]* *-2.05%*	372.52 *[4809.33]* *-41.84%*	1031.83 *[13321.25]* *-4.05%*	1096.51 *[14156.38]* *-4.51%*	267.96 *[3459.52]* *-39.84%*	203.28 *[2624.39]* *-45.43%*
Oilseeds	45.95 *[593.23]*	53.59 *[691.85]*	39.16 *[505.58]*	31.52 *[406.96]*	35.76 *[461.72]* *-22.17%*	48.38 *[624.57]* *-9.73%*	18.35 *[236.97]* *-53.13%*	5.74 *[74.12]* *-81.79%*	35.21 *[454.60]* *-1.54%*	46.71 *[603.05]* *-3.45%*	13.32 *[172.01]* *-27.41%*	1.82 *[23.56]* *-68.22%*
Other arable crops	2597.76 *[33537.99]*	986.16 *[12731.70]*	33.21 *[428.80]*	1644.81 *[21235.08]*	2144.23 *[27682.81]* *-17.46%*	990.41 *[12786.50]* *0.43%*	26.48 *[341.83]* *-20.28%*	1180.3 *[15238.14]* *-28.24%*	2180.27 *[28148.06]* *1.68%*	1036.15 *[13377.07]* *4.62%*	133.94 *[1729.27]* *405.88%*	1278.06 *[16500.26]* *8.28%*
Permanent crops & vegetables	1193.2 *[15404.62]*	540.75 *[6981.23]*		652.45 *[8423.38]*	1095.39 *[14141.94]* *-8.20%*	505.35 *[6524.32]* *-6.54%*		590.04 *[7617.62]* *-9.57%*	1095.39 *[14141.94]* *0.00%*	505.33 *[6523.97]* *-0.01%*	3.61 *[46.66]*	593.68 *[7664.63]* *0.62%*
Fodder production	36.99 *[477.51]*	43.74 *[564.72]*	3.69 *[47.70]*	-3.06 *[-39.50]*	41.44 *[535.00]* *12.04%*	46.2 *[596.51]* *5.63%*	3.41 *[44.06]* *-7.63%*	-1.35 *[-17.45]* *55.82%*	43.7 *[564.15]* *5.45%*	47.85 *[617.71]* *3.55%*	38.72 *[499.88]* *1034.46%*	34.57 *[446.32]* *2657.47%*
Beef meat production	183.59 *[2370.21]*	69.96 *[903.22]*	12.5 *[161.38]*	126.13 *[1628.37]*	145.34 *[1876.44]* *-20.83%*	72.88 *[940.86]* *4.17%*	17.26 *[222.88]* *38.11%*	89.73 *[1158.46]* *-28.86%*	140.12 *[1809.01]* *-3.59%*	62.5 *[806.92]* *-14.24%*	-100.00%	77.62 *[1002.09]* *-13.50%*
Set aside and fallow land	16.89 *[218.05]*	21.87 *[282.31]*	74.74 *[964.95]*	69.76 *[900.68]*	14.74 *[190.33]* *-12.71%*	25.47 *[328.83]* *16.48%*	85.13 *[1099.03]* *13.90%*	74.4 *[960.53]* *6.65%*	15.3 *[197.53]* *3.78%*	26.41 *[340.93]* *3.68%*	75.76 *[978.14]* *-11.00%*	64.66 *[834.74]* *-13.10%*
All cattle activities	267.57 *[3454.43]*	127.84 *[1650.48]*	12.5 *[161.38]*	152.23 *[1965.32]*	223.85 *[2890.00]* *-16.34%*	133.59 *[1724.73]* *4.50%*	18.31 *[236.37]* *46.47%*	108.57 *[1401.64]* *-28.68%*	206.75 *[2669.22]* *-7.64%*	117.65 *[1518.96]* *-11.93%*	-100.00%	89.1 *[1150.26]* *-17.93%*
Other animals	289.81 *[3741.51]*	152.47 *[1968.44]*	5.92 *[76.39]*	143.25 *[1849.46]*	269.48 *[3479.08]* *-7.01%*	150.46 *[1942.55]* *-1.32%*	3.34 *[43.11]* *-43.57%*	122.35 *[1579.64]* *-14.59%*	273.89 *[3536.00]* *1.64%*	151.7 *[1958.55]* *0.82%*	-100.00%	122.18 *[1577.45]* *-0.14%*
Sum	5635.83 *[72760.56]*	2928.39 *[37806.63]*	623.99 *[8055.94]*	3331.42 *[43009.87]*	4900.27 *[63264.33]* *-13.05%*	3048.18 *[39353.10]* *4.09%*	600.47 *[7752.34]* *-3.77%*	2452.57 *[31663.57]* *-26.38%*	4882.34 *[63032.75]* *-0.37%*	3028.31 *[39096.62]* *-0.65%*	533.33 *[6885.48]* *-11.18%*	2387.35 *[30821.61]* *-2.66%*

7. Environmental analysis

7.1.1 NPK balances

Nutrient balances are a widely used and generally accepted concept to measure the potential danger to water resources and long-term devaluation of the soil (FAIR3-CT96-1849, 1999). The general idea of these nutrient balances is straightforward: based on an appropriate system boundary definition, all sources and sinks are defined and the difference between them interpreted as total nutrients excess/surplus in the system (for details see Meudt and Britz, 1997).

Nutrient balances in CAPRI are built around the following elements:

- *Export of nutrients by harvested material per crop*. It depends on regional crop pattern and yields;
- *Organic fertiliser as output of manure at tail*. It depends on animal type, regional animal population and animal 'yields' as final weights or milk yield;
- *Mineral fertiliser*, as given from national statistics at sectoral level;
- *Ammonia losses (see annex 4)*.

Additional data is added to the model to represent deposition of nitrate (N), biological fixation and mineralisation. In Table (29) the nitrate (N-) balance is presented

Table (29) N-balance at regional level in CAPRI[9]

Input		**Output**	
Import by organic fertiliser (manure)	a	Export of nutrients with havested material	g
Import by anorganic fertiliser	b	Ammonia emissions from anorganic fertiliser application	h
Atmospheric deposition	c	Ammonia emissions from grazings	i
Biological fixation*	d	Ammonia emissions from organic fertiliser in storage and stable	j
Mineralisation (releases from soil available for the crop)	e	Total ammonia emissions	k=h+i+j
		Nutrient losses at soil level (SURPLUS)	l=f-g-k
Total Input	f=a+b+c+d+e	**Total Output (surplus included)**	m=l+k+g

* Conversion of molecular nitrogen into ammonia (e.g. lucerne)

European Union

In the table below the N-balance results at **European level** are presented. In the **Agenda reference run** [2009] compared to the Base year (1998) the import of nitrate (N) from manure decreases slightly, but this is counteracted by an increase in the import by mineral fertilizer. On the output side of the N-balance there is an increase in the export of nitrate (N) with harvested material. This increase results from the autonomous increase in yields per hectare from 1998 (base) to 2009. The increase in use of mineral fertilizer results into an increase in ammonia emission from mineral fertilizer. On the other hand, the decrease in use of manure results in a decrease in ammonia emission from stable and storage. The net result is a small decrease in total ammonia emission in the **Agenda reference run** compared to the base of about –0.7%. The net effect of changes in input and output components of the nitrate balance is that the nitrate (N-) surplus at soil level decreases with about –0.8% at average in the European Union.

[9] Detailed information concerning different components of the regional nutrient balances can be found in (Oudendag, Hoogeveen, Helming, 2002; Oudendag, Helming and Hoogeveen, 2002; Meudt and Britz, 1997).

Table (30) Nitrate surplus for the European Union

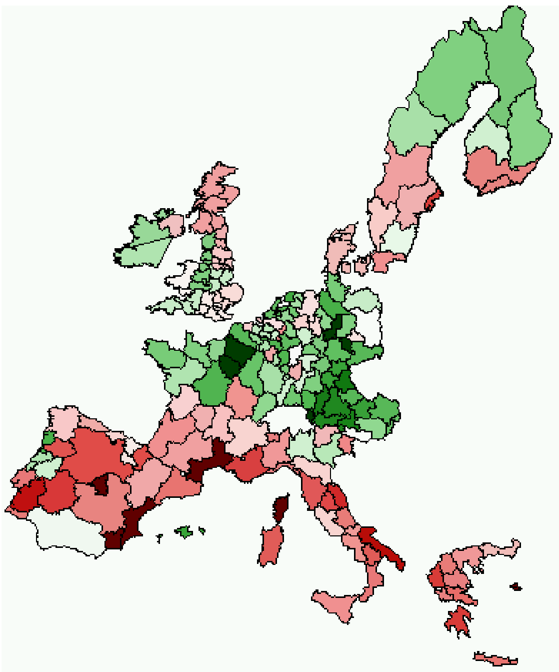
	Base year [1998]		Agenda reference run [2009]		CAP reform proposal 2003 [2009]	
European Union	*Impact*	*Impact per ha UAA*	*Impact*	*Impact per ha UAA*	*Impact*	*Impact per ha UAA*
Import by mineral fertilizer	9476.17	68.22	10422.54 *9.99%*	75.03 *9.97%*	9988.01 *-4.17%*	71.9 *-4.17%*
Export with harvest	8039.07	57.88	8481.59 *5.50%*	61.06 *5.49%*	8262.28 *-2.59%*	59.48 *-2.59%*
Import by manure	7828.88	56.36	7717.07 *-1.43%*	55.55 *-1.44%*	7426.95 *-3.76%*	53.46 *-3.76%*
Biological fixation	336.78	2.42	346.75 *2.96%*	2.5 *2.95%*	356.84 *2.91%*	2.57 *2.91%*
Releases from soil	4438.12	31.95	4421.27 *-0.38%*	31.83 *-0.39%*	4447.86 *0.60%*	32.02 *0.60%*
Atmospheric deposition	1966.93	14.16	1967.08 *0.01%*	14.16 *-0.01%*	1967.08 *0.00%*	14.16 *0.00%*
Ammonia losses from organic fertiliser	2076.91	14.95	2003.22 *-3.55%*	14.42 *-3.56%*	1941.63 *-3.07%*	13.98 *-3.07%*
Ammonia losses from anorganic fertiliser	405.12	2.92	446.21 *10.14%*	3.21 *10.13%*	427.65 *-4.16%*	3.08 *-4.16%*
Ammonia losses from soil	992.93	7.15	999.45 *0.66%*	7.19 *0.64%*	991.44 *-0.80%*	7.14 *-0.80%*
Surplus	4212.86	30.33	4181.06 *-0.75%*	30.1 *-0.77%*	4036.73 *-3.45%*	29.06 *-3.45%*

The table above shows that for the **CAP Reform Proposal 2003**, input of N from both manure and mineral fertiliser will decrease. This is the result of extensification of the cropping plan as fallow land and extensive grassland will increase and at the same time intensive grassland will decrease (+2.9% and –3.2% respectively, see above). This change in cropping plan also leads to a decrease in the export of nitrate (N) with harvested material. Due to the decreased production and application of manure and mineral the total emission of ammonia decreases with about –1.8%. The net effect of changes in input and output components is a decrease in nitrate (N) surplus losses at soil level of about –3.5%.

Regions

At a **regional level**, result of the **Agenda reference run** [2009] compared to the Base year (1998) with respect to N-surplus is shown in the next map. Effects vary from about –2% to -18% in regions in the UK, Ireland, The Netherlands, France, Germany, Sweden and Finland to more than +1% in regions in Southern Europe.

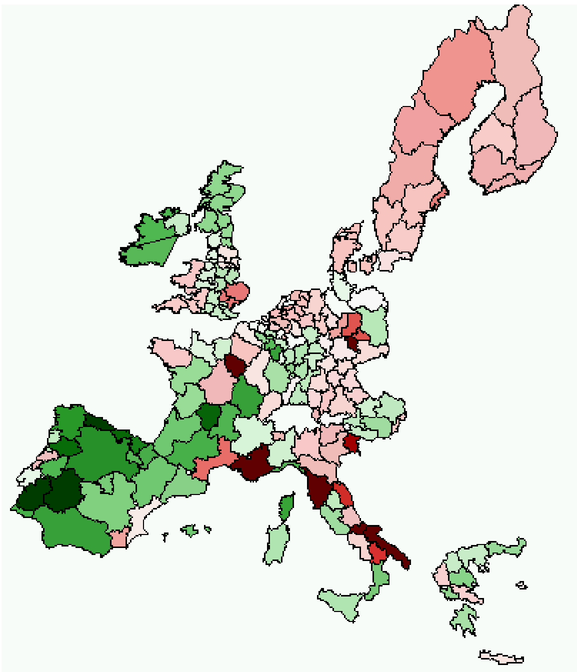
Map (6) Change N-surplus at soil level: Agenda 2000 versus base year situation (distribution at Nuts 2 level)



Note: From dark green to light green: between –18 % and –2 %, white around –1 % and from light red to dark red between 1 % and 25 %.

For the ‘**CAP Reform Proposal 2003**’ [2009] compared to **Agenda reference run**, effects varies from about –6% to -13% in regions in mainly Ireland, UK, France, Spain and some regions in Germany, Italy and Greece to more than +1% in the rest of Europe.

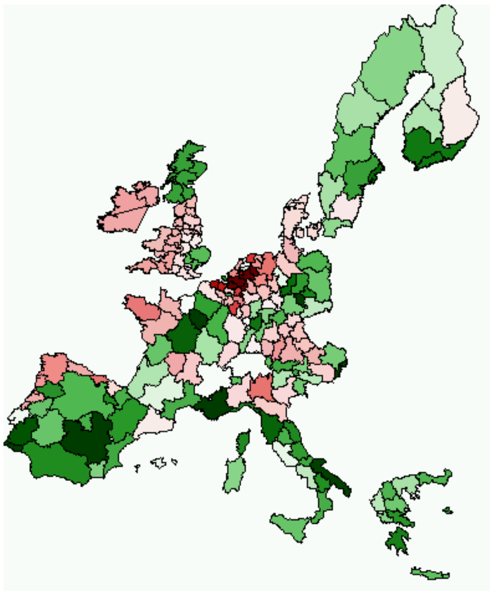
Map (7) Change Nitrate-surplus at soil level: ‘CAP Reform Proposal 2003’ versus Agenda 2000 (distribution at Nuts 2 level)



Note: From dark green to light green: between -13 % and –6 %, white around –2 % and from light red to dark red between 1 % and 23 %.

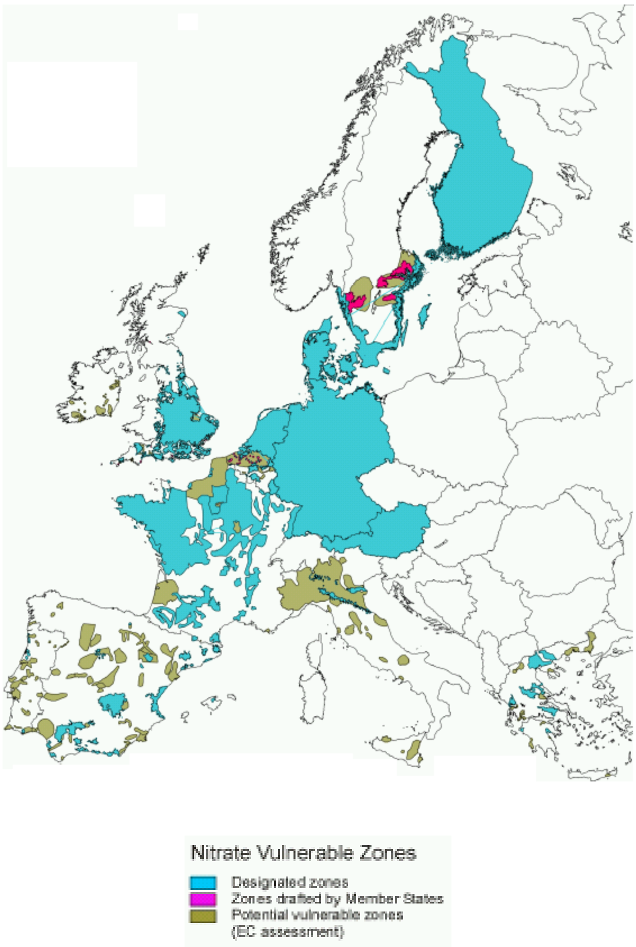
To complement the map above on relative changes, the map below shows the nitrate (N-) surplus at soil level in the **Agenda 2000 reference** [2009]. By comparing both maps we can see that regions with a very high change of nutrient surplus in the ‘**CAP Reform Proposal 2003**’ are not very representative (e.g. Puglia, in Italy, has about the highest change of nutrient surplus (+20%) but only a very small amount of nitrate surplus per hectare, 5 kg/ha in **Agenda 2000**)

Map (8) Nitrate Surplus at soil level: Agenda 2000 situation at Nuts 2 level (kg/ha)



Note: From dark green to light green: between 1 and 20 kg/ha average of nitrate surplus in the corresponding region, white around 29 and from light red to dark red between 40 and 275.

Map (9) Vulnerable zones (Nitrate Directive 91/676/EEC)



The analysis of nitrate surpluses and vulnerable zones requires some sort of GIS approach in order to map down the actual information included in the nitrate directive to NUTS II regions in CAPRI. Since this information is not included in the system, comparing visually both maps does a first analysis. **It is possible to observe that the regions with the highest percentage of sensitive areas, like France, East England, Germany, Netherlands, Denmark and Finland, present for the *'CAP Reform Proposal 2003'* simulation an average nitrate (N) surplus reduction of -1%, whereas the average reduction in the EU is about –3.5% compared to the *Agenda reference run*.**

Farm types

In Table (31) the Nitrate (N) surplus per selected farm type in the Base year (1998), **Agenda reference run** [2009] and '**CAP Reform Proposal 2003**' [2009] is given. The percentages in the Base year (1998) column give the difference between Base year (1998) and **Agenda reference run** [2009]. The percentages in the '**CAP Reform Proposal 2003**' [2009] column give the difference between **Agenda reference run** and '**CAP Reform Proposal 2003**' in 2009. Table (30) gives farm types, which are most dominant in the EU.

The highest nitrate surplus per hectare in the Base year (1998) is found at the following farm types: Dairy (69 kg N/ha), Cattle fattening and rearing (38 kg N/ha), Sheep & goats (20 kg N/ha), Specialised pigs (62 kg N/ha), Poultry (2292 kg N/ha), Livestock diversified (73 kg N/ha) and Livestock & crops diversified (25 kg N/ha). By far the largest contribution to total nitrate surplus in the EU is given by farm type dairy.

The remaining of this section on nitrate surplus per farm type consist of a general discussion of scenario effects and a discussion in more detail for some further selected farm types.

The **Agenda reference run** results into a further increase in nitrate surplus per hectare at farm types Cattle fattening & rearing, Sheep & goats, Speciliased pigs and Poultry. This is mainly explained by the increase in the number other cows, fattening pigs and poultry. The largest decrease in nitrate surplus per hectare is found at farm type Dairy (-4.7%). This is explained by the decrease of the number of dairy cows and the increase in extensive grassland use.

The '**CAP Reform Proposal 2003**' [2009] compared to the **Agenda reference run** [2009] results into a further decrease of the nitrate surplus per hectare at farm type Dairy. The largest decrease in nitrate surplus per hectare however is expected at farm type Cattle fattening & rairing (-11.4%). This is explained by the decrease in the number of cattle fattening. The nitrate surplus per hectare at farm types Specialist pigs and Poultry is rather stable. A small increase in nitrate surplus is found at farm type Field crops diversified.

Table (31) Table Nitrate (N) surplus per farm type

	Base year [1998]		Agenda reference run [2009]		'CAP Reform Proposal 2003' [2009]	
	Impact	*Impact per ha UAA*	*Impact*	*Impact per ha UAA*	*Impact*	*Impact per ha UAA*
Specialist COP (other than rice) or various field crops	217.14	6	218.8 *0.76%*	6.05 *0.76%*	217.8 *-0.46%*	6.02 *-0.46%*
Specialist Rice or Rice & COP	0.15	4.79	0.15 *-1.80%*	4.71 *-1.76%*	0.15 *-1.37%*	4.65 *-1.37%*
Root crops	7.01	2.75	5.86 *-16.34%*	2.3 *-16.34%*	5.74 *-2.15%*	2.25 *-2.15%*
Permanent crops & vegetables	49.81	5.56	53.77 *7.95%*	5.99 *7.70%*	50.69 *-5.73%*	5.64 *-5.73%*
Dairy	1449.4	69.3	1381.05 *-4.72%*	66.03 *-4.72%*	1354.28 *-1.94%*	64.75 *-1.94%*
Cattle fattening & rairing	279.78	38.39	292.77 *4.64%*	40.17 *4.64%*	259.5 *-11.36%*	35.6 *-11.36%*
Sheep & goats	253.34	19.61	256.26 *1.15%*	19.84 *1.15%*	241.39 *-5.80%*	18.69 *-5.80%*
Specialist pigs	88.71	62.29	91.96 *3.66%*	64.58 *3.67%*	92.14 *0.19%*	64.7 *0.19%*
poultry	6.43	2292.37	6.92 *7.63%*	2467.34 *7.63%*	6.9 *-0.35%*	2458.63 *-0.35%*
Field crops diversified	13.98	4.26	14.46 *3.38%*	4.41 *3.40%*	14.73 *1.86%*	4.49 *1.86%*
Livestock diversified	47.8	73.37	47.6 *-0.41%*	73.08 *-0.41%*	46.99 *-1.28%*	72.14 *-1.28%*
Livestock & crops diversified	192.91	24.68	193.5 *0.31%*	24.76 *0.31%*	190.32 *-1.65%*	24.35 *-1.65%*
Various	1606.39	43.57	1617.96 *0.72%*	43.88 *0.72%*	1556.11 *-3.82%*	42.2 *-3.82%*

In annex 6 the results with respect to all environmental indicators for the selected farm types are presented. In the **Agenda reference run** [2009] compared to the Base year (1998) phosphate surplus per hectare increases at all farm types, except at farm types Dairy, Livestock diversified and Various. The increase in phosphate surplus per hectare at farms with livestock ranges from almost +8% at farm type Poultry to about +5% at farm type Cattle fattening & rairing. Potassium surplus per hectare decreases at farm types Specialist Rice or Rice & COP, Root crops, Dairy, Livestock diversified, Livestock and crops diversified and Various. The increase at livestock farms ranges from +7.6% at farm type Poultry to almost +5% at farm type Cattle fattening & rairing.

The '**CAP Reform Proposal 2003**' [2009] compared to the **Agenda reference run** [2009] results into a decrease of phosphate and potassium surplus per hectare for all farm types, except a small increase in phosphate and potassium surplus per hectare at farm type Specialist Rice or Rice & COP and a small increase in phosphate surplus at farm type Specialised pigs (+0.2%). The decrease in phosphate surplus per hectare ranges from –11.8% at farm type Cattle fattening & rairing to –0.3% at farm type Poultry. The decrease in potassium surplus per hectare ranges from –12.6% at farm type Cattle fattening & rairing to -0.3% at farm type Specialised pigs.

Detailed analyses of nitrate balance per farm type

The nitrate balances for farm types Specialist COP (other than rice) or various field crops, Dairy, Cattle fattening & rairing and Field crops diversified will be discussed in more detail.

The nitrate balance for farm type specialist COP (other than rice) shows an increase in import of mineral fertilizer and animal manure under the **Agenda reference run** compared to the Base year (1998). On the output side of the nitrate balance there is an increase in export of nitrate with harvest and a relative strong increase in emission of ammonia. The resulting effect of the **Agenda reference run** on nitrate surplus is relatively small.

The **CAP Reform Proposal 2003** results into a small decrease of the nitrate surplus at farm type Specialist COP (other than rice). This is the result of both a decrease in import of mineral fertilizer and manure. This decrease at the input side is partly offset by a decrease of export of nitrate with harvest and a decrease in emission of ammonia at the output side.

Table (32) Nitrate (N) balance farm type Specialist COP (other than rice) or various field crops

	Base year [1998]		Agenda reference run [2009]		CAP reform proposal 2003 [2009]	
	Impact	*Impact per ha UAA*	*Impact*	*Impact per ha UAA*	*Impact*	*Impact per ha UAA*
Import by mineral fertilizer	3957.43	109.36	4367.8 *10.37%*	120.69 *10.37%*	4215.66 *-3.48%*	116.49 *-3.48%*
Export with harvest	2714.75	75.02	2919.33 *7.54%*	80.67 *7.54%*	2849.48 *-2.39%*	78.74 *-2.39%*
Import by manure	483.21	13.35	499.3 *3.33%*	13.8 *3.33%*	484.16 *-3.03%*	13.38 *-3.03%*
Biological fixation	50.23	1.39	52.45 *4.41%*	1.45 *4.41%*	53.06 *1.16%*	1.47 *1.16%*
Releases from soil	957.39	26.46	951.62 *-0.60%*	26.3 *-0.60%*	960.93 *0.98%*	26.55 *0.98%*
Atmospheric deposition	492.07	13.6	492.06 *0.00%*	13.6 *0.00%*	492.06 *0.00%*	13.6 *0.00%*
Ammonia losses from organic fertiliser	130.33	3.6	134.23 *2.99%*	3.71 *2.99%*	130.55 *-2.74%*	3.61 *-2.74%*
Ammonia losses from anorganic fertiliser	181.72	5.02	200.31 *10.23%*	5.54 *10.23%*	192.96 *-3.67%*	5.33 *-3.67%*
Ammonia losses from soil	265.89	7.35	269.42 *1.33%*	7.44 *1.33%*	265.93 *-1.29%*	7.35 *-1.29%*
Surplus	217.14	6	218.8 *0.76%*	6.05 *0.76%*	217.8 *-0.46%*	6.02 *-0.46%*

The next nitrate balance to be discussed in more detail is the nitrate balance for farm type Dairy. Compared to farm type Specialist COP, the use of nitrate from mineral fertiliser is relatively low and the use of nitrate from animal manure is relatively high at farm type Dairy. Contrary to farm type Specialist COP (other than rice) the nitrate surplus at farm type Dairy decreases under the **Agenda reference run** as compared to the Base year. This is mainly explained by the relative strong decrease in import of nitrate by manure. This effect on nitrate surplus is only partly offset by the relative to farm type Specialist COP large increase in import of mineral fertiliser and small increase in nitrate export with harvest.

The **CAP Reform Proposal 2003** results in a decrease of nitrate import from both mineral fertilizer and animal manure at farm type Dairy. A switch to more extensive production systems at farm type Dairy mainly explains the former decrease. The latter decrease is explained by a strong decrease of the number of beef cattle at farm type Dairy and related decrease in manure production. The decreasing effect of **CAP Reform Proposal 2003** on manure production from beef cattle more than offset the increase in manure production from dairy cows at the average dairy farm in the EU. The number of dairy cows increases due to the expansion of the milk quota under **CAP Reform Proposal 2003**.

Table (33) Nitrate (N) balance farm type Dairy

	Base year [1998]			Agenda reference run [2009]			CAP reform proposal 2003 [2009]		
		Impact	*Impact per ha UAA*		*Impact*	*Impact per ha UAA*		*Impact*	*Impact per ha UAA*
Import by mineral fertilizer		895.13	42.8		1016.06 *13.51%*	48.58 *13.51%*		977.01 *-3.84%*	46.72 *-3.84%*
Export with harvest		1116.98	53.41		1162.71 *4.09%*	55.59 *4.09%*		1143.58 *-1.64%*	54.68 *-1.64%*
Import by manure		2474.77	118.33		2309.75 *-6.67%*	110.44 *-6.67%*		2262.97 *-2.03%*	108.2 *-2.03%*
Biological fixation		84.93	4.06		88.45 *4.14%*	4.23 *4.14%*		92.36 *4.43%*	4.42 *4.43%*
Releases from soil		866.41	41.43		865.04 *-0.16%*	41.36 *-0.16%*		865.31 *0.03%*	41.37 *0.03%*
Atmos-pheric deposition		370.62	17.72		370.62 *0.00%*	17.72 *0.00%*		370.62 *0.00%*	17.72 *0.00%*
Ammonia losses from organic fertiliser		644.65	30.82		570.4 *-11.52%*	27.27 *-11.52%*		559.46 *-1.92%*	26.75 *-1.92%*
Ammonia losses from anorganic fertiliser		32.16	1.54		36.64 *13.92%*	1.75 *13.92%*		35.19 *-3.94%*	1.68 *-3.94%*
Ammonia losses from soil		168.6	8.06		168.65 *0.03%*	8.06 *0.03%*		167.61 *-0.62%*	8.01 *-0.62%*
Surplus		1449.4	69.3		1381.05 *-4.72%*	66.03 *-4.72%*		1354.28 *-1.94%*	64.75 *-1.94%*

The effects of **CAP Reform Proposal 2003** on nitrate balance at farm type Dairy also applies to the effect on the nitrate balance at farm type Cattle fattening & rairing. However the switch to extensive production systems is stronger and the effect of the decrease in the number of beef cattle on total manure production is bigger. The relative effect on number of beef cattle at farm type Cattle fattening & rairing is however smaller compared to farm type Dairy. This shows the tendency of specialisation coming from the **CAP Reform Proposal 2003**.

The next table shows in detail the nitrate balance for farm type Specialist pigs. In the **Agenda reference run** the nitrate surplus at farm type Specialist Pigs increases compared to the Base year. This is due to both an increase in import by mineral fertilizer and an import by animal manure. The latter results from an increase in number of pork.

Under the **CAP Reform Proposal 2003** farm type Specialist Pigs also switches to extensive grassland production and this results into a decrease in the import of nitrate by mineral fertilizer. The import of nitrate by manure is hardly affected due to a combination of a constant number of pork and poultry, a decrease in the number of beef cattle and an increase in the number of dairy cows.

The different scenarios in about the same way as farm type Specialist Pigs affect the nitrate balance of farm type Poultry. The small differences in relative changes in nitrate surplus between the two farm types can be explained by differences in farm structure.

Table (34) Nitrate (N) balance farm type Specialist Pigs

	Base year [1998]			Agenda reference run [2009]			CAP reform proposal 2003 [2009]		
		Impact	*Impact per ha UAA*		*Impact*	*Impact per ha UAA*		*Impact*	*Impact per ha UAA*
Import by mineral fertilizer		135.55	95.18		139.96 *3.26%*	98.29 *3.27%*		132.72 *-5.18%*	93.2 *-5.18%*
Export with harvest		110.15	77.35		112.27 *1.92%*	78.84 *1.93%*		108.98 *-2.93%*	76.53 *-2.93%*
Import by manure		170.62	119.81		177.03 *3.76%*	124.32 *3.77%*		177.03 *0.00%*	124.32 *0.00%*
Biological fixation		1.29	0.9		1.34 *4.36%*	0.94 *4.37%*		1.52 *13.17%*	1.07 *13.17%*
Releases from soil		31.67	22.24		32.01 *1.08%*	22.48 *1.09%*		32.76 *2.32%*	23 *2.32%*
Atmos-pheric deposition		21.5	15.1		21.5 *-0.01%*	15.1 *-0.01%*		21.5 *0.00%*	15.1 *0.00%*
Ammonia losses from organic fertiliser		62.81	44.1		64.87 *3.28%*	45.55 *3.29%*		64.88 *0.02%*	45.56 *0.02%*
Ammonia losses from anorganic fertiliser		4.18	2.94		4.39 *4.93%*	3.08 *4.94%*		4.21 *-4.20%*	2.95 *-4.20%*
Ammonia losses from soil		10.75	7.55		10.89 *1.31%*	7.65 *1.31%*		10.78 *-1.06%*	7.57 *-1.06%*
Surplus		88.71	62.29		91.96 *3.66%*	64.58 *3.67%*		92.14 *0.19%*	64.7 *0.19%*

The last nitrate balance to be discussed in detail is the nitrate balance for farm type Field crops diversified. This is the only farm type where nitrate surplus increases under the **CAP Reform Proposal 2003**, namely 1.86% compared to the **Agenda reference run**. This effect is mainly explained by the relative low ratio between import of nitrate by mineral fertilizer and manure and export of nitrate with harvest as compared to other farm types. As a result the decrease in nitrate import by mineral fertiliser and manure is offset by a decrease in nitrate export with harvest. Moreover, at the output side of the nitrate balance, the **CAP Reform Proposal 2003** also leads to a decrease in emission of nitrate as ammonia. As a result of these changes at both the input and output side of the nitrate balance, the nitrate surplus could increase.

Table (35) Nitrate (N) balance farm type Field crops diversified

	Base year [1998]		Agenda reference run [2009]		CAP reform proposal 2003 [2009]	
	Impact	*Impact per ha UAA*	*Impact*	*Impact per ha UAA*	*Impact*	*Impact per ha UAA*
Import by mineral fertilizer	174.67	53.23	197.17 *12.89%*	60.1 *12.91%*	188.91 *-4.19%*	57.59 *-4.19%*
Export with harvest	140.33	42.77	151.32 *7.83%*	46.13 *7.85%*	147.04 *-2.83%*	44.82 *-2.83%*
Import by manure	33.07	10.08	34.61 *4.67%*	10.55 *4.69%*	33.66 *-2.75%*	10.26 *-2.75%*
Biological fixation	2.75	0.84	2.77 *0.90%*	0.84 *0.92%*	2.85 *2.74%*	0.87 *2.74%*
Releases from soil	88.59	27	88.38 *-0.24%*	26.94 *-0.22%*	88.54 *0.18%*	26.99 *0.18%*
Atmos-pheric deposition	29.02	8.84	29.01 *-0.02%*	8.84 *-0.01%*	29.01 *0.00%*	8.84 *0.00%*
Ammonia losses from organic fertiliser	10.29	3.13	10.75 *4.56%*	3.28 *4.58%*	10.49 *-2.49%*	3.2 *-2.49%*
Ammonia losses from anorganic fertiliser	9.89	3.01	11.14 *12.64%*	3.4 *12.66%*	10.64 *-4.52%*	3.24 *-4.52%*
Ammonia losses from soil	19.56	5.96	19.58 *0.11%*	5.97 *0.13%*	19.23 *-1.79%*	5.86 *-1.79%*
Surplus	13.98	4.26	14.46 *3.38%*	4.41 *3.40%*	14.73 *1.86%*	4.49 *1.86%*

To conclude, the effects of the **CAP Reform Proposal 2003** on the nitrate balances per farm type are complex. In general, the effect of **CAP Reform Proposal 2003** on nitrate surplus at crop farms is mainly a function of the ratio between import of nitrate with mineral fertiliser and manure and export with harvest. The effect of **CAP Reform Proposal 2003** on nitrate surplus at livestock farms is mainly a function of the share of manure from beef cattle in total manure production and the possibility to switch to extensive production systems. Moreover, the decrease in nitrate import from mineral fertiliser and manure also results into a decrease in ammonia emission.

7.1.2 Ammonia output

Table (36) shows ammonia output for the selected farm types under different runs. In the **Agenda reference run** [2009] compared to the Base year (1998) ammonia output increases for all farm types, except for farm type Dairy (-5.5%). The largest increase in ammonia output in the **Agenda reference run** compared to the base is found for farm type Root crops (+11.6%). The increase in ammonia output at farm type Root crop is explained by an increase in nitrate (N) from especially mineral fertilizer and a rather high ratio between import of nitrate from manure and mineral fertiliser and export of nitrate (N) with harvest. The increase in import of manure is explained by an increase in own manure production from other cows, pork and poultry.

In the '**CAP Reform Proposal 2003**' [2009] compared to **Agenda reference run** [2009] the ammonia output decreases for all farm types. The decrease ranges from –11% for farm type Cattle fattening & rairing to –0.3% for farm type Poultry.

Table (36) Table Ammonia output per selected farm type

	Base year [1998]		Agenda reference run		CAP reform proposal 2003	
	Impact	*Impact per ha UAA*	*Impact*	*Impact per ha UAA*	*Impact*	*Impact per ha UAA*
Specialist COP (other than rice) or various field crops	**310.98**	**8.59**	**334.54** *7.57%*	**9.24** *7.57%*	**323.51** *-3.30%*	**8.94** *-3.30%*
Specialist Rice or Rice & COP	**0.28**	**8.87**	**0.34** *22.17%*	**10.84** *22.22%*	**0.34** *-1.13%*	**10.71** *-1.13%*
Root crops	**20.74**	**8.15**	**23.15** *11.62%*	**9.09** *11.62%*	**22.45** *-3.04%*	**8.82** *-3.04%*
Permanent crops & vegetables	**50.55**	**5.64**	**52.3** *3.45%*	**5.82** *3.21%*	**49.43** *-5.48%*	**5.5** *-5.48%*
Dairy	**642.1**	**30.7**	**607.04** *-5.46%*	**29.03** *-5.46%*	**594.66** *-2.04%*	**28.43** *-2.04%*
Cattle fattening & rairing	**115.03**	**15.78**	**120.61** *4.85%*	**16.55** *4.84%*	**107.36** *-10.98%*	**14.73** *-10.98%*
Sheep & goats	**71.04**	**5.5**	**72.79** *2.47%*	**5.63** *2.47%*	**68.35** *-6.10%*	**5.29** *-6.10%*
Specialist pigs	**66.65**	**46.8**	**69.26** *3.92%*	**48.63** *3.93%*	**69.09** *-0.25%*	**48.52** *-0.25%*
poultry	**4.07**	**1449.44**	**4.39** *7.82%*	**1562.8** *7.82%*	**4.37** *-0.33%*	**1557.63** *-0.33%*
Field crops diversified	**20.1**	**6.13**	**21.9** *8.93%*	**6.67** *8.95%*	**21.12** *-3.52%*	**6.44** *-3.52%*
Livestock diversified	**28.19**	**43.28**	**28.44** *0.88%*	**43.65** *0.88%*	**28.02** *-1.47%*	**43.01** *-1.47%*
Livestock & crops diversified	**149.98**	**19.19**	**153.31** *2.22%*	**19.61** *2.23%*	**149.57** *-2.44%*	**19.13** *-2.44%*
Various	**941.72**	**25.54**	**961.38** *2.09%*	**26.07** *2.09%*	**931.02** *-3.16%*	**25.25** *-3.16%*

7.1.3 Global Warming Emissions

The CAPRI Model covers different greenhouse emissions relevant for Agriculture. For animal production activities *methane* emissions are calculated through uniform coefficients at EU level per animal type. These emissions are disaggregated at Nuts II level according to the number of animals produced in the corresponding region. In crop production these coefficients depend not only on the production level (hectares) but also on the amount of fertiliser applied per hectare in each regions (as reported by EUROSTAT and REGIO). The amount of *nitrous oxide* and *methane* from biotic processes released in the atmosphere is approached through nitrogen contain in mineral and organic fertiliser on soils.

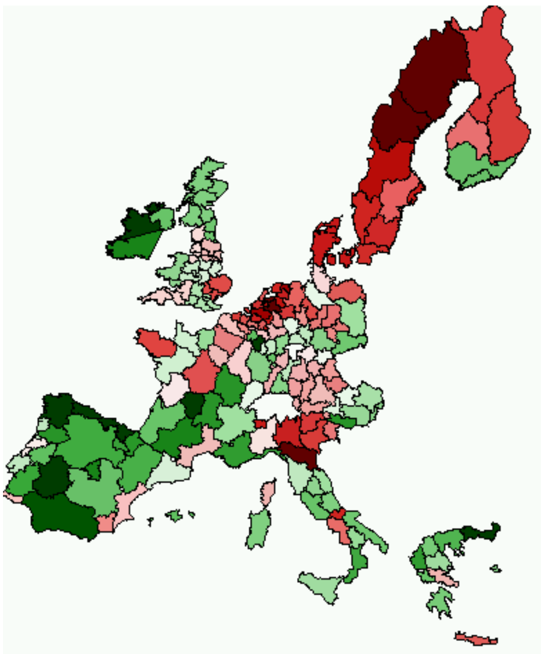
Table (37) Global warming potential per selected farm type

	Base year [1998]			Agenda reference run [2009]			CAP reform proposal 2003 [2009]		
Global warming potential	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*
Specialist COP (other than rice) or various field crops	**35876.51**	**35876.51**	**991.37**	**39233.79** *9.36%*	**39233.79** *9.36%*	**1084.14** *9.36%*	**37923.40** *-3.34%*	**37923.40** *-3.34%*	**1047.93** *-3.34%*
Specialist Rice or Rice & COP	**38.13**	**38.13**	**1212.16**	**48.37** *26.86%*	**48.37** *26.86%*	**1538.33** *26.91%*	**47.66** *-1.48%*	**47.66** *-1.48%*	**1515.52** *-1.48%*
Root crops	**3644.82**	**3644.82**	**1431.44**	**4129.61** *13.30%*	**4129.61** *13.30%*	**1621.88** *13.30%*	**4038.46** *-2.21%*	**4038.46** *-2.21%*	**1586.08** *-2.21%*
Permanent crops & vegetables	**3530.97**	**3530.97**	**394.01**	**3576.88** *1.30%*	**3576.88** *1.30%*	**398.20** *1.06%*	**3380.13** *-5.50%*	**3380.13** *-5.50%*	**376.30** *-5.50%*
Dairy	**23302.90**	**23302.90**	**1114.22**	**22779.37** *-2.25%*	**22779.37** *-2.25%*	**1089.19** *-2.25%*	**22006.68** *-3.39%*	**22006.68** *-3.39%*	**1052.24** *-3.39%*
Cattle fattening & rairing	**5077.92**	**5077.92**	**696.68**	**5229.20** *2.98%*	**5229.20** *2.98%*	**717.42** *2.98%*	**4779.17** *-8.61%*	**4779.17** *-8.61%*	**655.68** *-8.61%*
Sheep & goats	**5403.77**	**5403.77**	**418.30**	**5400.92** *-0.05%*	**5400.92** *-0.05%*	**418.08** *-0.05%*	**5140.46** *-4.82%*	**5140.46** *-4.82%*	**397.92** *-4.82%*
Specialist pigs	**2365.66**	**2365.66**	**1661.12**	**2498.19** *5.60%*	**2498.19** *5.60%*	**1754.34** *5.61%*	**2440.72** *-2.30%*	**2440.72** *-2.30%*	**1713.98** *-2.30%*
Poultry	**10.07**	**10.07**	**3588.24**	**10.67** *5.92%*	**10.67** *5.92%*	**3800.70** *5.92%*	**10.59** *-0.69%*	**10.59** *-0.69%*	**3774.40** *-0.69%*
Field crops diversified	**1670.13**	**1670.13**	**509.01**	**1853.88** *11.00%*	**1853.88** *11.00%*	**565.12** *11.02%*	**1782.40** *-3.86%*	**1782.40** *-3.86%*	**543.33** *-3.86%*
Livestock diversified	**947.46**	**947.46**	**1454.42**	**983.87** *3.84%*	**983.87** *3.84%*	**1510.32** *3.84%*	**957.45** *-2.69%*	**957.45** *-2.69%*	**1469.76** *-2.69%*
Livestock & crops diversified	**8258.61**	**8258.61**	**1056.51**	**8701.84** *5.37%*	**8701.84** *5.37%*	**1113.24** *5.37%*	**8278.26** *-4.87%*	**8278.26** *-4.87%*	**1059.05** *-4.87%*
Various	**38988.11**	**38988.11**	**1057.40**	**40461.58** *3.78%*	**40461.58** *3.78%*	**1097.39** *3.78%*	**38523.29** *-4.79%*	**38523.29** *-4.79%*	**1044.82** *-4.79%*

The results observed in the previous table are directly linked to the shifts in production already commented (since ecological production and other technologies are not modelled). It is interesting to see how NO_2 emissions increase heavily in certain crop production farm types like root crops, field corps diversified and specialist COP. This is mainly due to the increases in production for Grandes Cultures in Agenda 2000 due to higher premiums and to the exogenous shift of permanent crops and vegetables from the base year to the reference run (consistent increasing rate of 3.9% for Europe). On the other side a similar explanation can be derived for the animal production activities, with methane emissions as the relevant ones. Pig and poultry specialist farm types increase GW emissions in 5-6%, with similar increases in production as cereal activities. The Global Warming effect is though smaller due to the fact that methane has a smaller conversion factor (less prolonged radiation in the atmosphere, as reported by the IPCCC). Dairy specialist farm types see emissions decrease due to a higher intensification of production and the quota mechanism binding production increases.

For the CAP Reform Proposal 2003 the effects are completely different, dominating exclusively shifts between activities according to economic profitability. Emissions would follow in this case exclusively production shifts (already explained).

Map (10) Change in Global Warming Potentials: 'CAP Reform Proposal 2003' versus Agenda 2000 (distribution at Nuts 2 level)



Note: From dark green to light green: between –11 % and –6 %, white around –4 % and from light red to dark red between -3 % and 0 %.

Global Warming Potentials (GWP) decrease under a 'CAP Reform Proposal 2003' scenario (-4.15%) with respect to Agenda 2000. The GWP coefficients affecting each relevant emission gas are calculated yearly by the IPCC and are shown in Table (38).

Table (38) Global Warming Potentials (100 years effect)

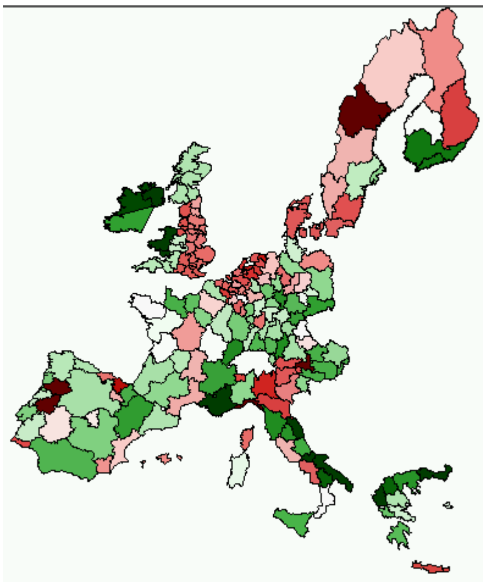
Methane	Carbon Dioxide	Nitrous oxide
21	1	310

Source: IPCC 2001

The analysis of the changes in individual global warming relevant gases at a regional level are graphically shown in the following maps:

- *Carbon Dioxide emissions* drop due to a decrease in crop production and increase in fallow land (24 %). In other words, the reduction of acreage coupled with a similar reduction on production (after discounting yield increases due to technical progresses and not to higher application of fertiliser), forces the system to reduce total emissions. If agricultural area is also considered constant, than emissions per hectare also decrease in overall (as shown in the mapping tool).

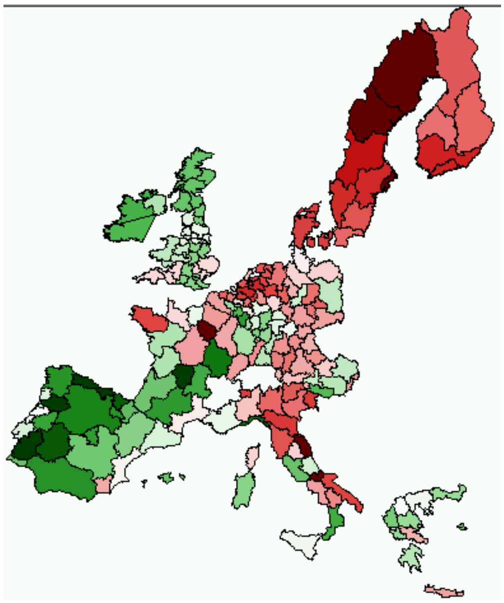
Map (11) Change in Carbon Dioxide Emissions: 'CAP Reform Proposal 2003' versus Agenda 2000 (distribution at Nuts 2 level)



Note: From dark green to light green: between –20 % and -5 %, white around -3 % and from light red to dark red between -1 % and 3 %.

- *Methane emissions* continue to drop affected by the reduction in cattle number (-6 %). This effect is partially cancelled out by the increase in number for other animals (pig production, laying hens and other animals), however having them a lower methane emission coefficient per head.

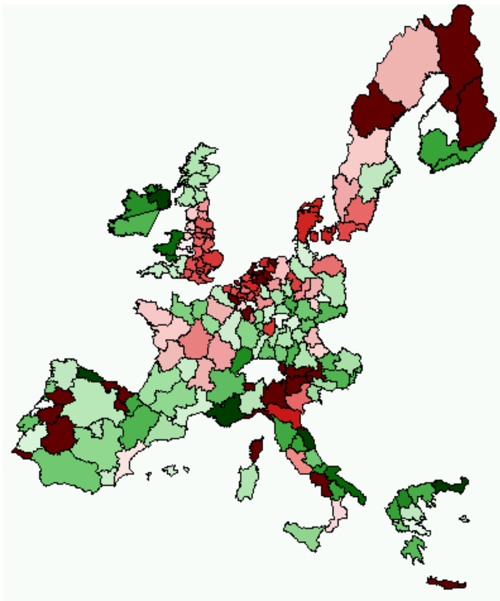
Map (12) Change in Methane Emissions from animals: 'CAP Reform Proposal 2003' versus Agenda 2000 (distribution at Nuts 2 level)



Note: From dark green to light green: between –11 % and -5 %, white around -4 % and from light red to dark red between -2 % and 4 %.

- *Nitrous Oxide emissions* (N2O) fall correlated to crop production and CO2 emissions, as shown in the following map.

Map (13) Change in Nitrous Oxide Emissions: 'CAP Reform Proposal 2003' versus Agenda 2000 (distribution at Nuts 2 level)



Note: From dark green to light green: between –19 % and -4 %, white around -3 % and from light red to dark red between -2 % and 16 %.

The overall effect for the different gases and their translation into GWPs for the different scenarios is shown in the next table.

Table (39) Global Warming Emissions (t)

Global Warming	Base year [1998]			Agenda reference run [2009]			CAP reform proposal 2003 [2009]		
European Union	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*
Methane output	**2447.45**	**51396.48**	**17.62**	**2361.50** *-3.51%*	**49591.58** *-3.51%*	**17.00** *-3.53%*	**2252.40** *-4.62%*	**47300.31** *-4.62%*	**16.21** *-4.62%*
Global warming potential	**129115.07**	**129115.07**	**929.57**	**134908.16** *4.49%*	**134908.16** *4.49%*	**971.15** *4.47%*	**129308.68** *-4.15%*	**129308.68** *-4.15%*	**930.84** *-4.15%*
Ammonium output	**2421.42**		**17.43**	**2449.43** *1.16%*		**17.63** *1.14%*	**2369.28** *-3.27%*		**17.06** *-3.27%*
Methane from animals	**2363.95**	**49642.92**	**17.02**	**2269.98** *-3.97%*	**47669.68** *-3.97%*	**16.34** *-3.99%*	**2164.18** *-4.66%*	**45447.85** *-4.66%*	**15.58** *-4.66%*
Methane linked to fertiliser use	**83.50**	**1753.56**	**0.60**	**95.58** *14.46%*	**2007.17** *14.46%*	**0.69** *14.45%*	**92.16** *-3.58%*	**1935.39** *-3.58%*	**0.66** *-3.58%*
CO2 linked to fertiliser use	**33257.63**	**33257.63**	**239.44**	**40394.11** *21.46%*	**40394.11** *21.46%*	**290.78** *21.44%*	**39011.45** *-3.42%*	**39011.45** *-3.42%*	**280.83** *-3.42%*
N20 linked to fertiliser use	**143.42**	**44460.96**	**1.03**	**157.74** *9.98%*	**48898.60** *9.98%*	**1.14** *9.97%*	**151.18** *-4.16%*	**46864.58** *-4.16%*	**1.09** *-4.16%*

7.1.4 Water Balances

Water deficits are defined by the difference between the crop water requirements plus evapo-transpiration during the growth cycle and the rain in that period. They are calculated on a daily basis and accumulated. These indicator is always equal or less than zero.

Water deficits allow measuring the irrigation requirements. This indicator can be interpreted as a measure of the pressure on water as a natural resource.

This indicator is pertinent essentially in Southern Regions of Europe. Of course, when irrigation management is technically inefficient, irrigation can be associated also with pollution, but this indicator does not allow such interpretation.

Water balances are calculated for the complete calendar year, reason explaining why it is exceptional to get negative values. This indicator can be interpreted as enhancing the chemical pollution risk, associated with the leaching and runoff of fertilizers and pesticides. This indicator is useful even in Southern Europe, because on an annual basis the balance can be positive, even with high deficits concerning the plant water requirement during the growing seasons.

The meteorological data from JRC includes for 10 years monthly data from 1992-2001 minimum and maximum temperature, rainfall, wind speed and et0 (evapo-transpiration with Penman-M).

The soil coverage has been extracted from the CAPRI database for 1994 by identifying for each NUTS II region the 5 principal cultures (including grassland and fallow) by their surface proportion. The next step has been to quantify agronomic criteria like the Kc for each stage.

The majority of Kc was obtained from the FAO CropWat package and from CropSyst. However, several Kc's had to be estimated as the data was unavailable such as for perennial cultures (grapes, citrus or olives), grassland and fallow. Set-aside land was considered as grassland and the Kc adjusted as Ray-Grass.

The growth cycles had to be adjusted for specific climate extremes but they are essentially based on CropWat and CropSyst data, as they seem to depend more on plant variety than on latitude. Perennial productions growth cycles have been estimated to 10% planted, 80% in production and 10% in attrition.

Planting dates had to be adjusted because even inside a NUTS2 region, planting dates for specific crops can be distinct by weeks to months.

Table (40) Water balances, 10 year daily average (mm)

	Base year [1998]		Agenda reference run		CAP reform proposal 2003		
	Impact	*Impact per ha UAA*	*Impact*	*Impact per ha UAA*	*Impact*		*Impact per ha UAA*
Specialist COP (other than rice) or various field crops	9956.03	275.11	9812.99 *-1.44%*	271.16 *-1.44%*	9468.3 *-3.51%*		261.64 *-3.51%*
Specialist Rice or Rice & COP	-2.5	-79.41	-2.48 *0.67%*	-78.91 *0.63%*	-2.39 *3.86%*		-75.87 *3.86%*
Root crops	1070.21	420.31	1076.38 *0.58%*	422.74 *0.58%*	1052.7 *-2.20%*		413.44 *-2.20%*
Permanent crops and vegetables	-2115.89	-236.11	-2112.78 *0.15%*	-235.21 *0.38%*	-2167.7 *-2.60%*		-241.32 *-2.60%*
Field crops diversified	3	0.91	3.56 *18.72%*	1.08 *18.75%*	-12.87 *-461.94%*		-3.92 *-461.94%*

By the moment the model assign the water balances observed for the five most frequent crops in a region equally to all activities in this regions (rough average). From Table (40) it is possible to carefully observe that regions with a high proportion of vegetables and perennials have a higher water deficit than cereal specialist regions. All information attached to animal activities and mixed production is not included, due to the fact that water balances are not relevant for them. The '**CAP Reform Proposal 2003**' results for water follow the results of the supply model, as water is just a passive indicator.

Water balances could be combined with *nutrient balances* per region to construct an indicator for "risk of leaching". Regions with high water balances and nutrient surpluses at the same time might have a higher risk of environmental damage through nutrient leaching than others. On the other side, water balances in a region and yields are also analysed together, with the idea of looking at possible correlation between low yield regions and negative water balances during crop production, water deficits[10].

[10] Water deficits do not refer to the whole year, but to the cropping season.

8. Further improvements: the inclusion of endogenous yields

It is important to note that modelling systems as CAPRI are more or less permanently in development. First of all, any application will detect things to correct in the various data sources used, and the way they are integrated in the modelling system. A long list of small things to correct is one outcome of a major application as the '**CAP Reform Proposal 2003**' impact assessment from autumn 2002, and the team has used the time to work on that list. We will not discuss these changes further on, as their impact at aggregated EU level can be neglected. Secondly, new algorithms and methodological approaches were tested and validated since then, and are now integrated in the new runs.

From a micro theory point of view, endogenous yields are an effect of changes in output/input relations and thus relate to the problem of optimal input mix. There are different options to model endogenous yields in quantitative modelling systems. The main one is a production function approach where output is a non-linear function of all inputs. It is generally found in Computable General Equilibrium models and thus coupled to a rather high aggregation level for outputs and inputs, linked to typically rather restrictive technology assumption as constant substitution elasticity's between any pair of inputs. An intermediate one describes output as a function of one "lead input", e.g. nitrate, where all other inputs are adjusted to match the intensity of the "lead input". Both approaches require non-linear constraints in the system.

(Aggregate) programming models use typically different "technologies" to capture substitution possibilities. Each of these technologies comprise on Leontief bundle of input/output coefficients. By mixing different shares of these technologies, the programming model mimics non-linearity's in the underlying technology. Often, these bundles are constructed by running process models.

CAPRI introduced different technologies relatively early in the context of different production system as organic or conventional production. Relating data where sampled in the context of another FAIR project, which then borrowed CAPRI for simulation experiments. Unfortunately, the relating data set was not updated afterwards.

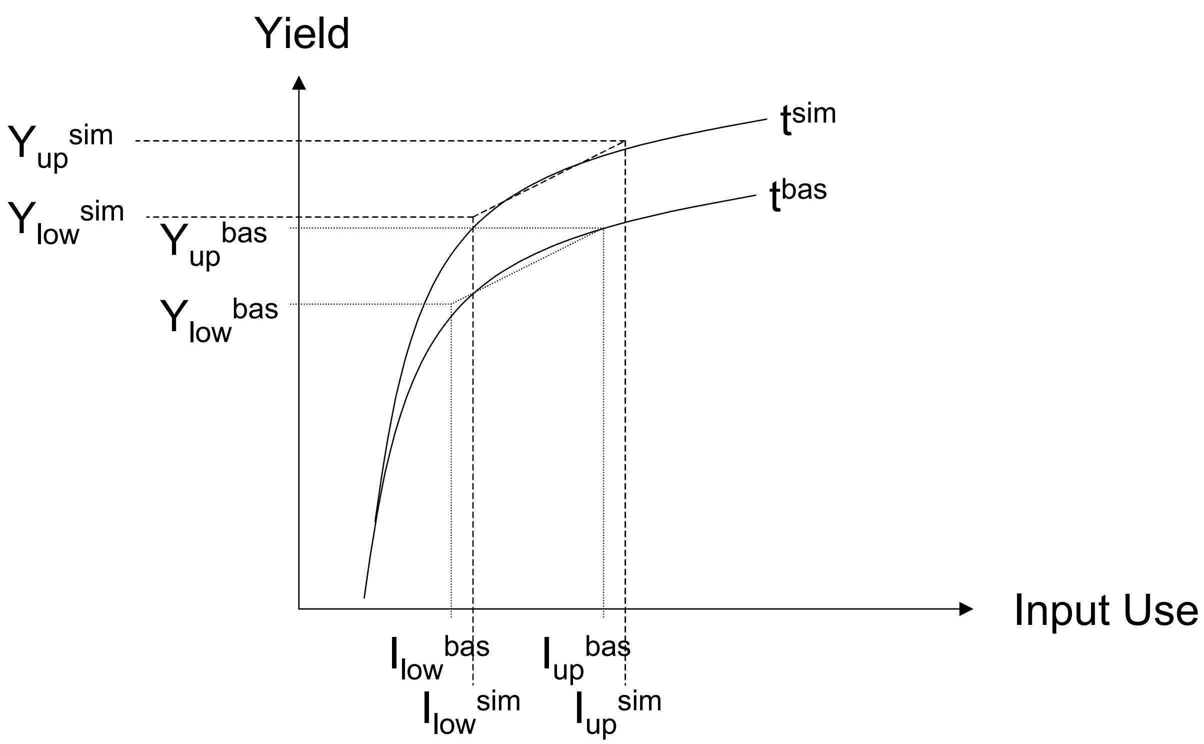
Instead, a rather simplistic approach was integrated in the CAPRI system. Two “standard” technologies are introduced for each endogenous crop activity with +20 % and –20 % yield difference against the average, and +30 % and –30 % difference against the average in all not directly yield dependent inputs (e.g. fertiliser application). The assumption captures decreasing marginal returns to per ha input use. Both “technologies” are cropped with a 50/50 relation in the base year. In an ex ante simulation run, changes in the relation can hence be interpreted as changes in realisation of technical progress compared to a continuation of technical progress – increases in yields - as based on trend analysis.

The relation between the non-linear yield response function and the different technologies introduced in the CAPRI system are shown in the diagram below. The non-linear curve represents the “true” relation between changes in input use and the yield response, and shows the typical decreasing marginal productivity of input use. It should be noted that the diagram does not relates to a single input, but to a bundle of inputs. Imagine as an example increasing in nitrate fertilising. A yield increase can only result if no other nutrient limits crop growth, so that all other nutrients need to be increased as well if fertiliser level had been adjusted to expected crop growth in the starting situation. On the other hand, increased yields will increase energy use during harvesting and drying to handle higher quantities.

The two points (Y_{up};I_{up}) and (Y_{low};I_{low}) show the two linear technologies introduced. The base year situation is calibrated to observed yields and input use with each technology at 50%, so that the weighted average between the two technologies represents observed behaviour. Technical progress shifts the yield response curve from t^{bas} to t^{sim}, allowing higher yields at unchanged input use (input saving technical progress). The horizontal component of the shift is determined by trend analysis of observed yields, i.e. it represents realised technical progress. A new point at a 50%/50% mix on t^{sim} would hence represent a realisation of technical progress as in the past. The related input quantities for the two technologies are determined by assuming input saving technical progress of 0.2% per year. At unchanged price relations, we would hence expect higher yields at increased input use; the later however with a slower increase.

Changes in the policy and market incentive will lead to movement on the straight line connecting the two points. The final combination chosen represent the profit maximal combination of input and outputs.

Figure (7) Modelling of endogenous yields in CAPRI



9. Further discussion on possible effects of the 'CAP Reform Proposal 2003'

9.1. Effects on land rents and barriers to newcomers

Already in the past, the introduction of direct support increased land rents. As the income from direct support per ha is known and non-stochastic, it is rational for a lessor to use the premium as a kind of minimum price floor on contracts. Already the '92 reform process with its shift from price to direct income support has hence tendentially increased land rents. On the other hand, under a coupled premium scheme, "harvesting" the premium requires some marketable production so that rents may drop below direct support per ha if costs of production exceed revenues. Decoupling in such areas may actually increase land rents, whereas in all cases where the land still provides market revenues, de-coupling per se should not have a sizeable impact on land rents. The price effect of the '**CAP Reform Proposal 2003**' on land rents is not clear. Administrative prices for cereals are further reduced. Market prices especially for rye are simulated to follow the drop, whereas other cereals prices are slightly increasing.

For newcomers, or farmers wishing to increase their areas, the decoupled premium introduces a rigid price floor on land to lease. That land rent is probably higher compared to **Agenda 2000** in regions with a very low profitability where production was solely maintained to receive coupled premiums before. However, increases in fallow land in these regions are pronounced, and interest in buying or leasing land for agricultural production in these regions should be low anyway.

In more favourable region, the decreased prices for outputs may reduce somewhat land rents. The reduced risk by the decoupled system however countervails, so that the general direction is not clear. But the overall change should not be drastic. In such regions, newcomers or growing farms had to struggle already in the past with land value determined by high administrative prices in the eighties and early nineties, and then the effect of coupled support after the '92 reform. It is however clear that in such regions the decoupled scheme introduces a price floor on land rents.

There are however some critical points in the current proposal. Firstly, the text states that land set-aside has to remain fallow in the future. However, a plot judged as marginal from the viewpoint of the current user e.g. by a unfavourable distance from the farm, and thus converted to fallow land under the 10% set-aside obligation, may well be an interesting plot for another farmer. That introduces a certain degree of inflexibility in local land markets.

9.2. Effects on irrigation

Increasing pressure on irrigation is an effect of either increased irrigation need per crop – i.e. intensification – and/or changes in the cropping pattern towards with crops with higher irrigation needs. In the **Agenda reference run**, the overall level of perennials is forecasted to remain almost stable, so that pressure from irrigation of these crops should not change much at global scale. Naturally, at regional or even farm type level, water pressure may increase. Some of these effects are discussed above. Technical progress increasing yields drives up water needs of the plants. The water balances discussed above cannot capture that effect as the coefficients had been derived with biophysical models using input data from the base year.

For the crops receiving coupled premiums in **Agenda 2000**, the de-coupled premiums lead to a decrease in areas. In the model, these crops are mostly replaced either by fallow land or extensive fodder production. The latter require less irrigation water and thus reduce the pressure on water balances.

Countervailing are possible increases in vegetables and perennials as potential damaging candidates, which require typically higher irrigation quantities per ha compared to “Grandes Cultures”. Unfortunately, the model cannot help here as vegetables and perennials are in the current version exogenously trend forecasted and don’t react to market or policy incentives. That will change in the near future when results from the CAP-STRAT project provided by the Spanish team will be integrated in the system. However, vegetables and perennials require specific machinery, a complete different marketing chain and changes in production quantities impact on regional prices, so that probable increases are restricted.

10. Case studies

10.1. Phytosanitary leaching to ground water: Impact analysis for the I-PHY indicator for FR300 Nord Pas de Calais and FR60-Midi-Pyrénées regions

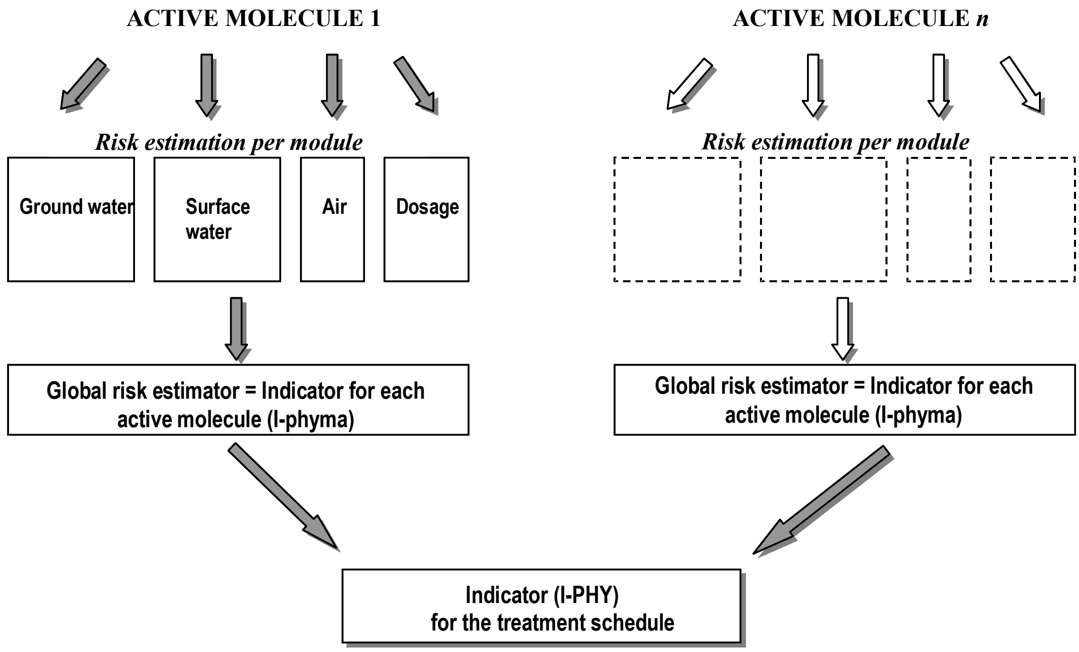
10.1.1 Introduction

The work done in this field crops package constitutes a first outline of what could be developed into an indicator of the impact of phytosanitary products on the environment. It takes into account and is interested exclusively in the pulverized field treatments on water and air. While we have to agree later on about what is the required data, in order to make this indicator more operational as a decision tool, the developed methodology is easily perfectible as it can be extended to all cultures.

This approach is based on field expertise and strongly depends on the technical literature as we do not have detailed information for each culture, in each NUTS2 regions, for the three techniques (CONVentional, INTEgrated, ORGAnic). For example, Austria was divided into two (high and low Austria) and not into 11 NUTS2 regions. For Belgium, the technical results of the area of Gembloux were generalized for the whole country. In France, in conventional or reasoned techniques, the majority of the comparisons confront, for field crops, Ile de France and Centre with the Midi-Pyrenees. However, concerning organic techniques there are many studies for western France (Brittany and Pays of the Loire) and South-west.

These remarks concerning the methodology explain most of the gaps in our results (lacking data is indicated as X for fallow, special cultures and perennial cultures) and about the precautions to take as for their interpretation. Some strong tendencies emerge clearly. The levels of the indicator "pesticides" (I-PHY) make it indeed possible to clearly separate the management techniques of the cultures: organic production naturally has less impact since it prohibits the use of synthetic chemical. We are also able to compare between cultures and European regions.

Figure (8) Construction of the plant protection indicator



Indicators

- The indicators are relative grades with 1 as a reference for organic soft wheat.
- They express the potential environmental risk related to the use of pesticides.
- They have been calculated for 9 crops for every region where soil types and meteorological data, practices and product documentation were available.

Table (41) Case study: dominant crops with their respective acreage (1000 ha)[11]

FR620	GRAE	MAIZ	SWHE	SUNF	BARL
	488.64	231.10	227.01	126.43	101.29
FR300	SWHE	BARL	FMAI	SUGB	GRAE
	275.88	69.94	56.82	64.65	99.85

Table (42) Compounded I-PHY indicator for conventional agriculture

FR620	GRAE	MAIZ	SWHE	SUNF	BARL	TOTAL
	n/a	0.08	0.04	0.03	0.01	**0.16**
FR300	SWHE	BARL	FMAI	SUGB	GRAE	
	0.10	0.01	0.05	n/a	n/a	**0.16**

Table (43) Compounded I-PHY indicator for integrated agriculture

FR620	GRAE	MAIZ	SWHE	SUNF	BARL	TOTAL
	n/a	0.13	0.10	0.08	0.02	**0.32**
FR300	SWHE	BARL	FMAI	SUGB	GRAE	
	0.24	0.04	0.07	n/a	n/a	**0.35**

[11] See codes in Annex 3 (13.3).

Table (44) Compounded I-PHY indicator for organic agriculture

FR620	GRAE	MAIZ	SWHE	SUNF	BARL	**TOTAL**
	n/a	0.20	0.19	0.11	0.08	**0.58**
FR300	SWHE	BARL	FMAI	SUGB	GRAE	
	0.49	0.12	0.10	n/a	n/a	**0.70**

Global pollution indicator assuming the following proportions of systems with the cropping pattern of **Agenda reference run**:

	CONVENTIONAL	100%
SCENARIO 1	INTEGRATED	0%
	ORGANIC	0%

Scenario 1 is staying at 100% in conventional agriculture.

	CONVENTIONAL	0%
SCENARIO 2	INTEGRATED	100%
	ORGANIC	0%

Scenario 2 is moving to 100% in integrated agriculture.

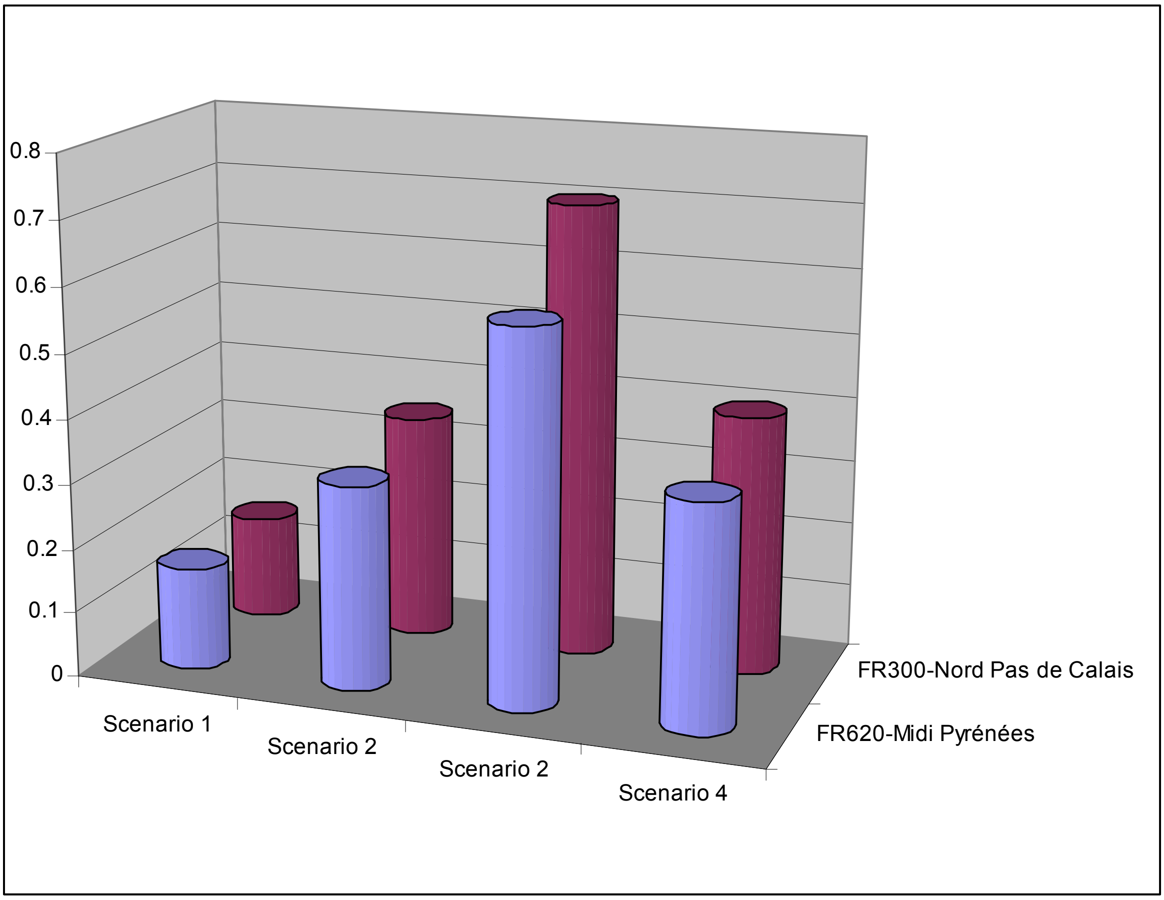
	CONVENTIONAL	0%
SCENARIO 3	INTEGRATED	0%
	ORGANIC	100%

Scenario 3 is moving to 100% in organic agriculture.

	CONVENTIONAL	34%
SCENARIO 4	INTEGRATED	33%
	ORGANIC	33%

Scenario 4 is an equal distribution among the 3 different production systems.

Figure (9) Impact of scenarios of changes in production systems on plant protection indicator



Scenario 1:

The global phytosanitary pollution indicator is about the same in FR620 and FR300 for conventional production.

Scenario 2:

The global phytosanitary pollution indicator is about the same in FR620 and FR300 for integrated production but they are about two times better than the conventional production system.

Scenario 3:

By moving the entire production to an organic system, we observe a huge global improvement for the phytosanitary pollution indicator. However FR300 is experiencing a 2-percentage point better improvement than FR620.

Scenario 4:

An equal distribution of the cropping pattern among the 3 different production systems, one can see an improvement for the phytosanitary pollution indicator that is superior to Scenario 2 (complete move to integrated production). However FR300 is still experiencing a 1-percentage point better improvement than FR620.

I Conventional agriculture

It is possible to note a significant difference between winter cultures (cereals with straw and colza for example) and spring cultures (corn, sunflower...). The first, remaining longer in the field, require in general a more important phytosanitary protection (in particular weedkillers and insecticides). The seconds have a shorter vegetative cycle requiring fewer chemical interventions. This is amplified in the areas with rainy winters (the United Kingdom, Ireland, Brittany) because the fields must be cleaned early on with root-based weedkillers, which are persistent in the soil. On the other hand, this is not true in the northern European countries like Finland, Norway, Sweden or Denmark, because the climatic conditions are such that productions like colza and cereals are planted, like corn, after the winter and thus become spring cultures with a shorter vegetative cycle.

It is also possible to distinguish certain European regions by their different levels of productivity. The traditional NORTH-SOUTH distinction however is not significant with regard to the impact of the phytosanitary products on the environment because different kinds of products are used. In the United Kingdom, in the Netherlands or in the north of France for example, the levels of productivity require an important level of plant protection (presence of growth regulators and several fungicides on wheat for example). However, the level of the indicator is not necessarily lower than for those known for more limited yields because of more extensive techniques. In this case, choosing older, less expensive phytosanitary products, with definitely less favourable toxicological and eco-toxicological profiles, generally does the reduction of the input costs.

Within the same cultures, there are also differences. Thus, in general, the silage corn (FMAI) obtains better scores that the grain corn, because it requires a lower level of protection (in particular insecticides). It is the same for the cultures led in rotation compared to monocultures (SWHE2, MAIZ2, FMAI2). In the second case, the generally stronger parasitic pressure requires a more important use of phytosanitary products.

It is interesting to note that, in general, the "notes" attributed to cereals and corn are largely higher than those of oil crops like colza, the sunflower or soya. The shear size of the wheat acreage is such that private research (agrochemicals) privileged this market. With more homologations and technological innovations, the phytosanitary products for cereals in general have a lesser environmental impact compared to the older products used for oil crops.

It would be interesting to do a European regionalized survey because probably local Laws governing the authorization of phytosanitary products could perhaps better explain the differences obtained between the European regions.

II The integrated agriculture

At the European level, the definition for these agricultural practices has nowhere the same significance (neither the same technical constraints), not even for the same cultures. Germany and Austria, as well as the countries of the North of Europe have strict standards (OILB, 1993). In France, the emergent concept of Reasoned Agriculture does not have a tangible impact on the use of phytosanitary products (VEREIJKEN and VIAUX, 1990 - GIRARDIN, 1993). In the Mediterranean countries, only the perennial cultures (arboriculture and wine grapes) have true technical norms (PI, Iso 14000...) but they are not taken into account in this study.

Hence, we dispose only of little technical documentation for this intermediate way between conventional agriculture and organic agriculture. As there is a lack of information for certain NUTS II regions, we had to extrapolate the results resulting from surrounding regions. In general, the results obtained are better than those of the conventional agriculture as the chemical treatment is being applied as a last resort only, after the "preventive" measures such as crop rotation, the use of natural auxiliaries or mechanical weeding.

The before mentioned observations about the differences in scores between cultures, or areas, remain the same.

III Organic agriculture

With regard to organic agriculture from we note little variability between NUTSII regions. This is sometimes due to the lack of data requiring the extrapolation from surrounding regions, and sometimes due to the fact that the practices follow national norms rather than being technically linked to local pedoclimatic conditions. The results obtained are very good, and are essentially based on the technical methodology. Thus for example, there is no chemical treatment of the seeds for the majority of cereals cultivated in organic agriculture at the moment of this study (the 90's) and they are not differentiated from conventionally treated seeds. In the same way, the impacts on the soil (in particular on the micro fauna and the flora of the soil) are not taken into account in the construction of the indicator, by lack of scientific field knowledge; the treatments containing sulphur or copper, frequently used in biological agriculture, do not have an incidence here. Besides they relate to more arboriculture, wine grapes and field crops. In fact, only some foliar treatments, in particular insecticides certainly natural but also toxic (pyrethrums, rotenone...), explain the differences between cultures, disadvantaging the oil crops again, and in particular winter colza.

10.2. Farm bio-economic modelling by integration of a biophysical and economic model. Case study for a specialized "Grandes Cultures" farm in French Midi-Pyrénnées Region

10.2.1 Methodology

Source of information are the following:

- Data Base of the Agricultural Chamber of the Region Midi Pyrénnées (DB). This Data Base is updated in a regular way. It was built out of information originated in Agricultural Census.
- Simulated yield and nitrate pollution values, obtained using the biophysical model "CropSyst" (CS)

- Chemical pollution produced by plant protection treatments is evaluated using an expert system, as in CAPRI model

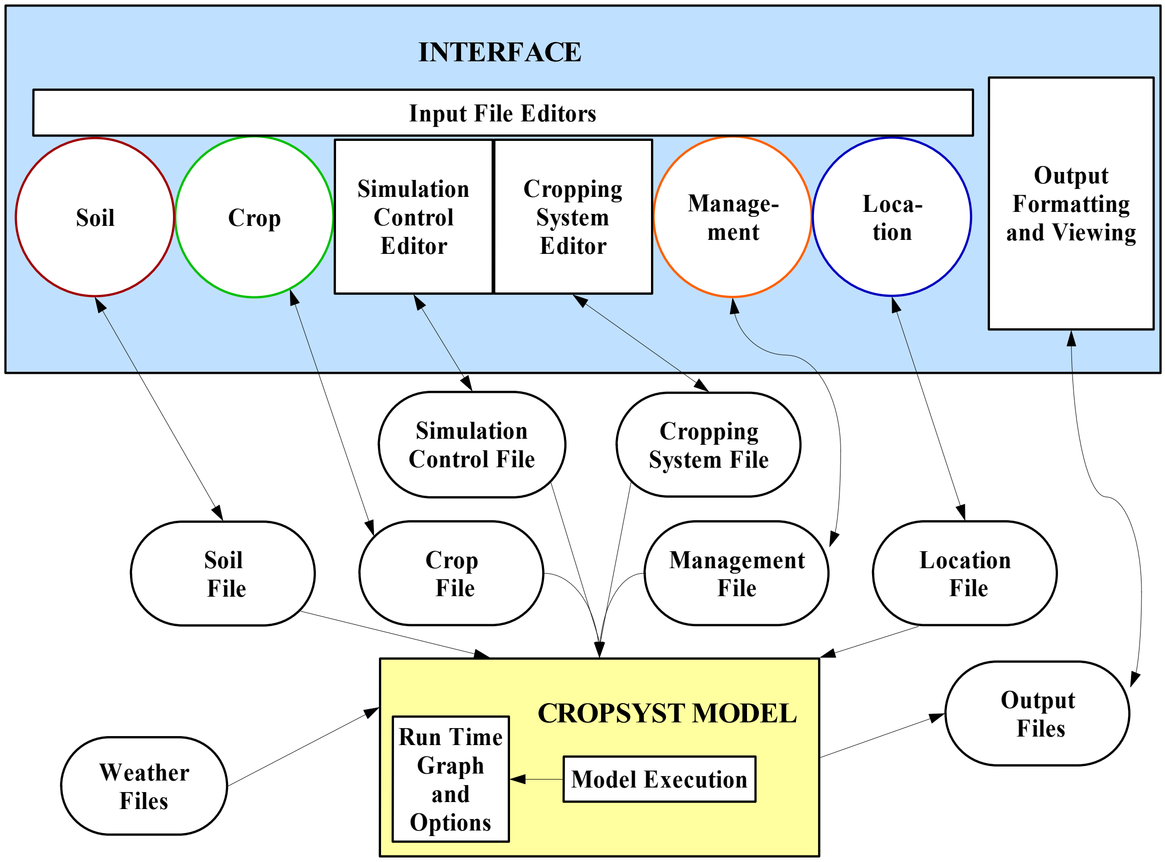
The basic information used from the DB concerns the production costs, nitrogen use, water use and yields. This data was compared with the data used in CAPRI Model concerning a specialized "Grandes Cultures" farm. The differences are not significative (table in appendix). The only relatively important difference is that in the CAPRI "farm", the effect of aggregation originated in the source (FADN data) includes animal production activities that are absent in the DB. As CS does not simulate the pollution originated by animal production, we decided to build the farm model only with the principal crop activities.

Crops included in the model are soft wheat, durum wheat, maize, barley, sunflower and soybeans. These are the largely dominant crops in the region that is the second French producing region for these activities.

10.2.2 The use of CropSyst for generating simulated data

CropSyst model system can be represented with Figure (10).

Figure (10) Flow chart of bio-physical CropSyst Model

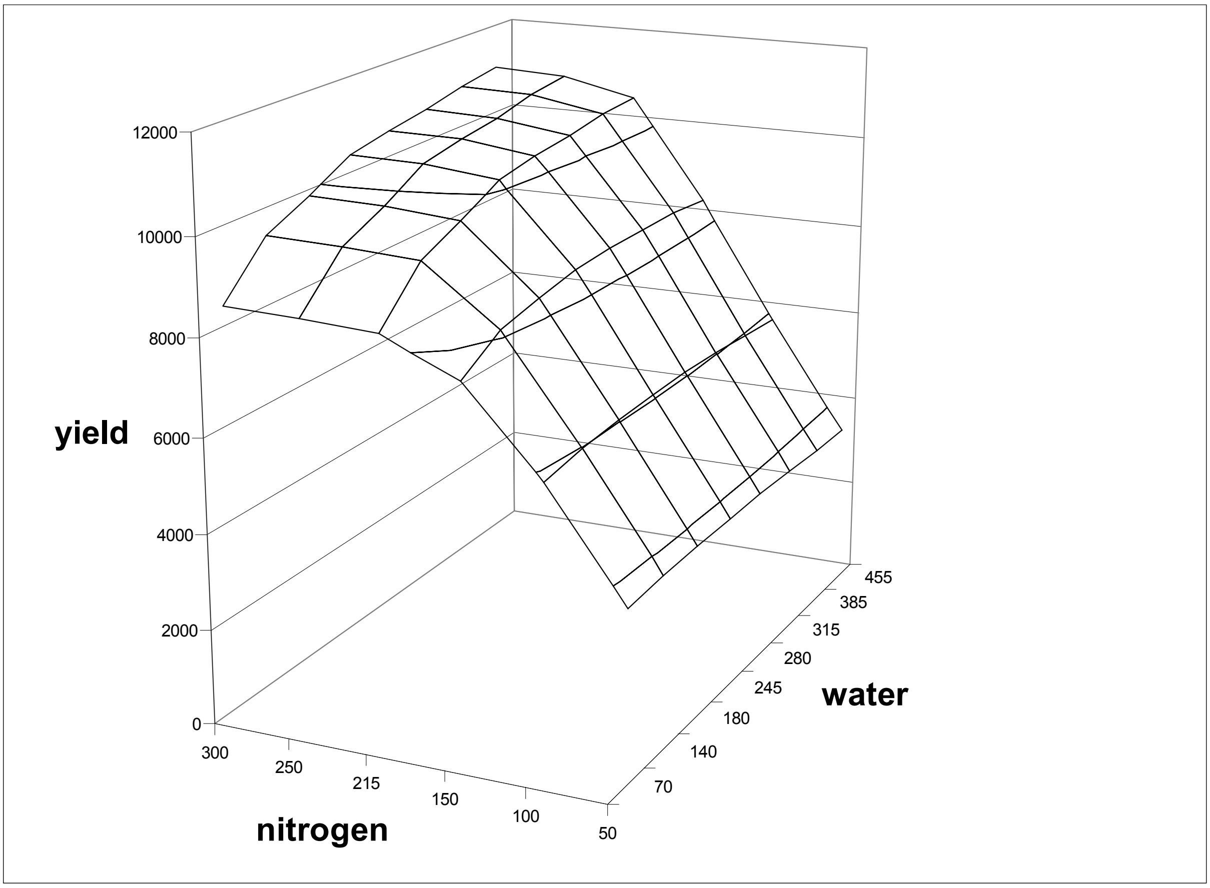


We used the climate data of the principal "Grandes Cultures" area of the Region, and two type of soils, Clay-calcareous *"Terreforts",* and Boulbennes, that are the dominant ones. CropSyst was calibrated in order to obtain the observed yields in each type of soil using the conventional type of management. This model is particularly responsive to Nitrate fertilization and irrigation. It does not simulate accurately different type of tillage systems. It does not simulate either the effects of plant protection treatments, reason explaining the use of an expert system to take this issue into account.

Once CropSyst calibrated, we simulate a large number of management alternatives, in order to obtain a surface of yield response to water and nitrogen.

In Figure (11) we can observe the response yield function of maize in a boulbenne soil to water and nitrogen.

Figure (11) Yield surface response to irrigation and nitrogen in CropSyst



It shows the low input substitutability between nitrogen and water. With the prevailing conditions of this region, an average, yields depend more on nitrogen than on irrigation water, but this presentation does not show the water provided by rain. If we consider also the rain, or if we take a very dry year, the complementarity between water and nitrogen appears in a more drastic manner.

In the case of rain fed crops, as wheat, barley and sunflower, we simulated the response to nitrogen. In all the cases, the effects on nitrate percolation have been also simulated. Figure (12) and Figure (13) present the results obtained for barley in terms of yields and nitrate leaching for the two different soils.

Figure (12) Barley yield and nitrate leaching in clay calcareous soil as simulated by CropSyst

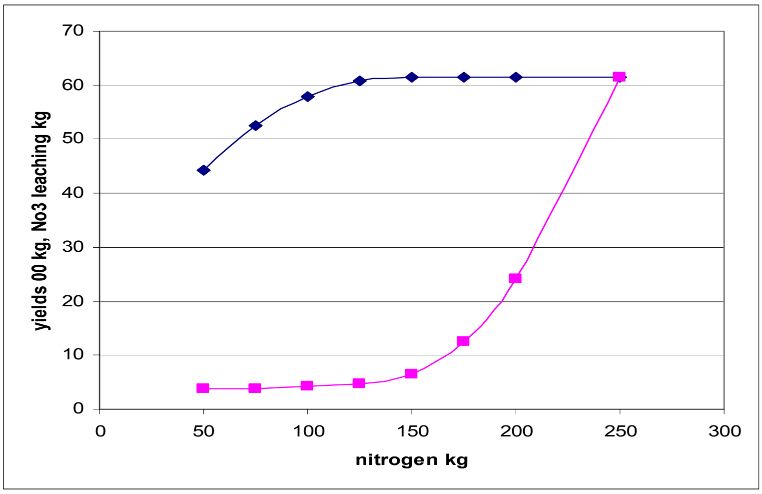
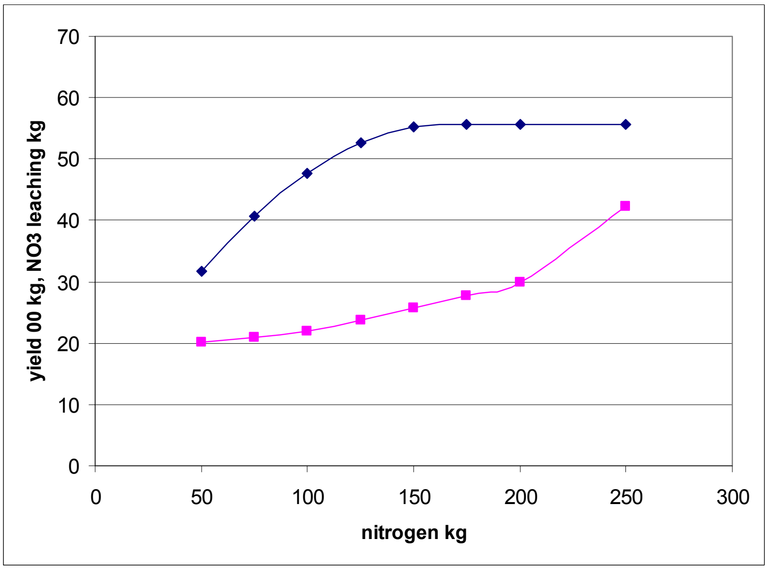


Figure (13) Barley yield and nitrate leaching in boulbenne soil as simulated by CropSyst



In the two previous figures the importance of the soil, both concerning yields and pollution appears in a clear way. In rain fed conditions, the clay soils have a better water retention that is the cause of higher yields and lower pollution compared to "boulbennes".

Simulations have been performed using 8 levels of fertilisation for the rain fed crops (soft wheat, durum wheat, barley and sunflower) and 6 levels of irrigation for maize and soybeans, combined with the 8 levels of fertilisation. We obtain then 8 production techniques for rain fed crops and 48 for irrigated ones. All these simulated data on yield and nitrate leaching are the information that is used ad input for the farm model.

10.2.3 The farm model

The farm model is a mathematical programming model, in which the farm profit is maximised. The specific characteristics of this model are:

- A very detailed technical specification concerning soils, yields responses to water and nitrogen, nitrogen leaching functions to water and nitrogen.
- Yields are defined by taking into account a moderate yield reduction when the surface occupied by a specific crop increases. The hypothesis is that a maximum yield 10 % above the average observed one could be obtained in the first unit of soil. If all available soil were used by one crop, the yield would be reduced, in the case of cereals, to 10 % less than the reference yield, and in the case of oilseeds (more sensible to monoculture practices), 30 % reduction. This procedure allows avoiding classic overspecialisation that appears in standard linear programming farm models. It is a simple approach using a primal definition of technologies. In other words, for each activity, defined as a crop, in a certain soil, to which a certain volume of irrigation and nitrogen is applied, we have a reference yield. But the yield that will play a role in the model is calculated as a linear function of the relative surface occupied by the crop. For a reference yield of 100, the yield may take a maximum value of 110 and a minimum of 90 in the case of cereals, a minimum of 70 in the case of oilseeds.
- The costs other than nitrogen and water, for the observed amounts of these inputs are the ones provided by the DB. For the other production techniques, these costs are assumed proportional to nitrogen costs, except in the case of soybean for which we used the irrigation costs as basis (soybean crop is not fertilised with nitrogen).

- The model has a structure that allows simulating different type of agro-environmental policies as well as the definition of subsidy levels necessary to give incentives to the adoption of environmentally friendly production techniques.

In a first step, we calibrated the model in order to obtain a cropping pattern close to the observed one. Taking into account that it is a non-linear model, with two soil restrictions and with decreasing yields as a function of the crop surface, the calibration was not very difficult, and it was only necessary to introduce small corrections in the gradient of decreasing yields.

After calibrating the model, we tested different options to obtain a 50% reduction of nitrate pollution and chemical pressure:

- A constraint on nitrate pollution and chemical pressure (normative model), in order to observe the minimum possible cost (in terms of revenue) associated with this environmental amelioration

- A tax on nitrate emission combined with a subsidy to organic production and a tax to conventional production (theoretical exercise, a tax to surplus application of nitrogen can be a proxy to the emission tax simulated here).

- A tax on nitrogen use and on conventional practices in order to reduce nitrate and chemical pollution combined with a subsidy to organic production.

For all these experiments, we calculate a social cost, measured as the sum of the private loss determined by the reduction of farmers' revenue plus the budgetary cost of subsidies minus taxes. The results being compared we can have a comparative table, on the basis of achieving the same environmental goals.

We can observe that a combination of the emission tax with subsidies to organic production and taxation on conventional production gives lower social costs than the use of a tax on nitrogen. The low efficiency of taxes on nitrogen application has been already shown in many studies. The reason of this phenomenon is related with the fact that there is not a linear relation between the level of nitrogen application and the level of pollution. The complexity of these relations make that specific agri-environmental policies, may be more efficient than simple taxes.

To conclude, this type of modelling approach may be used at regional level, to define the level of subsidies required to obtain environmental improvements at the lowest possible cost.

10.3. Nitrate (NO_3) in upper ground water on Dutch dairy farms.

10.3.1 Introduction

Nitrogen (N-) loss at the soil balance is a robust indicator for potential nitrate (NO_3) leaching to groundwater. This is even more so for nitrate in upper ground water. In this case study a module is developed to calculate nitrate (NO_3) in the upper groundwater level on dairy farms on sandy soils in the Netherlands. The module uses CAPRI outputs as an input. The calculation is based on a detailed nitrogen balance at crop level and an econometric estimation of the relationship between potential nitrate leaching to groundwater and the concentration of NO_3 in the upper groundwater (Fraters, et al., 1997). The later (econometric) estimation is only valid for dairy and livestock farms on sandy soils.

To estimate potential nitrogen (N) for leaching as nitrate (NO_3), a detailed nitrogen balance at crop level is calculated, based on the approach, which is used in the Nutrient Flow Model (NFM). The NFM is developed in the Netherlands and calculates detailed N-balances at crop level among other things based on crop growth models (Dijk, Leneman and van der Veen, 1996). The N-balance in NFM decomposes N-losses into denitrification, mutation soil storage, fixation and potential nitrogen for leaching as nitrate.

A more detailed description of the NFM can be found in the appendix. The next paragraph describes the Nitrogen -(N) balance for crops used in the NFM. Next the formula for nitrate (NO_3) in the upper groundwater level is described. Next the linkage with the CAPRI model is described and we end with an application of the developed method to analyse the effect of the 'Mid Term Review of Agenda 2000' (July 2002) on nitrate (NO_3) in the upper groundwater on Dutch dairy farms on sandy soils.

10.3.2 N-balance for crops in NFM

In Figure (14) the balance used in the NFM-model is shown. Besides denitrification, mutation soil storage and fixation, the balance is the same as in CAPRI.

Figure (14) N-balance for crops in SSM

Inputs		**Outputs**	
Organic fertilizer	a	f	Removal with crops
Anorg. Fertilizer	b	g	Ammonia emission
Deposition	c	h	Denitrification
Biological fixation	d	i	Mutation soil storage
Mineralization	e	j	Fixation
			Potential nitrogen for leaching as nitrate

Potential N available for leaching as NO_3-= a + b + c + d + e - f - g - h - i - j

In the NFM method removal with crops is based on yield functions, with stubble included. However, stubble and leaves are rested on the field. The process of mineralization will release minerals in the stubble, leaves and other parts of the plant. In the NFM mineralization is subtracted by calculating mutation soil storage. So you find it at the output side, but with a minus sign.

Inputs

Organic fertilizer

Organic fertilizer is applied to the crops. Not all nitrogen from organic fertilizer will be directly available for crops. Part of it is incorporated in organic material (Norg) and will be slowly transformed into mineral N. Part of Norg, which will be transformed to Nmin within one year, is called Ne. The rest of Norg is pointed as Nr. The utilization of Nmin by crops depends on the time of applying slurry.

Anorganic fertilizer

It can be assumed that all applied nitrogen from anorganic fertilizer will be available for the crops.

Deposition

With the process of deposition (dry and wet) nitrogen is added to the soil. Not all nitrogen from deposition is supplied to the soil during the growing season. Therefore not all nitrogen will be uptakable for the crops. This needs to be taken into account. In the Netherlands about 70% of the nitrogen from deposition can be used for crop growth.

Biological fixation

Fabaceae like legumes and clover are able to fix nitrogen from the air. In the NFM a fixed factor is used for crops belonging to the Fabaceae.

Mineralization

In the soil nitrogen can be found as incorporated in organic materials (Norg) or appear to be direct available (Nmin). Norg can be turned over in Nmin (mineralization) and Nmin can be turned over into Norg (immobilization). Net it's a matter of mineralization. Under grass mineralization is expected to be higher compared to other crops as a result of large rests of stubble. Part of the mineralization process takes place after the growing season. So not all nitrogen released by this process is available for crops. Norg can be found in crop residuals, organic soil materials, faeces of grazing animals and applied slurry. Nmin can be found in anorganic and organic fertilizer and deposition.

Outputs

Crop removal

We distinguish between crop removal and crop uptake. Crop removal is defined as crop uptake minus stubble and leaves rested on the field. Removal with crops is simply the amount of nutrients in the harvested materials. This is the product of the weight of harvested materials multiplied by the nutrient content.

The uptake is more complicated. Crop uptake is directly related to crop production. Crop production is related to the availability of nitrogen for the crops. The availability consists of supply of organic fertilizer, anorganic fertilizer, soil type, deposition, mineralization of the soil and the moisture providing capacity of the soil. The moisture providing capacity is the amount of water the soil can supply to the crops in time of dry periods during the growing season.

There is a relationship between the supply of nitrogen to the crops and availability of nitrogen and between supply of nitrogen to the crops and N uptake. The first mentioned relationship is a first-degree function, the latter a non-orthogonal hyperbole.

The availability of nitrogen to the crops is the sum of:

- the available nitrogen from anorganic fertilizer;
- the available nitrogen from organic fertilizer;
- the available nitrogen from deposition;
- the available nitrogen from mineralisation;
- and in some cases biofixation.

The standard formula for the non-orthogonal hyperbole is:

$-AY^2 + BY + XY + CX = 0$

where

X = N available

Y = N uptake

A, B, C = parameters, depending on moisture providing capacity, soil type and crop type.

For several crops, soil types, moisture providing capacities, parameters for the hyperbole are available in the NFM.

Emission of ammonia

Ammonia emission takes place from manure (faeces and urine) by micro organisms. Places distinguished where emission of ammonia takes place are stable, storage, pasture during grazing, crops and pasture as a result of applying manure. More detailed information can be found in Oudendag et al (2002).

Also emission of ammonia occurs while applying anorganic fertilizer. The emission fraction is related to the type of fertilizer.

Denitrification

Denitrification is the microbiological conversion of nitrate (NO_3^-) to N_2 with NO_2^-, NO and N_2O as intermediate products (Oenema et al, 2002). The next factors are needed for the process of denitrification:

- NO_3^-, NO_2^- or NO;
- anaerobic circumstances;
- easily degradable organic material;
- pH between 5 and 8;
- temperature between 4 and 65 ^oC.

In the Dutch NFM-model denitrification is a fixed coefficient multiplied by the difference between Navailable and Nuptake by crops added with the N supply to the soil which is not available for the crops. This way of calculating is a real point for discussion. For instance groundwater level is influencing the anaerobic circumstances and soil type the availability of easily degradable organic material.

Mutation soil storage

Mutation of soil storage of nitrogen is defined as the sum of Nr in applied manure (including faeces from grazing animals), Nr in crop residuals and Nr in non-harvested crop parts minus nitrogen from mineralization.

Fixation

Fixation is defined as the Nitrogen (N) in organic manure that is not available for crop growth.

10.3.3 Nitrate in upper ground water on Dutch dairy farms with sandy soils

In Fraters et al (1997) a function was estimated between the potential N available for leaching as NO_3 and the concentration of nitrate in the upper groundwater level for dairy farms on sandy soils. The estimation is based on a four years monitoring programme started in 1992. Goal of the monitoring was to assess the quality of the upper groundwater in the sandy regions of the Netherlands affected by fertiliser and manure use in agriculture.

The upper 100 cm of groundwater occurring within five metres of the surface was ample at 99 farms (80 cattle and 19 arable) situated in the central, northern, eastern and southern sandy regions of the Netherlands. The samples where analysed for chloride, nitrate, ammonium, potassium, dissolved organic carbon and phosphate (ortho and total).

The formula for the relation between N-surplus and nitrate in groundwater is:

$$\ln(\text{nitrate}) = -2.75 + 0.90 * \ln(\text{dilution}) + 0.45 * \ln(\text{N-surplus}) + 0.44 * \ln(\text{P-state}) + 0.074 * \ln(\text{pcmais}) - 0.059 * \ln(\text{wet}) + 0.054 * \ln(\text{dry})$$

$R^2 = 0.642$

Dilution = factor depending on precipitation, evaporation etc. The factor is specific for a year and per farm (0.5-1.5)

N-surplus = average farm N-surplus (potential nitrate) calculated by NFM-method (kg/ha)

P-state = average P-fertilization state (1 to 5)

Pcmais = part of maize in total fodder area (%)

wet = part of the soil with ground water class I t/m IV (%)

dry = part of the soil with ground water class VII t/m VIII (%)

10.3.4 Results

The nitrogen (N) balance is based on data from CAPRI (endogenous source) and the NFM (exogenous source). Important elements of the N-balance are use of organic and anorganic fertiliser per crop. At the moment this is not calculated at crop level by CAPRI directly. A program is used which calculates ex-post the use of organic and anorganic fertiliser per crop based on (a) minimum application of anorganic fertiliser and (b) total fertiliser requirement per crop.

Table (45) shows the effect of **Agenda 2000** reference run compared to the base for the average dairy farm in different regions in the Netherlands with mainly sandy soils.[12] The sandy regions are located south and east of the Netherlands. The utilised agricultural area on the average dairy farm in the Netherlands consists of about 27 hectare of grassland and about 6 hectare of fodder maize.

In the **Agenda reference run** the nitrate concentration in the ground water decreases compared to the base. This is especially the result of the increased uptake and the shift to more extensive use of grassland. Table 6.1 also shows the effect on nitrate in upper ground water under '**CAP Reform Proposal 2003**' compared to **Agenda reference run**. It can be concluded that the effect

[12] Results presented in this paragraph are based on the commissions policy proposals of Juli 2002 and earlier calculations with CAPRI without the farm type programming models included (LEI, IAP, IAM, December 2002).

of the '**CAP Reform Proposal 2003**' on nitrate in upper ground water on the average dairy farm is about zero.

Table (45) Table Weighted average concentration of nitrate (NO_3) in the upper meter of the groundwater under grassland and fodder maize in the sandy areas of the Netherlands (mg N/liter)

Region	Base	Agenda reference run	'CAP Reform Proposal 2003'	% difference	% difference
	mgN.l-1	mg N.l-1	mg N.l-1	Agenda-Base	'CAP Reform Proposal 2003'-Agenda
Overijssel (NL210)	73.2	67.5	67.6	-7.9	0.2
Gelderland (NL220)	72.5	67.3	67.4	-7.1	0.1
Utrecht (NL310)	68.8	62.8	62.9	-8.7	0.1
Noord-Brabant (NL410)	75.1	69.9	69.9	-7.0	0.0
Limburg (NL420)	77.0	71.6	71.6	-6.9	0.0
Total	73.3	67.8	67.9	-7.5	0.1

Source: CAPRI, LEI

10.4. Pesticide use in the Netherlands and in the EU

10.4.1 Data

In the Dutch FADN a lot of data can be found with respect to the use of pesticides in Dutch agriculture and horticulture. The use of pesticides is gathered at crop level and pesticides are distinguished in categories like insecticides, fungicides, herbicides, growth hormones, disinfections of the soil (nematocides) and others. The use of pesticides can be described in kg active ingredient, name of the active ingredient and attributed costs. Table (46) shows the average application of pesticides in active ingredients per crop per year in the period 1994-1996 in the Netherlands.

Table (46) Average use of pesticides per crop per year in the Netherlands, 1994-1996, kg active ingredient per ha.

	Total	Insecticide	Fungicide	Herbicide	Nematicide	Other
Grassland	1.17			1.17		
Fodder maize	3.78			1.80		1.95
Soft wheat	4.09	0.20	0.92	2.20		0.71
Rye and meslin	1.44		0.37	0.79		0.24
Oats	2.23	0.12	0.21	1.56		0.34
Grain maize	2.43			1.36		1.07
Pulses	3.43	0.12	0.86	1.83		0.62
Rape	1.49	0.30	0.44	0.75		
Text	6.97	0.20		6.51		0.20
Potatoes	23.40	0.38	9.60	3.11	8.29	1.99
Sugar beets	7.06	0.23	0.03	3.53	1.43	1.87
Tomatoes	9.10					
Nurseries	7.00					
Flowers	45.30					
Other crops	**5.50**					

Source: LEI

10.4.2 Results[13]

Changes in use of active ingredients from pesticides under the reference run compared to the base run for the Netherlands and the EU as a whole are presented in Table (47). In case of the EU as a

[13] Again, results presented here are based on the commissions policy proposals of Juli 2002 and earlier calculations with CAPRI without the farm type programming models included (LEI, IAP, IAM, December 2002).

whole, Dutch input coefficients are applied to other countries as well. It is clear that this is a simplification of reality. It can be observed that under the reference run the application of pesticides will decrease compared to the base. The decrease in the Netherlands exceeds the decrease in the EU as a whole. This is totally the result of changes in cropping plan, as it is assumed that input per crop will not change over time.

Table (47) also shows changes in use of active ingredients from pesticides under '**CAP Reform Proposal 2003**' compared to Agenda 2000. For the EU as a whole it is expected that total use of active ingredients from pesticides will decrease under '**CAP Reform Proposal 2003**' compared to the base. For the Netherlands the picture is quite different, as the use of active ingredients will increase. This is explained by the relative importance of root crops, especially potatoes, in the Netherlands.

Table (47) Use of pesticides in the Netherlands and in the EU as a whole (% differences)

Category	**Agenda/Base**		**'CAP Reform Proposal 2003'/Agenda**	
Categorie	**Netherlands**	**EU**	**Netherlands**	**EU**
Insecticide	-6.6	-4.7	-0.2	-2.9
Fungicide	-8.1	-5.3	0.8	-4.7
Herbicide	-3.5	-2.1	-0.3	-3.5
Nematocide	-7.9	-6.8	1.9	2.6
Others	-5.2	-5.2	-0.2	-6.5
Total	-3.1	-1.9	0.3	-2.9

Source: CAPRI, LEI

11. Conclusions

11.1. Introduction

The CAP has faced significant changes in the last decade. The 1992 reform initiated a stronger orientation to world market price – increased competition – by reducing intervention prices and thus budget outlays for market interventions. The negative effect on farmers' income was offset by compensation payments, an instrument opening up clear avenues for cross-compliance between the economic income goal and the reduction of negative environmental externalities. The compensation payments introduced since then allow for modulation at regional or even farm level according to negative environmental effects. This was, for example, introduced in animal production by coupling stocking densities and premium levels. However, most of the compensation payments are not strongly linked to environmental effects.

This report is directed at an application of the CAPRI modelling system as it stands now, to analyse the effects of the '**CAP Reform Proposal 2003**' at NUTS 2 level against the **Agenda reference run** in 2009. The reference run simulates the status quo policy for the simulation horizon, including the full introduction of the Agenda 2000 policy proposal. It is predicted in the **Agenda reference run** that in 2009 the number of cattle activities will be decreased with about -5% compared to the base situation in 1998. This is mainly due to increased milk production per dairy cow resulting into a decrease of the number of dairy cows due to the continuation of the milk quota system. From the other hand the number of suckler cows will increase, while the number of male adult beef cattle for fattening is about stable (small reduction). With respect to land use it is predicted that hectare of cereals and oilseeds will decrease with –1% and –17% respectively. It is further predicted that the hectare of set aside and fallow land will increase with about 16% under **Agenda reference run** compared to the base. Effects on environmental indicators are modest. For example, effects on N-losses at soil level, ammonia emission and Global Warming Emissions are limited at European level, however regional and farm types effects can be big. For example, at farm type dairy the nitrate (N) surplus decreases with about –4.7%.

Under the **CAP Reform Proposal 2003** it is predicted that the number of cattle activities will decrease with about -7% compared to the Agenda reference run. This is mainly due to increased number of suckler cows and male adult beef cattle for fattening. With respect to land use it is predicted that hectare of cereals and oilseeds will decrease with –8% and –3% respectively compared to Agenda reference run. It is further predicted that the hectare of set aside and fallow land will again increase with about 12% compared to the Agenda reference run. The **CAP Reform Proposal 2003** decreases the emissions to the environment, ranging in order of magnitude from –4.7% for methane emission from manure to about –3% for nitrate (N) surplus and phosphate surplus. Again effects at the regional and farm level can be substantial bigger. For example, at farm type Cattle fattening & rairing the nitrate (N) surplus decreases with about –11.4%.

The remaining of this chapter discusses the possible contribution of the CAP reforms to further integrate environmental concerns in management practices at farm level. Second, some possible alternative scenarios are discussed.[14]

11.2. Agenda 2000, 'CAP Reform Proposal 2003' and the environment

The recent reform of the CAP, Agenda 2000, gives Member States for the first time the opportunity to take action on the environment in the framework of CAP instruments defined uniformly at European level, by allowing them to ascribe environmental conditions to some CAP payments to farmers (Regulation 1259/1999, article 3 on 'environmental protection requirements'). The opportunities brought about by this new instrument are very significant. However, as it is yet unknown how Member States will use these opportunities, their impact on the environment is not clear.

To include environmental concerns in every day management practice at farm level, generally requires the possibility to use less intensive production systems. As a result more land is needed to reach the same level of production and probably also income. With high prices for land

[14] These were already presented in Intermediate Report II (LEI, IAP and IAM, May 2002). The first proposed scenario mimics the 'CAP Reform Proposal 2003' scenario of which the effects are analysed in this report.

incentives in that direction are very limited. Agenda 2000 proposals stimulates less intensive production systems, which is indicated by the modelling results as an increase in set-aside and fallow land and a substitution of grassland intensively used for extensive grassland. However, some remarks must be made. On the first place the changes in cropping plan are rather limited on an European scale. Second, the effects on environmental indicators are also rather limited on an European scale. This is mainly due to the limited reduction in total number of cattle activities. In this respect modelling results point at counteracting effects. Increased use of less intensive production systems result in a slowing down of the increase in milk production per dairy cow, compared to past developments. This means that more dairy cows are needed and more manure from dairy cows is produced, to fully produce the milk quota.

Following the same line of reasoning '**CAP Reform Proposal 2003**' further stimulates adoption of less intensive production systems. It is predicted that there will be a substantial reduction in the production of organic fertilisers, especially from beef cattle and a further increase in the use of extensive grassland activities. These developments, although still rather small in size, makes it more easy for farmers to accepts environmental conditions ascribed to some CAP payments like Regulation 1259/1999, article 3 on 'environmental protection requirements'.

11.3. Proposed scenarios

The Agenda 2000 package corrected on the one hand some unfortunate signals introduced by the original regime by reducing premiums in oilseeds. Further on, a rather limited move in direction of milk market reform where initiated. From an environmental viewpoint, Member States were given the opportunity to reduce premiums depending on socio-economic or environmental criteria and to re-distribute the gained budget outlays for the remuneration of positive externalities. The response to that avenue is so far rather restricted.

The package designed in 1999 was seen as a further step in a process of reforming the CAP in the light of challenges in the years ahead: east expansion of the union, a new round of trade liberalisation negotiations, increased public concern regarding negative externalities and a higher awareness of positive ones.

The concept of “multi-functionality” was developed, together with some other partners in trade negotiations – notably Norway, Switzerland, Korea and Japan – featuring a combination of rather high protection of agriculture, agricultural production systems in sensible landscapes and public concern that further liberalisation steps could provoke drastic negative effects especially if agriculture would move out of marginal areas. The idea behind the concept is to build up a line of arguments either to defend or relabel the “amber box”, for the EU covering the current premium scheme. The rather limited instruments falling in the “green” box should be expanded to cover further positive externalities of agriculture.

From an environmental viewpoint, the consequences of that line of argumentation are not yet fully clear. If the amber box would be completely removed, the far most important policy instrument of last decade’s CAP – the compensation payments – would not longer be allowed. That would open considerable options to introduce payments under the “green box”. On the other hand, many of the effects discussed under “multi functionality” regarding “amber box” instruments relate to production system which could indeed feature positive environmental externalities, even if society may stress different externalities as viable rural communities, tourism etc.

It seems clear however, that any reform steps will relate to a scheme to distribute the outlays currently managed as compensation payments. The proposed scenarios relate hence to such scheme.

The combination of budget lines, market pressures and international trade agreements makes the so-called compensation payments the by far most important instrument for further CAP reform steps. From an agri-environmental viewpoint, policy options currently discussed should be analysed according to their environmental cons and pros and counterfactuals defined with a more pronounced orientation towards environmental goals. The following scenarios are proposed.

1. “***Uniform premiums***”. After uniform premiums for “Grandes Cultures” had been introduced with the “Agenda 2000” package, a logical step seems the re-distribution of all existing payments towards agricultural land, thus further reducing the allocation impact of the premiums and converting them to a more de-coupled instrument. This proposal had been discussed not only in scientific circles and seems one possible alternative. In order to follow

the current budget liens, current budget outlay for compensation payments for "Grandes Cultures" would be distributed to arable land (without sugar beet), with premium levels defined so that the income re-distribution effect at regional level is minimised. Naturally, such a scheme would create at first glance a disincentive for "Grandes cultures", probably offset by abolishment of set-aside obligations. Premium for grassland at regional level would be fixed according to the premiums paid to beef, sheep and dairy processes in the base year – again with a disincentive for these activities. Details relate to the question how fodder produced on arable land is embedded in the compensation scheme. Perennial crops are exempt from premiums. That scenario would constitute a kind of (further) de-coupled premium scheme without cross-compliance as regions with high yields and stocking densities would receive higher premiums per ha. The administration of the compensation payments would be much simpler as they would solely depend on the amount of arable and grassland cropped by a farm, thus reducing control and administration costs. The environmental effects are not clear beforehand as crop mix and herd sizes and intensity of production would change, especially if set-aside obligations are removed.

2. ***"Uniform premiums depending on production system"***. An easy to manage variant to the simple re-distribution scheme named "uniform premiums" would pay different per ha premiums per arable and grassland to conventional and biological production systems. Biological production systems are already clearly defined by European legislation, so that existing rule could be applied at farm level. However, total budget outlays would not be known beforehand if the premium level would be fixed in absolute terms for each system. An alternative could consist in a fixed percentage difference between biological and conventional farming, so that the absolute premiums would crop if the share of biological farming increases. The scheme would be relatively easy to manage, and would require simply the classification of a farm as conventional or biological to determine the amount of payments received. Administrative and control costs would be higher then for the non-classified uniform premium scheme, but still lower as for the scheme under Agenda 2000. A problem from a modelling viewpoint is the fact that switches to biological production system are long-term decisions, and that price differential between conventional and biological products probably depends on the shares.

3. "***Premiums coupled to environmental indicators***". Such a scheme would modify payments for arable and grassland according to environmental pro and cons. Payments could be cut if certain threshold levels are exceeded or made a function of indicators as nitrate surplus or output of climate relevant gases. Such schemes need a careful discussion of control and administration costs coupled to them, as environmental indicators would need to be defined and checked at farm level. Modelling results needs careful interpretation as well, as results are derived at aggregate level (region/farm type).

.

12. References

Armington, Paul S. (1969), A Theory of Demand for Products Distinguished by Place of Production, IMF Staff Papers 16, pp. 159-178

Dijk, J., H. Leneman, M.Q. vander Veen. The Nutrient Flow Model for Dutch Agriculture; A Tool for Environmental Policy Evaluation. Journal of Environmental Management 46, 43-44, 1996

FAIR3-CT96-1849 (1999) http://www.agp.uni-bonn.de/agpo/rsrch/capri/finrep.pdf.

Fraters, B., H.A. Vissenberg, L.J.M. Boumans, T. de Haan, D. W. de Hoop (1997). Results of the measurement program groundwater quality at farm level at sandy soils in the Netherlands, 1992-1995 (in Dutch with English summary). Report number 714801014. Bilthoven, RIVM

Heckelei, Thomas and Wolfgang Britz (1999). Maximum Entropy Specification of PMP in CAPRI, CAPRI working paper 99-09, http://www.agp.uni-bonn.de/agpo/rsrch/capri.

LEI, IAP and IAM, Development of models and tools for environmental impact assessment. Inception report. February 2001

LEI, IAP and IAM, Development of models and tools for environmental impact assessment. Intermediate report I. December 2001.

LEI, IAP and IAM, Development of models and tools for environmental impact assessment. Intermediate report II. May 2002.

LEI, IAP and IAM, Development of models and tools for environmental impact assessment. Concept final report. December 2002.

Meudt, M. and W. Britz (1997). The CAPRI nitrogen balance. CAPRI working paper Working paper 97-04, http://www.agp.uni-bonn.de/agpo/rsrch/capri.

Oenema, O., G.L. Velthof, N. Verdoes, P.W.G. Groot Koerkamp, G.J. Monteny, A. Bannink, H.G. van der Meer, K.W. van der Hoek: Forfaitaire waarden voor gasvormige stikstofverliezen uit stallen en mestopslagen. Wageningen, Alterra, IMAG, IS-Lelystad, PRI, PVV, RIVM, 2000. Alterra-rapport 107.

Oudendag, D., M. Hoogeveen and J. Helming (2002). Documentation AMMO-module, LEI, internal paper.

Oudendag, D., J. Helming and M. Hoogeveen (2002). Refinement of the CAPRI nitrate balance for the Netherlands: a case study to embed soil specific data in CAPRI., LEI, internal paper

Tritten, C., B. Henry de Frahan, W.Britz (2001). Regionalisation of the Rest of the World Aggregate, CAPRI working paper 01-01, http://www.agp.uni-bonn.de/agpo/rsrch/capri.

13. Annexes

Annex 1: Premium details used in the simulation runs

Annex 2: Production activities in the data base

Annex 3: Output, inputs, income indicators, political variables and processed products in the data base

Annex 4: Ammonia module

Annex 5: Principles of the NFM

Annex 6: Environmental indicators and nitrate (N) balance for some selected farm types

13.1. Annex 1: Premium details used in the simulation runs

ACTIVITIES		Codes in CAPRI	Regions	Base year 98[1)]	Agenda 2009[2)]	'CAP Reform Proposal 2003' [2009][2)]
Grandes Cultures*	€/t (hsty cereals, oilseeds or pulses respectively)	SWHE, DWHE, BARL, RYEM, OATS, MAIZ, OCER, PULS, SETA, NONF, MAIF	EU	54,34	63,00	65,50 (dec)
Oilseeds*	€/t (hsty cereals)	RAPE, SUNF, SOYA	EU	-	63,00	65,50 (dec)
Protein Crops*	€/t (hsty pulses)	PULS	EU	24,15 (+)	9,5 (+)	9,5 (+)
Oilseeds*	€/t (hsty oilseeds)	RAPE, SUNF, SOYA	EU	112,13 (+)	-	
Durum Wheat Traditional*	€/ha	DWHE	Specific	344,5 (+)	344,50	250 (dec)
Durum Wheat Established*	€/ha		Rest	138,9 (+)	138,90	-
Durum Wheat Established*	€/t			-	-	15
Non food production on set aside	€/ha	NONF	EU	-	-	45
Suckler Cows*	€/head	SCOW	EU	175,09	200	200 (dec)
Bulls*	€/head	BULL, BULH	EU	135	210	210 (dec)
Dairy cows**	€/head	DCOL, DCOH	EU	-	17,24	17,24 (dec)
Dairy cows (national envelope)**			EU	-	200 (+)	200 (+)

ACTIVITIES		Codes in CAPRI	Regions	Base year 98[1)]	Agenda 2009[2)]	'CAP Reform Proposal 2003' [2009][2)]
Slaughtering for adult cattle**	€/head (slaughtered)	DCOL, DCOH, DCOW, BULL, BULH, HEIL, HEIH	EU	-	80 (+)	80 (+) (dec)
Slaughtering for calves**	€/head (slaughtered)	CAMF, CAFF	EU	-	50	50 (dec)
Swedish Dairy Cows*	€/1000l milk	DCOW	SE070, SE080	117 (+)	117 (+)	117 (+)
Finnish Dairy Cows*			FI	87,5 (+)	87,5 (+)	87,5 (+)
Silage*	€/t (hsty)	OFAR	SE, FI	63	63	63
Paddy rice*	€/ha	PARI	EL, ES, FR, IT, PT	188-246	318-393	-
Paddy rice*	€/t		EL, ES, FR, IT, PT	-	-	75
Farm income rice premium*	€/t		EL, ES, FR, IT, PT	-	-	102 (dec)
Sheep and goats*	€/head	SHGM	SE, DK, FI, UK, IR, NL	5-40	16.8	16.8 (dec)
Sheep and goats*			Rest EU	5-40	21	21 (dec)
Sheep and goats (national envelope)**			EU	-	100	100 (dec)
(hsty) according to historiy yield						
(+) additional payments to given ones (Euros)		* Physical ceiling for payments		1) 3 year average 1997-1999, nominal € 1998		
(dec) decoupled payments		** Budgetary ceiling for payments		2) 3 year average 1997-1999, nominal € 2009		

13.2. Annex 2: Production activities in the data base

Group	Activity	Code
Cereals	Soft wheat	SWHE
	Durum wheat	DWHE
	Rye and Meslin	RYEM
	Barley	BARL
	Oats	OATS
	Paddy rice	PARI
	Maize	MAIZ
	Other cereals	OCER
Oilseeds	Rape	RAPE
	Sunflower	SUNF
	Soya	SOYA
	Olives for oil	OLIV
	Other oilseeds	OOIL
Other annual crops	Pulses	PULS
	Potatoes	POTA
	Sugar beet	SUGB
	Flax and hemp	TEXT
	Tobacco	TOBA
	Other industrial crops	OIND
Vegetables	Tomatoes	TOMA
Fruits	Other vegetables	OVEG
Other perennials	Apples, pear & peaches	APPL
	Citrus fruits	CITR
	Other fruits	OFRU
	Table grapes	TAGR
	Table olives	TABO
	Table wine	TWIN
	Other wine	OWIN

Group	Activity	Code
	Flowers Other marketable crops	FLOW OCRO
Fodder production	Fodder maize Fodder root crops Other fodder on arable land Graze and grazing	MAIF ROOF OFAR GRAS
Fallow land and set-aside	Set-aside idling Non food production on set-aside Fallow land	SETA NONF FALL
Cattle	Dairy cows Sucker cows Male adult cattle fattening Heifers fattening Heifers raising Fattening of male calves Fattening of female calves Raising of male calves Raising of female calves	DCOW SCOW BULF HEIF HEIR CAMF CAFF CAMR CAFR
Pigs, poultry and other animals	Pig fattening Pig breeding Poultry fattening Laying hens Sheep and goat fattening Sheep and goat for milk Other animals	PIGF SOWS POUF HENS SHGF SHGM OANI

13.3. Annex 3: Output, inputs, income indicators, political variables and processed products in the data base

Group	Item	Code
Outputs		
Cereals	Soft wheat	SWHE
	Durum wheat	DWHE
	Rye and Meslin	RYEM
	Barley	BARL
	Oats	OATS
	Paddy rice	PARI
	Maize	MAIZ
	Other cereals	OCER
Oilseeds	Rape	RAPE
	Sunflower	SUNF
	Soya	SOYA
	Olives for oil	OLIV
	Other oilseeds	OOIL
Other annual crops	Pulses	PULS
	Potatoes	POTA
	Sugar beet	SUGB
	Flax and hemp	TEXT
	Tobacco	TOBA
	Other industrial crops	OIND
Vegetables	Tomatoes	TOMA
Fruits	Other vegetables	OVEG
Other perennials	Apples, pear & peaches	APPL
	Citrus fruits	CITR
	Other fruits	OFRU
	Table grapes	TAGR

Group	Item	Code
	Table olives	TABO
	Table wine	TWIN
	Other wine	OWIN
	Nurseries	NURS
	Flowers	FLOW
	Other marketable crops	OCRO
Fodder	Gras	GRAS
	Fodder maize	MAIF
	Other fodder from arable land	OFAR
	Fodder root crops	ROOF
	Straw	STRA
Marketable products from animal product	Milk from cows	COMI
	Beef	BEEF
	Veal	VEAL
	Pork meat	PORK
	Sheep and goat meat	SGMT
	Sheep and goat milk	SGMI
	Poultry meat	POUM
	Other marketable animal products	OANI
Intermediate products from animal production	Milk from cows for feeding	COMF
	Milk from sheep and goat cows for feeding	SGMF
	Young cows	YCOW
	Young bulls	YBUL
	Young heifers	YHEI
	Young male calves	YCAM
	Young female calves	YCAF
	Piglets	YPIG
	Lambs	YLAM
	Chicken	YCHI

Group	Item	Code
	Nitrogen from manure Phosphate from manure Potassium from manure	MANN MANP MANK
Other Output from EAA	Renting of milk quota Agricultural services	RQUO SERO
Inputs		
Mineral and organic fertiliser **Seed and plant protection**	Nitrogen fertiliser Phosphate fertiliser Potassium fertiliser Calcium fertiliser Seed Plant protection	NITF PHOF POTF CAOF SEED PLAP
Feedings tuff	Feed cereals Feed rich protein Feed rich energy Feed based on milk products Gras Fodder maize Other Feed from arable land Fodder root crops Feed other Straw	FCER FPRO FENE FMIL FGRA FMAI FOFA FROO FOTH FSTRA
Young animal **Other animal specific inputs**	Young cow Young bull Young heifer Young male calf Young female calf Piglet Lamb	ICOW IBUL IHEI ICAM ICAF IPIG ILAM

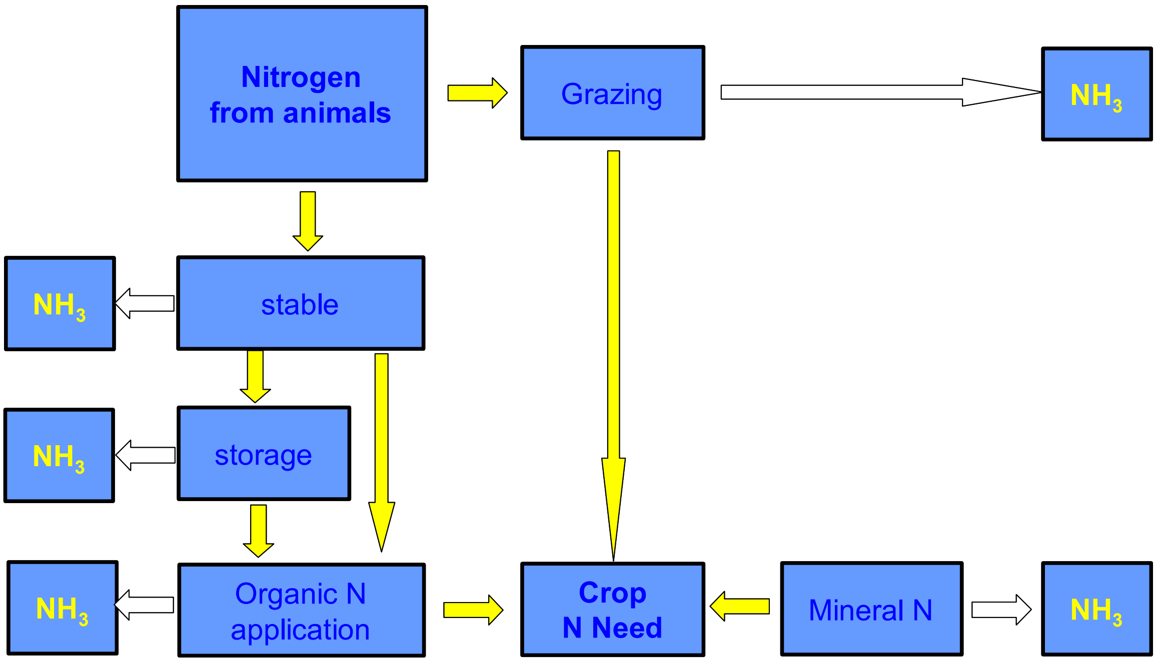
Group	Item	Code
	Chicken Pharmaceutical inputs	ICHI IPHA
General inputs	Repair and machinery Energy Water Agricultural services input Other inputs	REPA ENER WATR SERI INPO
Income indicators	Production value Total input costs Total variable input costs Total overheads Gross margin Gross value added at market prices CAP premium effectively paid Gross value added at market prices plus CAP premiums	TOOU TOIN TOVA TOOV GRMA GVAM PRME MGVA
Activity level	Cropped area, slaughtered heads or herd size	LEVL
Political variables Relating to activities	Base area or herd Historic yield Premium per ton historic yield Set-aside rate Premium declared below base area/herd	BASL HSTY PRET SETR PRMD
Processed products	Rice milled Molasse Starch Sugar Rape seed oil Sunflower seed oil	RICE MOLA STAR SUGA RAPO SUNO

Group	**Item**	**Code**
	Soya oil	SOYO
	Olive oil	OLIO
	Other oil	OTHO
	Rape seed cake	RAPC
	Sunflower seed cake	SUNC
	Soya cake	SOYC
	Olive cakes	OLIC
	Other cakes	OTHC
	Butter	BUTT
	Skimmed milk powder	SMIP
	Cheese	CHES
	Fresh milk products	FRMI
	Creams	CREM
	Concentrated milk	COCM
	Whole milk powder	WMIP

13.4. Annex 4: Ammonia module

The ammonia output module takes the nitrogen output per animal from the existing CAPRI module, replacing the current fixed coefficient approach with uniform European factors per animal type by Member State specific ones, taking into account differences in storage and housing systems between the Member States. The general approach follows the work at IASSA and hence applies the factors derived from the European Emission Inventory Guidelines (2001). The diagram below shows the NH_3 sinks taken into account by coefficients.

Figure (15) Ammonia sinks in the Ammonia emission module



In the diagram above, white arrows represent ammonia losses and are based on uniform or Member State specific coefficients. A first Member State specific coefficients characterises for each animal type the share of time spent on grassland and spent in the stable. Uniform coefficients then determine losses during grazing and losses in the stable, the latter divided into liquid and solid housing systems.

A further Member State specific coefficient distributes the manure produced in the stable into storage or no-storage systems, where again Member State specific loss coefficients determine Ammonia emission from storage. Finally, uniform coefficients determine losses during application of manure and mineral fertiliser.

Technically, the underlying calculations are embedded as GAMS code in a separate module both called during updates of the data base and model runs. The relevant coefficients are stored as a separate table, Table (48), a transparent solution allowing to quickly perform sensitivity analysis or updates of the underlying coefficients.

Table (48) Coefficients used in the Ammonia module

Code	Coefficient	Specific at	Source/Update possibility/regionalisation
“HouseShare”, ”Graz”	Distribution factor into grazing and in-stable	Member State and animal type	IASSA
“LossFact”, “Graz”	Loss factor during grasses	“	IASSA/ EEIG
“TypeShare”, HouseType	Distribution factor into no-storage, liquid, solid	“	IASSA
“LossFact”, HouseType	Loss factor stable	“	IASSA/EEIG
“LossFacT”, StoreType	Loss factor storage	“	IASSA/EEIG
“LossFact” ApplType	Loss factor manure application	Memberstate	IASSA/EEIG
“Anog”,”Total”	Loss factor mineral application	Member State	IASSA

13.5. Annex 5: Principle of the NFM

The principle of the model is presented in Figure (16) (see also van der Veen et al., 1993; Dijk et al, 1996).

Figure (16) Nutrient flows in an agricultural production system

```
external                           external
 inputs      >•••••      ••••••>  outputs
                  •      •
  ••••••••••••••••••••••••••••••••••••••••
  •          ••••••••••••••             •
  •    •••••>•  LIVESTOCK ••••••••      •
  •    •     ••••••••••••••      •      •
  •   feed                    manure    •
  •    •     ••••••••••••••      •      •
  •    •••••••  CROPS     •      •      •
  •          ••••••••••^•••      •      •
  •              •      •        •      •
  •          ••••••••••••••      •      •
  •          •ROOT SYSTEM •<••••••      •
  •          ••••••••••••••             •
  ••••••••••••••••••••••••••••••••••••••••
                  •      •
  external <••••      •••••••• < external
   outputs                        inputs
```

Conceptually, the model splits up activities related to animal production and crop production for each farm to simulate. Both types of agricultural production activities import nutrients from outside the farm by purchases of external fertilisers and feedingstuff, respectively. Nutrients are transported from the farm via the sales of products (arable crops, milk, meat, manure, etcetera) and are lost into the non-agricultural environment i.e. ammonia emission, denitrification and nitrate leaching (external outputs). Besides that, internal flows of nutrients exist, in particular on dairy farms and mixed farm types, where crops are used to feed the livestock and manure is used for crop growth (internal inputs and outputs). With the soil defined as laying inside of the system boundary, nutrients are stored and released from storage within the system as well, as in the case of phosphate and organic nitrogen. Technical aspects are incorporated in the model by means of crop growth models and nutrient balances for animals.

The model is in its origin a farm level model. Horizontal boundaries are defined as geographical boundaries of land use. Vertical boundaries are less easy to define, but are considered to be the lower side of the root system of crops and the upper side of animals, stables and so on.

Technical models concerning crop production and animal production have been incorporated as modules in the NFM. They describe the production process and in this way they relate nutrient outputs to nutrient inputs. The crop models contain relations between available nitrogen and uptake of nitrogen by crops, between uptake of nitrogen and dry matter production and between nitrogen input and different types of losses. These models are based on experimental research (Aarts and Middelkoop, 1990; Middelkoop and Aarts, 1991; Van de Ven, 1992) and are available for arable crops as well as for fodder crops (grass and maize).

With regard to the livestock the nutrient content of the excreted manure is calculated as the difference between the nutrient content of the sold products (meat, milk, etcetera) and the nutrient uptake from feed. Feeding practises are defined exogenously for each animal type, in the case of cows reflected the level of milk yield. The composition of the feed intake of the cattle depends on the crop production at farm level. For this agricultural system a balance of nutrients can be calculated on a yearly basis. The balance of nutrients reflects the external inputs (purchases) and external outputs (sales), as well as changes of nitrogen storage in the soil. Also balances of the cropping system (one for each crop), the livestock system and the soil system are generated by the model. These balances are the core of the model outcomes.

The starting point of the calculations at farm level are the composition and the size of the livestock, the area and cropping pattern and the purchases of variable inputs. These data are either taken from given statistical data as the Agricultural Census or survey data, or can be generated by an economic modelling system.

Apart from the data typically available from Census statistics, some other sources containing information on farm level are used (milk quota per farm, soil characteristics) as well as purchases of variable inputs: as chemical fertiliser, manure, roughage and concentrates. Most of this data at the level of the farming type are covered by the disaggregated CAPRI database ex-post as well as comprised in the results of model runs.

Figure (17) gives a view on the results of the NFM for nitrogen, phosphorus, potassium and carbon. Some results as for instance the input of fertiliser are more of less directly obtained from the external inputs. Other, i.e. crop sales, is a result of calculations of agricultural production and farm management etc.

Figure (17) General formulation of N, P, K and C input and output (per farm)

Inputs		Outputs	
Concentrates	cattle	Milk	
	pigs	Animal products (excl. milk)	
	poultry	Silage maize	
Silage maize		Conservated grass	
Conservated grass		Cash crops : cereals, beet, potato etc	
Animal Manure	cattle	Animal Manure	cattle
	pigs		pigs
	poultry		poultry
Fertilizer		Emissions:	
		Mineral Nitrogen in soil	
Deposition		Denitrification in root zone	
Assimilation		Ammonia emission:	
		housing	
		grazing	
		application	
		storage manure	
		Net soil storage nitrogen	
		Net soil storage phosphorus	
		Potassium in soil	
		Carbon Dioxide:	
		digestive processes	
		storage manure	
		Methane:	
		digestive processes	
		storage manure	

The nutrient flow model is able, by its high technical content, to evaluate policy aiming at reducing several types of emission. Its starting aggregation level is the farm, which enables the model to use external information on the behaviour of farmers (Dijk et al, 1996). The variation between farms is one of the main features of the NFM.

The model is complex, which can be a disadvantage. But, because all flows had to be modelled consistently, the NFM can evaluate inputs from different sources for instance in scenario circumstances on their consistency.

Annex 6: Environmental indicators and nitrate (N) balance for some selected farm types

	Base year [1998]			Agenda reference run [2009]			CAP reform proposal 2003		
Specialist COP (other than rice) or various field crops	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*
Nitrate surplus	**217.14**		**6**	**218.8** *0.76%*		**6.05** *0.76%*	**217.8** *-0.46%*		**6.02** *-0.46%*
Phosphate surplus	**95.68**		**2.64**	**99.29** *3.77%*		**2.74** *3.77%*	**96.81** *-2.50%*		**2.68** *-2.50%*
Potassium surplus	**168.31**		**4.65**	**169.45** *0.68%*		**4.68** *0.68%*	**162.97** *-3.82%*		**4.5** *-3.82%*
Water deficite/surplus	**9956.03**		**275.11**	**9812.99** *-1.44%*		**271.16** *-1.44%*	**9468.26** *-3.51%*		**261.64** *-3.51%*
Methane output	**168.07**	**3529.43**	**4.64**	**172.55** *2.67%*	**3623.53** *2.67%*	**4.77** *2.67%*	**166.82** *-3.32%*	**3503.25** *-3.32%*	**4.61** *-3.32%*
Global warming potential	**35876.51**	**35876.51**	**991.37**	**39233.79** *9.36%*	**39233.79** *9.36%*	**1084.14** *9.36%*	**37923.4** *-3.34%*	**37923.4** *-3.34%*	**1047.93** *-3.34%*
Ammonium output	**310.98**		**8.59**	**334.54** *7.57%*		**9.24** *7.57%*	**323.51** *-3.30%*		**8.94** *-3.30%*
Methane from animals	**133.45**	**2802.48**	**3.69**	**134.53** *0.81%*	**2825.05** *0.81%*	**3.72** *0.81%*	**130.02** *-3.35%*	**2730.43** *-3.35%*	**3.59** *-3.35%*
Methane linked to fertiliser use	**34.62**	**726.95**	**0.96**	**38.02** *9.84%*	**798.49** *9.84%*	**1.05** *9.84%*	**36.8** *-3.21%*	**772.82** *-3.21%*	**1.02** *-3.21%*
CO2 linked to fertiliser use	**13782.64**	**13782.64**	**380.85**	**15122.31** *9.72%*	**15122.31** *9.72%*	**417.87** *9.72%*	**14644.93** *-3.16%*	**14644.93** *-3.16%*	**404.68** *-3.16%*
N20 linked to fertiliser use	**59.89**	**18564.44**	**1.65**	**66.09** *10.36%*	**20487.95** *10.36%*	**1.83** *10.36%*	**63.79** *-3.48%*	**19775.22** *-3.48%*	**1.76** *-3.48%*

	Base year [1998]			Agenda reference run [2009]			CAP reform proposal 2003		
Specialist Rice or Rice & COP	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*
Nitrate surplus	**0.15**		**4.79**	**0.15** *-1.80%*		**4.71** *-1.76%*	**0.15** *-1.37%*		**4.65** *-1.37%*
Phosphate surplus	**0.08**		**2.48**	**0.08** *2.91%*		**2.55** *2.95%*	**0.08** *0.60%*		**2.56** *0.60%*
Potassium surplus	**0.12**		**3.71**	**0.12** *-0.78%*		**3.68** *-0.74%*	**0.12** *2.00%*		**3.75** *2.00%*
Water deficite/surplus	**-2.5**		**-79.41**	**-2.48** *0.67%*		**-78.91** *0.63%*	**-2.39** *3.86%*		**-75.87** *3.86%*
Methane output	**0.1**	**2.09**	**3.16**	**0.11** *6.73%*	**2.23** *6.73%*	**3.37** *6.77%*	**0.11** *-0.94%*	**2.21** *-0.94%*	**3.34** *-0.94%*
Global warming potential	**38.13**	**38.13**	**1212.16**	**48.37** *26.86%*	**48.37** *26.86%*	**1538.33** *26.91%*	**47.66** *-1.48%*	**47.66** *-1.48%*	**1515.52** *-1.48%*
Ammonium output	**0.28**		**8.87**	**0.34** *22.17%*		**10.84** *22.22%*	**0.34** *-1.13%*		**10.71** *-1.13%*
Methane from animals	**0.06**	**1.26**	**1.91**	**0.06** *-6.61%*	**1.18** *-6.61%*	**1.78** *-6.58%*	**0.06** *-0.42%*	**1.17** *-0.42%*	**1.77** *-0.42%*
Methane linked to fertiliser use	**0.04**	**0.83**	**1.25**	**0.05** *27.07%*	**1.05** *27.07%*	**1.59** *27.11%*	**0.05** *-1.52%*	**1.03** *-1.52%*	**1.57** *-1.52%*
CO2 linked to fertiliser use	**15.69**	**15.69**	**498.87**	**19.88** *26.67%*	**19.88** *26.67%*	**632.18** *26.72%*	**19.58** *-1.53%*	**19.58** *-1.53%*	**622.53** *-1.53%*
N20 linked to fertiliser use	**0.07**	**20.35**	**2.09**	**0.08** *29.06%*	**26.27** *29.06%*	**2.69** *29.11%*	**0.08** *-1.50%*	**25.87** *-1.50%*	**2.65** *-1.50%*

	Base year [1998]			Agenda reference run [2009]			CAP reform proposal 2003		
Root crops	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*
Nitrate surplus	**7.01**		**2.75**	**5.86** *-16.34%*		**2.3** *-16.34%*	**5.74** *-2.15%*		**2.25** *-2.15%*
Phosphate surplus	**2.69**		**1.06**	**2.83** *5.26%*		**1.11** *5.26%*	**2.68** *-5.22%*		**1.05** *-5.22%*
Potassium surplus	**4.72**		**1.85**	**4.6** *-2.42%*		**1.81** *-2.42%*	**4.35** *-5.48%*		**1.71** *-5.48%*
Water deficite/surplus	**1070.21**		**420.31**	**1076.38** *0.58%*		**422.74** *0.58%*	**1052.69** *-2.20%*		**413.44** *-2.20%*
Methane output	**9.03**	**189.73**	**3.55**	**9.57** *5.93%*	**200.99** *5.93%*	**3.76** *5.93%*	**9.17** *-4.14%*	**192.66** *-4.14%*	**3.6** *-4.14%*
Global warming potential	**3644.82**	**3644.82**	**1431.44**	**4129.61** *13.30%*	**4129.61** *13.30%*	**1621.88** *13.30%*	**4038.46** *-2.21%*	**4038.46** *-2.21%*	**1586.08** *-2.21%*
Ammonium output	**20.74**		**8.15**	**23.15** *11.62%*		**9.09** *11.62%*	**22.45** *-3.04%*		**8.82** *-3.04%*
Methane from animals	**5.32**	**111.68**	**2.09**	**5.37** *0.89%*	**112.68** *0.89%*	**2.11** *0.89%*	**5.05** *-5.88%*	**106.05** *-5.88%*	**1.98** *-5.88%*
Methane linked to fertiliser use	**3.72**	**78.05**	**1.46**	**4.21** *13.15%*	**88.31** *13.15%*	**1.65** *13.15%*	**4.12** *-1.92%*	**86.61** *-1.92%*	**1.62** *-1.92%*
CO2 linked to fertiliser use	**1475.62**	**1475.62**	**579.53**	**1666.39** *12.93%*	**1666.39** *12.93%*	**654.46** *12.93%*	**1635.52** *-1.85%*	**1635.52** *-1.85%*	**642.34** *-1.85%*
N20 linked to fertiliser use	**6.39**	**1979.46**	**2.51**	**7.3** *14.29%*	**2262.23** *14.29%*	**2.87** *14.29%*	**7.13** *-2.30%*	**2210.28** *-2.30%*	**2.8** *-2.30%*

	Base year [1998]			**Agenda reference run [2009]**			**CAP reform proposal 2003**		
Permanent crops & vegetables	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*
Nitrate surplus	**49.81**		**5.56**	**53.77** *7.95%*		**5.99** *7.70%*	**50.69** *-5.73%*		**5.64** *-5.73%*
Phosphate surplus	**26.33**		**2.94**	**27.8** *5.56%*		**3.09** *5.31%*	**26.58** *-4.37%*		**2.96** *-4.37%*
Potassium surplus	**43.25**		**4.83**	**44.51** *2.93%*		**4.96** *2.69%*	**40.86** *-8.21%*		**4.55** *-8.21%*
Water deficite/surplus	**-2115.89**		**-236.11**	**-2112.78** *0.15%*		**-235.21** *0.38%*	**-2167.66** *-2.60%*		**-241.32** *-2.60%*
Methane output	**31.3**	**657.22**	**3.49**	**31.12** *-0.56%*	**653.54** *-0.56%*	**3.46** *-0.79%*	**28.52** *-8.37%*	**598.85** *-8.37%*	**3.17** *-8.37%*
Global warming potential	**3530.97**	**3530.97**	**394.01**	**3576.88** *1.30%*	**3576.88** *1.30%*	**398.2** *1.06%*	**3380.13** *-5.50%*	**3380.13** *-5.50%*	**376.3** *-5.50%*
Ammonium output	**50.55**		**5.64**	**52.3** *3.45%*		**5.82** *3.21%*	**49.43** *-5.48%*		**5.5** *-5.48%*
Methane from animals	**28.07**	**589.54**	**3.13**	**27.85** *-0.79%*	**584.86** *-0.79%*	**3.1** *-1.03%*	**25.39** *-8.85%*	**533.12** *-8.85%*	**2.83** *-8.85%*
Methane linked to fertiliser use	**3.22**	**67.68**	**0.36**	**3.27** *1.47%*	**68.68** *1.47%*	**0.36** *1.24%*	**3.13** *-4.31%*	**65.72** *-4.31%*	**0.35** *-4.31%*
CO2 linked to fertiliser use	**1317.42**	**1317.42**	**147.01**	**1335.22** *1.35%*	**1335.22** *1.35%*	**148.64** *1.11%*	**1281.27** *-4.04%*	**1281.27** *-4.04%*	**142.64** *-4.04%*
N20 linked to fertiliser use	**5.02**	**1556.33**	**0.56**	**5.12** *2.04%*	**1588.12** *2.04%*	**0.57** *1.80%*	**4.84** *-5.55%*	**1500.01** *-5.55%*	**0.54** *-5.55%*

	Base year [1998]			Agenda reference run [2009]			CAP reform proposal 2003		
Dairy	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*
Nitrate surplus	**1449.4**		**69.3**	**1381.05** *-4.72%*		**66.03** *-4.72%*	**1354.28** *-1.94%*		**64.75** *-1.94%*
Phosphate surplus	**769.19**		**36.78**	**718.58** *-6.58%*		**34.36** *-6.58%*	**703.68** *-2.07%*		**33.65** *-2.07%*
Potassium surplus	**1870.81**		**89.45**	**1708.44** *-8.68%*		**81.69** *-8.68%*	**1660.79** *-2.79%*		**79.41** *-2.79%*
Water deficite/surplus	**5505.44**		**263.24**	**5426** *-1.44%*		**259.44** *-1.44%*	**5358.58** *-1.24%*		**256.22** *-1.24%*
Methane output	**755.61**	**15867.82**	**36.13**	**680.94** *-9.88%*	**14299.68** *-9.88%*	**32.56** *-9.88%*	**658.46** *-3.30%*	**13827.76** *-3.30%*	**31.48** *-3.30%*
Global warming potential	**23302.9**	**23302.9**	**1114.22**	**22779.37** *-2.25%*	**22779.37** *-2.25%*	**1089.19** *-2.25%*	**22006.68** *-3.39%*	**22006.68** *-3.39%*	**1052.24** *-3.39%*
Ammonium output	**642.1**		**30.7**	**607.04** *-5.46%*		**29.03** *-5.46%*	**594.66** *-2.04%*		**28.43** *-2.04%*
Methane from animals	**747.51**	**15697.74**	**35.74**	**671.66** *-10.15%*	**14104.89** *-10.15%*	**32.12** *-10.15%*	**649.49** *-3.30%*	**13639.36** *-3.30%*	**31.06** *-3.30%*
Methane linked to fertiliser use	**8.1**	**170.07**	**0.39**	**9.28** *14.53%*	**194.79** *14.53%*	**0.44** *14.53%*	**8.97** *-3.28%*	**188.4** *-3.28%*	**0.43** *-3.28%*
CO2 linked to fertiliser use	**3232.74**	**3232.74**	**154.57**	**3708.84** *14.73%*	**3708.84** *14.73%*	**177.34** *14.73%*	**3590.93** *-3.18%*	**3590.93** *-3.18%*	**171.7** *-3.18%*
N20 linked to fertiliser use	**13.56**	**4202.35**	**0.65**	**15.39** *13.53%*	**4770.85** *13.53%*	**0.74** *13.53%*	**14.8** *-3.83%*	**4588** *-3.83%*	**0.71** *-3.83%*

	Base year [1998]			Agenda reference run [2009]			CAP reform proposal 2003		
Cattle fattening & rairing	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*
Nitrate surplus	**279.78**		**38.39**	**292.77** *4.64%*		**40.17** *4.64%*	**259.5** *-11.36%*		**35.6** *-11.36%*
Phosphate surplus	**130.36**		**17.89**	**137.24** *5.28%*		**18.83** *5.27%*	**121.05** *-11.80%*		**16.61** *-11.80%*
Potassium surplus	**354.55**		**48.64**	**372.22** *4.98%*		**51.07** *4.98%*	**325.37** *-12.59%*		**44.64** *-12.59%*
Water deficite/surplus	**864.16**		**118.56**	**815.81** *-5.59%*		**111.92** *-5.60%*	**746.98** *-8.44%*		**102.48** *-8.44%*
Methane output	**155.07**	**3256.46**	**21.28**	**158.56** *2.25%*	**3329.69** *2.25%*	**21.75** *2.25%*	**141.98** *-10.45%*	**2981.68** *-10.45%*	**19.48** *-10.45%*
Global warming potential	**5077.92**	**5077.92**	**696.68**	**5229.2** *2.98%*	**5229.2** *2.98%*	**717.42** *2.98%*	**4779.17** *-8.61%*	**4779.17** *-8.61%*	**655.68** *-8.61%*
Ammonium output	**115.03**		**15.78**	**120.61** *4.85%*		**16.55** *4.84%*	**107.36** *-10.98%*		**14.73** *-10.98%*
Methane from animals	**153.07**	**3214.49**	**21**	**156.48** *2.23%*	**3286.15** *2.23%*	**21.47** *2.23%*	**140** *-10.53%*	**2940.04** *-10.53%*	**19.21** *-10.53%*
Methane linked to fertiliser use	**2**	**41.97**	**0.27**	**2.07** *3.74%*	**43.54** *3.74%*	**0.28** *3.73%*	**1.98** *-4.36%*	**41.64** *-4.36%*	**0.27** *-4.36%*
CO2 linked to fertiliser use	**806.11**	**806.11**	**110.6**	**833.78** *3.43%*	**833.78** *3.43%*	**114.39** *3.43%*	**801.53** *-3.87%*	**801.53** *-3.87%*	**109.97** *-3.87%*
N20 linked to fertiliser use	**3.28**	**1015.35**	**0.45**	**3.44** *4.96%*	**1065.73** *4.96%*	**0.47** *4.96%*	**3.21** *-6.55%*	**995.96** *-6.55%*	**0.44** *-6.55%*

	Base year [1998]			Agenda reference run [2009]			CAP reform proposal 2003		
Sheep & goats	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*
Nitrate surplus	**253.34**		**19.61**	**256.26** *1.15%*		**19.84** *1.15%*	**241.39** *-5.80%*		**18.69** *-5.80%*
Phosphate surplus	**94.84**		**7.34**	**95.9** *1.12%*		**7.42** *1.12%*	**88.41** *-7.81%*		**6.84** *-7.81%*
Potassium surplus	**266.28**		**20.61**	**270.1** *1.44%*		**20.91** *1.44%*	**246.38** *-8.78%*		**19.07** *-8.78%*
Water deficite/surplus	**-508.15**		**-39.34**	**-543.03** *-6.87%*		**-42.04** *-6.87%*	**-566.44** *-4.31%*		**-43.85** *-4.31%*
Methane output	**170.19**	**3573.97**	**13.17**	**169.31** *-0.52%*	**3555.47** *-0.52%*	**13.11** *-0.52%*	**157.27** *-7.11%*	**3302.71** *-7.11%*	**12.17** *-7.11%*
Global warming potential	**5403.77**	**5403.77**	**418.3**	**5400.92** *-0.05%*	**5400.92** *-0.05%*	**418.08** *-0.05%*	**5140.46** *-4.82%*	**5140.46** *-4.82%*	**397.92** *-4.82%*
Ammonium output	**71.04**		**5.5**	**72.79** *2.47%*		**5.63** *2.47%*	**68.35** *-6.10%*		**5.29** *-6.10%*
Methane from animals	**168.06**	**3529.28**	**13.01**	**167.16** *-0.53%*	**3510.42** *-0.53%*	**12.94** *-0.53%*	**155.12** *-7.20%*	**3257.54** *-7.20%*	**12.01** *-7.20%*
Methane linked to fertiliser use	**2.13**	**44.69**	**0.16**	**2.15** *0.82%*	**45.05** *0.82%*	**0.17** *0.82%*	**2.15** *0.27%*	**45.17** *0.27%*	**0.17** *0.27%*
CO2 linked to fertiliser use	**885.69**	**885.69**	**68.56**	**892.54** *0.77%*	**892.54** *0.77%*	**69.09** *0.77%*	**897.6** *0.57%*	**897.6** *0.57%*	**69.48** *0.57%*
N20 linked to fertiliser use	**3.05**	**944.11**	**0.24**	**3.07** *0.93%*	**952.9** *0.93%*	**0.24** *0.93%*	**3.03** *-1.34%*	**940.14** *-1.34%*	**0.23** *-1.34%*

	Base year [1998]			**Agenda reference run [2009]**			**CAP reform proposal 2003**		
Specialist pigs	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*
Nitrate surplus	**88.71**		**62.29**	**91.96** *3.66%*		**64.58** *3.67%*	**92.14** *0.19%*		**64.7** *0.19%*
Phosphate surplus	**82.59**		**57.99**	**86.15** *4.32%*		**60.5** *4.33%*	**86.35** *0.23%*		**60.64** *0.23%*
Potassium surplus	**87.21**		**61.24**	**90.17** *3.39%*		**63.32** *3.40%*	**89.95** *-0.25%*		**63.16** *-0.25%*
Water deficite/surplus	**456.07**		**320.24**	**450.95** *-1.12%*		**316.67** *-1.11%*	**440.79** *-2.25%*		**309.54** *-2.25%*
Methane output	**61.28**	**1286.85**	**43.03**	**65.91** *7.56%*	**1384.12** *7.56%*	**46.29** *7.57%*	**65.88** *-0.04%*	**1383.55** *-0.04%*	**46.27** *-0.04%*
Global warming potential	**2365.66**	**2365.66**	**1661.12**	**2498.19** *5.60%*	**2498.19** *5.60%*	**1754.34** *5.61%*	**2440.72** *-2.30%*	**2440.72** *-2.30%*	**1713.98** *-2.30%*
Ammonium output	**66.65**		**46.8**	**69.26** *3.92%*		**48.63** *3.93%*	**69.09** *-0.25%*		**48.52** *-0.25%*
Methane from animals	**60.15**	**1263.1**	**42.23**	**64.74** *7.64%*	**1359.6** *7.64%*	**45.47** *7.65%*	**64.77** *0.05%*	**1360.26** *0.05%*	**45.49** *0.05%*
Methane linked to fertiliser use	**1.13**	**23.75**	**0.79**	**1.17** *3.27%*	**24.52** *3.27%*	**0.82** *3.28%*	**1.11** *-5.04%*	**23.29** *-5.04%*	**0.78** *-5.04%*
CO2 linked to fertiliser use	**443.31**	**443.31**	**311.28**	**457.86** *3.28%*	**457.86** *3.28%*	**321.53** *3.29%*	**434.93** *-5.01%*	**434.93** *-5.01%*	**305.42** *-5.01%*
N20 linked to fertiliser use	**2.05**	**635.5**	**1.44**	**2.12** *3.26%*	**656.21** *3.26%*	**1.49** *3.27%*	**2.01** *-5.18%*	**622.25** *-5.18%*	**1.41** *-5.18%*

	Base year [1998]			**Agenda reference run [2009]**			**CAP reform proposal 2003**		
poultry	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*
Nitrate surplus	**6.43**		**2292.37**	**6.92** *7.63%*		**2467.34** *7.63%*	**6.9** *-0.35%*		**2458.63** *-0.35%*
Phosphate surplus	**7.52**		**2680.73**	**8.11** *7.85%*		**2891.16** *7.85%*	**8.09** *-0.33%*		**2881.63** *-0.33%*
Potassium surplus	**6.26**		**2229.98**	**6.74** *7.62%*		**2399.92** *7.62%*	**6.71** *-0.41%*		**2390.05** *-0.41%*
Water deficite/surplus	**0.7**		**249.83**	**0.7** *-0.38%*		**248.9** *-0.37%*	**0.69** *-1.04%*		**246.32** *-1.04%*
Methane output	**0.42**	**8.75**	**148.44**	**0.44** *5.61%*	**9.24** *5.61%*	**156.77** *5.61%*	**0.44** *-0.65%*	**9.18** *-0.65%*	**155.75** *-0.65%*
Global warming potential	**10.07**	**10.07**	**3588.24**	**10.67** *5.92%*	**10.67** *5.92%*	**3800.7** *5.92%*	**10.59** *-0.69%*	**10.59** *-0.69%*	**3774.4** *-0.69%*
Ammonium output	**4.07**		**1449.44**	**4.39** *7.82%*		**1562.8** *7.82%*	**4.37** *-0.33%*		**1557.63** *-0.33%*
Methane from animals	**0.42**	**8.72**	**147.92**	**0.44** *5.61%*	**9.21** *5.61%*	**156.22** *5.61%*	**0.44** *-0.65%*	**9.15** *-0.65%*	**155.19** *-0.65%*
Methane linked to fertiliser use	**0**	**0.03**	**0.52**	**0** *7.66%*	**0.03** *7.66%*	**0.56** *7.66%*	**0** *-0.87%*	**0.03** *-0.87%*	**0.55** *-0.87%*
CO2 linked to fertiliser use	**0.58**	**0.58**	**206.83**	**0.62** *7.55%*	**0.62** *7.55%*	**222.46** *7.56%*	**0.62** *-0.84%*	**0.62** *-0.84%*	**220.59** *-0.84%*
N20 linked to fertiliser use	**0**	**0.74**	**0.85**	**0** *8.25%*	**0.8** *8.25%*	**0.92** *8.26%*	**0** *-1.01%*	**0.79** *-1.01%*	**0.91** *-1.01%*

	Base year [1998]			**Agenda reference run [2009]**			**CAP reform proposal 2003**		
Field crops diversified	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*
Nitrate surplus	**13.98**		**4.26**	**14.46** *3.38%*		**4.41** *3.40%*	**14.73** *1.86%*		**4.49** *1.86%*
Phosphate surplus	**6.97**		**2.13**	**7.42** *6.44%*		**2.26** *6.46%*	**7.26** *-2.19%*		**2.21** *-2.19%*
Potassium surplus	**12.19**		**3.72**	**12.71** *4.25%*		**3.87** *4.27%*	**12.12** *-4.61%*		**3.7** *-4.61%*
Water deficite/surplus	**3**		**0.91**	**3.56** *18.72%*		**1.08** *18.75%*	**-12.87** *-461.94%*		**-3.92** *-461.94%*
Methane output	**9.48**	**198.98**	**2.89**	**9.77** *3.15%*	**205.26** *3.15%*	**2.98** *3.17%*	**9.44** *-3.40%*	**198.27** *-3.40%*	**2.88** *-3.40%*
Global warming potential	**1670.13**	**1670.13**	**509.01**	**1853.88** *11.00%*	**1853.88** *11.00%*	**565.12** *11.02%*	**1782.4** *-3.86%*	**1782.4** *-3.86%*	**543.33** *-3.86%*
Ammonium output	**20.1**		**6.13**	**21.9** *8.93%*		**6.67** *8.95%*	**21.12** *-3.52%*		**6.44** *-3.52%*
Methane from animals	**7.86**	**165.12**	**2.4**	**7.98** *1.46%*	**167.53** *1.46%*	**2.43** *1.48%*	**7.71** *-3.34%*	**161.94** *-3.34%*	**2.35** *-3.34%*
Methane linked to fertiliser use	**1.61**	**33.86**	**0.49**	**1.8** *11.40%*	**37.72** *11.40%*	**0.55** *11.42%*	**1.73** *-3.68%*	**36.33** *-3.68%*	**0.53** *-3.68%*
CO2 linked to fertiliser use	**651.14**	**651.14**	**198.45**	**723.14** *11.06%*	**723.14** *11.06%*	**220.44** *11.08%*	**697.37** *-3.56%*	**697.37** *-3.56%*	**212.58** *-3.56%*
N20 linked to fertiliser use	**2.65**	**820.01**	**0.81**	**2.99** *12.86%*	**925.48** *12.86%*	**0.91** *12.88%*	**2.86** *-4.18%*	**886.76** *-4.18%*	**0.87** *-4.18%*

	Base year [1998]			Agenda reference run [2009]			CAP reform proposal 2003		
Livestock diversified	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*
Nitrate surplus	**47.8**		**73.37**	**47.6** *-0.41%*		**73.08** *-0.41%*	**46.99** *-1.28%*		**72.14** *-1.28%*
Phosphate surplus	**33.36**		**51.21**	**33.44** *0.23%*		**51.33** *0.23%*	**33.06** *-1.11%*		**50.76** *-1.11%*
Potassium surplus	**55.47**		**85.15**	**53.32** *-3.87%*		**81.86** *-3.87%*	**52.09** *-2.32%*		**79.96** *-2.32%*
Water deficite/surplus	**115.67**		**177.56**	**115.15** *-0.45%*		**176.77** *-0.44%*	**112.61** *-2.21%*		**172.86** *-2.21%*
Methane output	**25.8**	**541.8**	**39.61**	**25.26** *-2.08%*	**530.52** *-2.08%*	**38.78** *-2.08%*	**24.69** *-2.26%*	**518.54** *-2.26%*	**37.91** *-2.26%*
Global warming potential	**947.46**	**947.46**	**1454.42**	**983.87** *3.84%*	**983.87** *3.84%*	**1510.32** *3.84%*	**957.45** *-2.69%*	**957.45** *-2.69%*	**1469.76** *-2.69%*
Ammonium output	**28.19**		**43.28**	**28.44** *0.88%*		**43.65** *0.88%*	**28.02** *-1.47%*		**43.01** *-1.47%*
Methane from animals	**25.37**	**532.76**	**38.94**	**24.78** *-2.32%*	**520.42** *-2.32%*	**38.04** *-2.32%*	**24.23** *-2.24%*	**508.75** *-2.24%*	**37.19** *-2.24%*
Methane linked to fertiliser use	**0.43**	**9.05**	**0.66**	**0.48** *11.65%*	**10.1** *11.65%*	**0.74** *11.65%*	**0.47** *-3.00%*	**9.8** *-3.00%*	**0.72** *-3.00%*
CO2 linked to fertiliser use	**169.8**	**169.8**	**260.66**	**189.54** *11.62%*	**189.54** *11.62%*	**290.95** *11.62%*	**183.98** *-2.93%*	**183.98** *-2.93%*	**282.43** *-2.93%*
N20 linked to fertiliser use	**0.76**	**235.85**	**1.17**	**0.85** *11.85%*	**263.81** *11.85%*	**1.31** *11.86%*	**0.82** *-3.37%*	**254.92** *-3.37%*	**1.26** *-3.37%*

	Base year [1998]			Agenda reference run [2009]			CAP reform proposal 2003		
Livestock & crops diversified	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*
Nitrate surplus	**192.91**		**24.68**	**193.5** *0.31%*		**24.76** *0.31%*	**190.32** *-1.65%*		**24.35** *-1.65%*
Phosphate surplus	**103.2**		**13.2**	**105.62** *2.35%*		**13.51** *2.36%*	**103.85** *-1.68%*		**13.29** *-1.68%*
Potassium surplus	**199.19**		**25.48**	**194.62** *-2.29%*		**24.9** *-2.29%*	**187.85** *-3.48%*		**24.03** *-3.48%*
Water deficite/surplus	**2878.52**		**368.24**	**2847.99** *-1.06%*		**364.35** *-1.06%*	**2787.98** *-2.11%*		**356.67** *-2.11%*
Methane output	**134.32**	**2820.72**	**17.18**	**133.02** *-0.96%*	**2793.51** *-0.96%*	**17.02** *-0.96%*	**129.48** *-2.66%*	**2719.12** *-2.66%*	**16.56** *-2.66%*
Global warming potential	**8258.61**	**8258.61**	**1056.51**	**8701.84** *5.37%*	**8701.84** *5.37%*	**1113.24** *5.37%*	**8278.26** *-4.87%*	**8278.26** *-4.87%*	**1059.05** *-4.87%*
Ammonium output	**149.98**		**19.19**	**153.31** *2.22%*		**19.61** *2.23%*	**149.57** *-2.44%*		**19.13** *-2.44%*
Methane from animals	**128.58**	**2700.24**	**16.45**	**126.79** *-1.39%*	**2662.61** *-1.39%*	**16.22** *-1.39%*	**123.6** *-2.51%*	**2595.67** *-2.51%*	**15.81** *-2.51%*
Methane linked to fertiliser use	**5.74**	**120.49**	**0.73**	**6.23** *8.65%*	**130.91** *8.65%*	**0.8** *8.65%*	**5.88** *-5.70%*	**123.45** *-5.70%*	**0.75** *-5.70%*
CO2 linked to fertiliser use	**2258.95**	**2258.95**	**288.98**	**2453.89** *8.63%*	**2453.89** *8.63%*	**313.93** *8.63%*	**2316.03** *-5.62%*	**2316.03** *-5.62%*	**296.29** *-5.62%*
N20 linked to fertiliser use	**10.25**	**3178.93**	**1.31**	**11.14** *8.67%*	**3454.43** *8.67%*	**1.43** *8.67%*	**10.46** *-6.12%*	**3243.12** *-6.12%*	**1.34** *-6.12%*

	Base year [1998]			Agenda reference run [2009]			CAP reform proposal 2003		
Various	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*	*Impact*	*Impact in GWP*	*Impact per ha UAA*
Nitrate surplus	**1606.39**		**43.57**	**1617.96** *0.72%*		**43.88** *0.72%*	**1556.11** *-3.82%*		**42.2** *-3.82%*
Phosphate surplus	**913.71**		**24.78**	**922.47** *0.96%*		**25.02** *0.96%*	**893.63** *-3.13%*		**24.24** *-3.13%*
Potassium surplus	**1808.72**		**49.05**	**1773.5** *-1.95%*		**48.1** *-1.94%*	**1678.8** *-5.34%*		**45.53** *-5.34%*
Water deficite/surplus	**4433.1**		**120.23**	**4318.34** *-2.59%*		**117.12** *-2.59%*	**4037** *-6.51%*		**109.49** *-6.51%*
Methane output	**926.79**	**19462.65**	**25.14**	**904.94** *-2.36%*	**19003.8** *-2.36%*	**24.54** *-2.36%*	**860.12** *-4.95%*	**18062.53** *-4.95%*	**23.33** *-4.95%*
Global warming potential	**38988.11**	**38988.11**	**1057.4**	**40461.58** *3.78%*	**40461.58** *3.78%*	**1097.39** *3.78%*	**38523.29** *-4.79%*	**38523.29** *-4.79%*	**1044.82** *-4.79%*
Ammonium output	**941.72**		**25.54**	**961.38** *2.09%*		**26.07** *2.09%*	**931.02** *-3.16%*		**25.25** *-3.16%*
Methane from animals	**906.02**	**19026.5**	**24.57**	**882.15** *-2.64%*	**18525.09** *-2.64%*	**23.93** *-2.63%*	**838.3** *-4.97%*	**17604.37** *-4.97%*	**22.74** *-4.97%*
Methane linked to fertiliser use	**20.77**	**436.16**	**0.56**	**22.8** *9.76%*	**478.71** *9.76%*	**0.62** *9.76%*	**21.82** *-4.29%*	**458.16** *-4.29%*	**0.59** *-4.29%*
CO2 linked to fertiliser use	**8217.95**	**8217.95**	**222.88**	**9013.96** *9.69%*	**9013.96** *9.69%*	**244.48** *9.69%*	**8639.52** *-4.15%*	**8639.52** *-4.15%*	**234.32** *-4.15%*
N20 linked to fertiliser use	**36.48**	**11307.51**	**0.99**	**40.14** *10.05%*	**12443.82** *10.05%*	**1.09** *10.05%*	**38.13** *-5.00%*	**11821.25** *-5.00%*	**1.03** *-5.00%*