ASSESSING THE REGIONAL AND ENVIRONMENTAL IMPACTS OF AGRICULTURAL POLICIES

AN EXTENSION OF THE POLICY EVALUATION MODEL AND AN APPLICATION TO SWITZERLAND

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BETTER POLICIES FOR BETTER LIVES

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This work is mandated under the 2013-14 Programme of Work and Budget (PWB) of the Committee for Agriculture (CoAg) under Output Area 3.2.1, Intermediate Output Result 1.3.

This technical document contains a description of the environmental module of the Policy Evaluation Model (PEM), which was developed in the context of an evaluation of the impact of agricultural policies on the environment in Switzerland.

It also contains a description of the new country module and parameters used in the publication *OECD Review of Agricultural Policies: Switzerland 2015*. The Swiss module is updated to represent three different geographical regions (plain, hilly and mountain), which allows assessing the regional impact of agricultural policies.

The publication of this document has been authorised by Ken Ash, Director of the Trade and Agriculture Directorate.

Comments are welcome and may be sent to tad.contact@oecd.org.

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Introduction

Agricultural sector models making use of agri-environmental indicators and integrated modelling systems (Britz et al., 2012) are increasingly used to evaluate policy reforms. Those include the farm-type model AROPAj (De Cara and Jayet, 2011) and the hybrid model CAPRI (Leip et al., 2011) for the European Union, the USDA-REAP model in the United States (Malcolm et al., 2012). In the Swiss context the farm-type model CH-FARMIS (Schader et al., 2013) and the sector model S-INTAGRAL in Switzerland (Hartmann et al., 2009) have been used. The OECD has developed the Stylised Agri-environmental Policy Impact Model (SAPIM) to provide farm-level analysis of policy effects under heterogeneous conditions, in particular with regard to nutrient surpluses and nutrient run-off (OECD, 2010).

This report documents the extension of the OECD Policy Evaluation Model (PEM) with an environmental module as well as a regional disaggrenation of production and regiojal-specific policies. Those extensions were developed in the context of an evaluation of the impact of agricultural policies on the environment in Switzerland and published in the *Review of Agricultural Policies: Switzerland 2015*. PEM is a partial equilibrium agricultural sector model that contains explicit factor markets (Martini, 2011). These factor markets, which include land, the use of chemicals and fertiliser, provide a direct connection between economic policy and farm activities. This allows for assessing environmental consequences of agricultural policies, in particular with regard to water pollution and GHG emission.

During the early development of PEM (OECD, 2001), a pilot study was conducted to investigate whether the relationship between agricultural policy, production and the environment could be quantified within the modelling framework. The conclusion of the pilot study was that PEM had the potential to be a useful framework in which to attempt the integration of environmental indicators, the inclusion of factor markets being of significant advantage. A subsequent appraisal of in-house data sets and modelling tools confirmed that PEM was a suitable tool for analysing the environmental effects of agricultural policies, since it already contains a representation of agricultural support policies and allows for a sophisticated treatment of land use and input use (such as fertiliser). Nutrient use, greenhouse gases, and pesticide use were identified as viable candidates for analysis.

Preliminary results on nitrogen balance simulations with PEM were discussed at the Joint Working Party on Environment and Agriculture. To this end, the model was used to simulate the effects of alternative agricultural policy instruments on input use, land allocation and production, the results of which were connected to a spreadsheet which quantifies the potential environmental effects of alternative policy instruments. The simulated results were then used as an input into a soil-surface nitrogen balance module that exploits nitrogen equivalent coefficients for inputs.

Other agri-environmental indicators may be fruitfully used in connection with PEM, in particular those relating to the intensity of farm input use, GHG emission, biodiversity and landscape. Other indicators are more challenging to integrate in any modelling framework, for example the farmland bird population indicator.

The paper is organized as follows. Section 1 introduces the series of agri-environmental indicators retained for the modelling work. Section 2 provides a short description of the PEM model. Section 3 outlines the framework for the computation of the indicators. The last section presents the new Switzerland country module and the data sources used to assess the policy impacts in the study *OECD Review of Agricultural Policies: Switzerland 2015* (OECD, 2015).

1. Agri-environmental indicators[1]

The following agri-environmental indicators are incorporated in the model: pesticide use, nutrient balances (nitrogen and phosphorous), gross emissions of greenhouse gas from agriculture, agriculture land cover types, and grazing animal stocking density.

Much of the information stems from the OECD Compendium on Agri-Environmental Indicators. Another important source is information from the Swiss Federal Office for Agriculture (FOAG) which is carrying out an agri-environmental monitoring. Those data include include a set of indicators related to the linkages between farm practices and environmental performance: nitrogen and phosphorous balances, pesticide use, energy consumption, coverage of agricultural soils, diversity and quality of ecological compensation areas (OFAG, 2014). In addition to those indicators, gross emissions of greenhouse gases are also computed in Switzerland and reported under the United Nations Framework Convention on Climate Change and the Kyoto Protocol (OFEN, 2012).[2]

Pesticide use

Agriculture uses pesticides to increase crop productivity and quality. The negative impacts of pesticides range from the risk of water pollution to the threat to the normal functioning of ecosystems because they are sprayed or spread across agricultural fields and often reach a destination other than the target species and sometimes runs off the fields. Direct exposure (through physical contact) and indirect exposure (through residue present in food and water) also raises concerns for human and wildlife health (OECD, 1999). In the OECD Compendium on Agri-Environmental Indicators, the indicator related to pesticide use is the change in *pesticide sales, in tonnes of active ingredients* (OECD, 2013).

Pesticides have different targets (e.g. insecticides, fungicides) and varying chemical composition, in terms of active ingredients and mixtures. Therefore, pesticide quantities are a “proxy measure of potential environmental pressure, since it does not convey information on the real levels of risk exposures for ecosystems and human health, which depend on other factors including toxicity, mobility and persistence” (OECD, 2013).

Nutrient balances

Nutrients, in particular nitrogen, phosphorus, and potassium, are essential to successful crop growing. The correct application of chemical fertiliser, livestock manure and sewage sludge are sustaining soil fertility, whereas selected farming practices such as cover crops and green manure are mitigating the loss of nutrients. Nutrient losses due to intakes in excess of crop and forage needs are however a potential threat to the environment. The harmful impacts include eutrophication of surface water caused by nutrient runoff, groundwater pollution by leaching, soil acidification, air pollution (notably ammonia), as well as greenhouse gas emissions (OECD, 1999). In the OECD compendium of Agri-Environmental Indicators, indicators related to agricultural nutrient balances include changes in *gross agricultural nitrogen (N) and phosphorus (P) balances, surplus or deficit* (OECD, 2013).

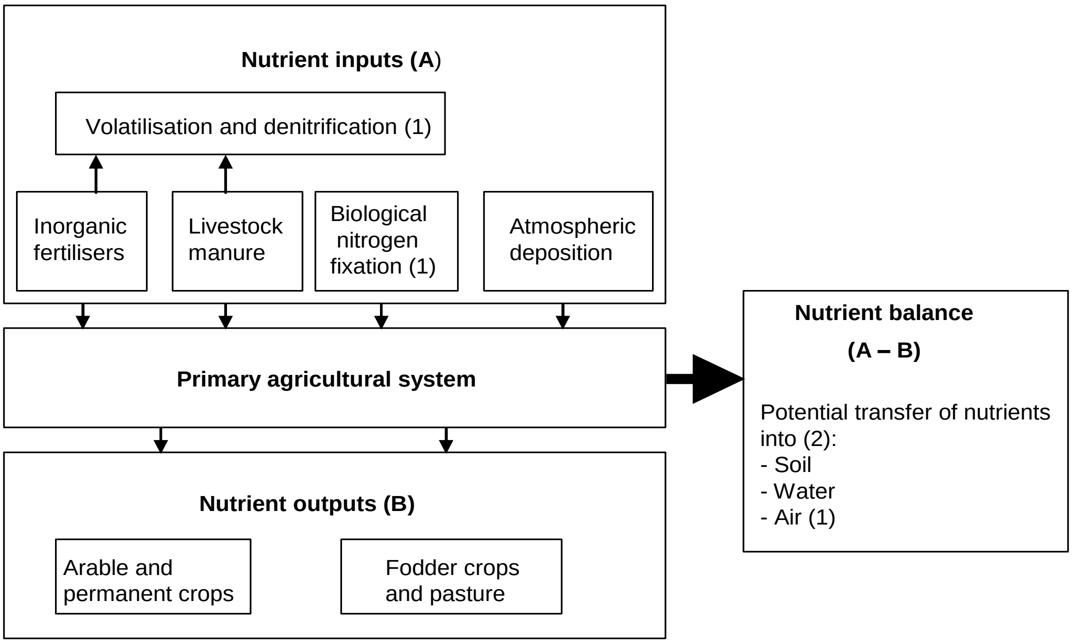
1. This section is primarily based on the OECD Compendium of Agri-environmental indicators (OECD, 2013).

2. While energy is a purchased farm factor included in the PEM model, it proved difficult to convert expenditures on energy into physical consumption, due to imprecise price data. In addition, there is no way to properly link the land uses modelled in PEM to soil coverage and ecological compensation areas, as the land use categories in the model are too aggregated. Therefore, those indicators are not included.

The gross nutrient balances (N and P) are calculated as the difference between the total quantity of nutrient inputs entering an agricultural system (mainly fertilisers, livestock manure), and the quantity of nutrient outputs leaving the system (mainly uptake of nutrients by crops and grassland), as elaborated in Figure 1). The land-size based nutrient budget approach is distinguished from other methods that take the farm or soil as the unit of analysis. The land budget approach aims to estimate the aggregate risk of pollution (air, soil and water) from nutrient and requires data on manure excretions. Advantages of the land budget include its consistency with greenhouse gas estimations and greater ease in disaggregating balances to regional level (Eurostat, 2013).

Nutrient balances are increasingly used in policy evaluation, in combination with farm and sector modelling tools (Leip et al. 2011, OECD, 2010). Limitations of nutrient balances include the accuracy of the underlying nutrient conversion coefficients and also the errors involved in estimating nutrient uptake by areas of pasture and some fodder crops (OECD, 2013).

Figure 1. Main elements in the gross nitrogen and phosphorus balance calculation



1. Applies to the nitrogen balance only.
2. Nutrients surplus to crop/pasture requirements are transported into the environment, potentially polluting soils, water and air, but a deficit of nutrients in soils can also occur to the detriment of soil fertility and crop productivity.

Source: OECD (2013).

Gross emissions of greenhouse gas

Agriculture contributes to emissions of greenhouse gas (GHG), in particular of methane largely derived from ruminant livestock’s enteric fermentation and animal wastes, paddy rice, fields and biomass burning, and of nitrous oxide originating from fertilisers, animal urine, waste storage sites, biomass burning and fossil fuel use. The relations between agriculture and climate change are not straight forward however because agriculture simultaneously provides a sink function through the fixation of carbon by crop and pasture land (OECD, 1999).

In the OECD Compendium of Agri-Environmental Indicators, the related indicator measures changes *in gross total agricultural greenhouse gas emissions (methane and nitrous oxide but excluding carbon dioxide)* (OECD, 2013). As their impact on climate change per ton of emission is different, it is not meaningful to directly sum the quantities of methane (CH_4) and nitrous oxide (N_2O) emissions. They should be aggregated into quantities of carbon dioxide equivalent (CO_2eq) using their Global Warming Potentials (GWP), a relative measure of how much heat a greenhouse gas traps in the atmosphere.

Biodiversity and landscape

The challenge for agriculture with respect to biodiversity is significant as it is a major user of land and water resources on which certain genetic resources and wild species are highly dependent. Efforts toward the conservation of birds on farmland may also help contribute to broader biodiversity goals of protecting the diversity of wild species and ecosystems associated with agriculture (OECD, 2013). One of the OECD indicators concerning agricultural biodiversity is *agricultural land cover types – arable crops, permanent crops and pasture areas*.

Tracking changes in the area of agricultural semi-natural habitats, can provide information on the extent of land that is subject to relatively "low intensity" farming practices, such as wooded pastures and extensive grasslands with little, if any, fertilisers and pesticides used in their management, and relatively undisturbed by machinery operations (especially during the nesting season) or not farmed at all, such as fallow land (uncultivated habitats on farmland, such as hedges). A limitation is that at present, for most countries, data of semi-natural habitats are collected at fairly broad levels of aggregation which impairs analysis of potential impacts on biodiversity. Indeed, the OECD compendium of Agri-Environmental Indicators uses the very broad category of *permanent pasture* as a proxy for semi-natural habitats, even if this is subject to caveats (OECD, 2013).

Within grassland, the *grazing animal stocking density* is a complementary indicator that aims to capture intensification or extensification of pastures (Mittenzwei et al., 2007). Indicators of landscape diversity in Switzerland have been elaborated in studies with CAPRI (Mittenzwei et al., 2007) and the agent-based model of regional agricultural structures AgriPoliS (Brady et al., 2009), both using adaptations of the *Shannon's Diversity Index* (SDI). Using such an index assumes that environmental benefits are related to landscape features as follows: "The more diverse and heterogeneous a landscape, the more complex its mosaic, and hence the more it can potentially contribute to amenity, recreational, cultural and knowledge values. The diversity of land use is usually expressed in terms of richness and evenness. Richness refers to the number of different land uses and evenness to the uniformity of distribution of the area of different uses" (Brady et al., 2009). SDI is a proportional abundance index and reflects both the evenness and richness of a set of land uses:

$$SDI = -\sum_{j=1}^{J} (P_j \cdot lnP_j)$$

where P_j is the share of the total land area covered by the j^{th} land use. This index is bounded between 0 (minimal diversity) and ln(1/J) (maximum diversity if all land uses are present in the same proportion.

2. General structure of the OECD Policy Evaluation Model

The PEM model provides a stylized representation of production, consumption, and trade of aggregates of major cereal and oilseeds crops, milk, and beef production in seven OECD countries or regions: Canada, the European Union, Japan, Korea, Mexico, Switzerland, and the United States.

Commodity supply is represented through a system of factor demand and factor supply equations. Excepting the rest of world module, where supply functions are directly specified as reduced forms, there are equations representing demand and supply responses for at least four categories of inputs (land, cows, other farm-owned factors and purchased factors) used to produce these commodities in the study countries. The factor demand equations reflect the usual assumptions of profit maximisation constrained by the production relationship. Thus, the commodity supply for the seven OECD countries or regions are embedded in the equations that determine equilibria in these input markets.

Policy simulation experiments usually involve relatively small changes in policy variables, because the estimations of the behavioural relationships in the model are valid around the observed equilibrium in the base. Simulating the model far away from the base equilibrium (e.g. complete elimination of government support programs for agriculture) would introduce approximation errors. For example, all the supply and demand relations in the model are approximated with constant elasticity linear equations.[3] Supply response corresponding to a medium term adjustment horizon of three to five years is reflected in the values assumed for the price elasticities of factor supplies and the parameters measuring the substitutability of factors in production as well as the factor shares.

No factor is assumed to be completely fixed in production, but land and other farm-owned factors are assumed to adjust relatively more slowly to price changes (have lower price elasticities of supply) than the purchased factors. Most supply parameters needed for the model come from systematic reviews of the empirical literature. Factor coverage differs from one country to another. Each country has three farm-owned factors: land, cows, and a residual “other farm owned factors”. The representation of the land market allows simulating payments based on area, payments based on non-current areas, and farm income. The set of purchased factors covered in each country includes, at the least, fertiliser and a residual “other purchased factors” and often many more (Table 1).

Commodity demand equations in the PEM relate domestic consumption to prices (at the farm level). Co-movement of prices may occur even when policy measures are targeted directly to only one or two of the crops because all six commodities may be substitutes (or complements) in *both* production *and* consumption. Grain and oilseed commodities are also inputs in the production of livestock commodities, which will induce co-movements in their prices.

Annex Table A.1 provides the list of model equations and parameters in a representative country module. This set of equations can vary to some degree by country depending on the implementation of particular polices that affect the structure of markets. In Swiss module, the milk quota regime that existed up to 2009 is represented in milk markets, while rice production is zero.

3. These types of equations provide log-linear approximations to the ‘true’ functional forms of the underlying production function, the associated factor demand equations and the equations of factor supply and commodity demand. The approximations would be better, especially for evaluating relatively large changes, if the underlying true production functions were of the constant elasticity of substitution, and the factor supply and commodity demand equations were truly log linear (Gardner, 1987).

As a part of the project *OECD Review of Agricultural Policies: Switzerland 2015*, the Swiss module of the model is updated to represent three different geographical regions (plain, hilly and mountain) and to generate selected environmental performance indicators. The new Swiss module assumes that certain input markets (land, cows and other farm owned capital) are region specific. The region specific production factors are not mobile between regions, and consequently those factor markets are region-specific, with their own supply, demand and prices. Section 5 documents the particularities of the Swiss module introduced in the report.

Table 1. Commodity and Factor Coverage in PEM

Wheat	Coarse grains	Oilseeds	Rice	Milk	Beef
Common wheat	Maize	Soybeans	All rice	Fluid	All beef
Durum wheat	Barley	Rapeseed		Manufacturing	
	Oats	Sunflower			
	Sorguhm				
	Farm-owned factors	**Substituable across commodities?**	**Purchase factors**	**Substitutable across commodities?**	
	Land	Yes (imperfect)	Chemicals	Yes	
	Cows	No	Energy	Yes	
	Other farm-owned	No	Fertiliser	Yes	
			Hired labour	Yes	
			Concentrate feed	No	
			Interest	Yes	
			Irrigation	Yes	
			Insurance	Yes	
			Machinery and equipment	Yes (crops only)[1]	
			Other inputs	Yes (crops only)[1]	

1. Machinery and Equipment and other purchased inputs are assumed perfectly transferable across crop uses, but specialized to dairy or beef production.
Source: Martini (2011).

3. Structure of the environmental module in PEM

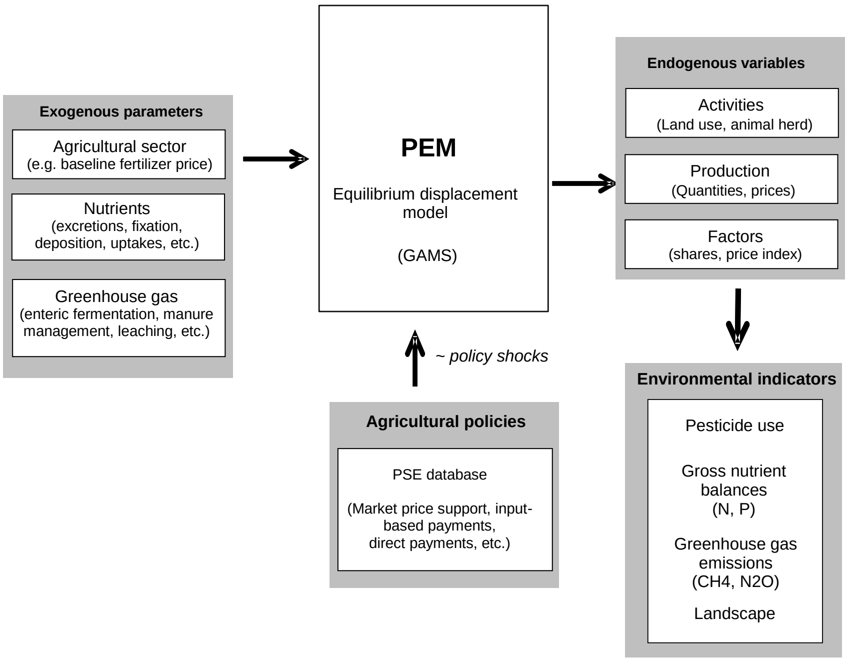
The baseline values of the agri-environmental indicators are computed from calibration values in PEM and from an inventory of agricultural sector and environmental parameters (Figure 2). Changes in the amount and composition of support to agriculture are estimated from the PSE tables and are introduced through changes in price wedges.

From the new simulated equilibrium following the policy shock, the environmental side module generates the relevant indicators (See Table A.3 in appendix), as well as their intermediate components; the latter being useful for consistency checks, as well as to assess specific issues, such as nitrous oxide emissions from nutrient run-off (Table A.4).

The agri-environmental indicators simulated with PEM are the following:

- Pesticide use on main arable crops (Kg active ingredient/ha);
- Gross Nitrogen Balance using the land budget approach (Kg N/ha);
- Gross Phosphorous Balance using the land budget approach (Kg P/ha);
- Gross emissions of greenhouse gas weighted by their Global Warming Potential (tons eqCO_2);
- Share of grassland in agricultural area (%);
- Shannon Diversity Index (SDI);
- Density of cattle on grassland.

Figure 2. Framework for assessing environmental impacts with PEM



The environmental module calculates the changes in the level of indicators after a policy shock relative to base levels (See list of equations in Table A.4). The calculations are implemented in the GAMS (General Algebraic Modeling System) language, in order to facilitate the replication of simulations and to routinely perform sensitivity analysis. The module makes use of two kinds of information. First, it uses the equilibrium levels of PEM endogenous variables:

- Activities: land use (Million ha) and animal herd (Million heads);
- Production: commodity quantities (Tons) and prices (USD/ton)
- Production factors: price index and cost-shares of the relevant production factors (e.g. chemicals, inorganic fertilisers).

The second input into the module is a set of parameters that vary by country, commodity or region and over time (Tables A.6 and A.7):

- Agricultural sector parameters, for example real prices of pesticides (in the baseline), share of nitrogen in the composition of inorganic fertilisers, proportion of milk that is marketed.
- Environmental parameters related to nutrient management and greenhouse gas emissions.

Only the first set of inputs is impacted by policy shocks, such as a reduction in market price support, a tax on fertiliser or an increase in direct payments to ruminants.

The major crop and livestock activities are represented in the PEM model, and the model covers all agricultural land uses, including land use for pastures and main arable crops (wheat, coarse grains, oilseeds), as well as land use for non-modelled commodities: “other arable land” (e.g. sugar beet, potato, fodder crops) and “miscellaneous land” (e.g. vine, fruits and vegetables) (Martini, 2011).

Two categories of cattle are distinguished: i) dairy cows producing milk and meat; ii) other cattle specializing in beef and veal meat (including suckler cows and calves). Other livestock categories (e.g. poultry, pigs, and sheep) are not modelled in PEM. It is therefore implicitly assumed that those sectors are not impacted by policy shocks (e.g. no substitution between red and white meat, no change in feed demand from the poultry and hog sectors, etc.).

Nitrogen budget

The calculation of nutrient budgets is based on total revenue and factor share data from the PEM model. PEM assumes that revenues equal expenditures, so that factor shares and revenue information are sufficient to identify total expenditures on inorganic fertiliser and land. Multiplying total expenditures by fertiliser factor shares, one obtains total expenditures on fertiliser (Martini, 2000).

Nitrogen inputs

For each main commodity group modelled (i.e. wheat, coarse grains, oilseeds), the expenditure on inorganic fertiliser is computed from the quantity of crop produced, supply price and factor cost-shares (Equation 1, thereafter Eq.1). The sum over all crops gives the total expenditures on fertiliser for the main arable crops (Eq.2).

The quantity of nitrogen fertiliser used for a crop is computed from the expenditure on fertiliser, multiplied by the share of nitrogen (thereafter N) in fertiliser expenditure, divided by the price of N fertiliser. The latter is computed from the baseline nitrogen price multiplied by the change in fertiliser price index, which is endogenously computed in PEM (Eq.3). The sum gives the total N fertiliser quantities for main arable crops (Eq.4). The intensity of N fertiliser use is computed from the quantity of N fertiliser divided by crop land use (Eq.5). This indicator is available for wheat, coarse grains, and oilseeds. Another interesting intermediary indicator is the intensity of N fertiliser use for all main arable crops (Eq.6).

For the three other land uses in PEM (i.e. “other arable land”, “pastures”, and “miscellaneous land”), there is no information on quantity, supply price and factor cost-shares. Therefore, it is assumed that the rate of fertiliser application is constant, independently from the policy shock. For those outputs, changes in fertiliser quantities occur only from changes in land use, i.e. through the substitution of main crops by other arable land, pastures or miscellaneous land, or the substitution within those land uses. Note that yields and nutrient uptakes per ha are also assumed to be fixed.

The quantity of N fertiliser for each ‘other’ land use is computed from an exogenous application rate and the land uses obtained from PEM (Eq.7). The sum gives the total N fertiliser quantities for other land uses (Eq.8), and adding quantities for main crops the total N fertiliser quantities in the country is obtained (Eq.9). The intensity of N fertiliser use is computed from the total N quantities divided by the total farmland, which is assumed to be constant (Eq.10).

The fixation of atmospheric nitrogen by leguminous crops is assumed to be only dependent on land use and an exogenous parameter (Eq.11). Three categories of land uses include leguminous crops: oilseeds (soya bean), other arable land (peas, lupine) and pastures (clover). The sum yields the total quantities of N from fixation (Eq.12). Free living organisms are the second source of biological nitrogen fixation in agricultural soils (Eq.13, Eq.14). The total biological fixation is the sum of fixation by leguminous crops and free living organisms (Eq.15).

The atmospheric deposition of nitrogen depends essentially on the location of farmland; for example, dry deposition of nitrogen oxides is greatest within large urban settlements and close to major highways. This information is lacking with the resolution of PEM model, so either a constant rate per ha for the country or a rate depending on the region is assumed. The quantities of N from deposition are computed from land uses and a parameter (Eq.16).

For each of the two cattle categories (i.e. “dairy cows”, “other cattle”), the quantities of N from manure are computed from the size of the herd and an excretion coefficient (Eq.17). For dairy cows, the nitrogen excretion coefficient (Kg N/head) depends on the intensity of production (Eq.18). The higher the quantities of milk produced per dairy cow, the higher the coefficient. However this function is not linear, the growth rate decreasing with production intensity. When the functional relationship is not available, a default value is taken. The quantity of milk per head is computed from the supply quantities and the herd size in PEM, with a correction for non-marketed milk (Eq.19). For other cattle, i.e. suckler cows, calves, bullocks and heifers, the excretion coefficient is assumed to be constant.

The sum of manure from dairy and other cattle gives the nitrogen from cattle manure (Eq.20). For livestock other than cattle, the total excretions (1 000 tons N) are assumed to be fixed and are computed from herd statistics and standard excretion coefficients. The sum of manure from cattle and other livestock gives the nitrogen from manure in the country (Eq.21).

The total nitrogen inputs in the country include the four aforementioned sources: inorganic fertiliser, manure from livestock, biological fixation and atmospheric deposition (Eq.22). Nitrogen intensity is computed from total nitrogen inputs and total farmland (Eq.23).

Nitrogen outputs

For the main crops, the supply quantities are endogenously computed in PEM. Production multiplied by an uptake coefficient (kg N per ton of crop) provides the nitrogen uptake for each crop (Eq.24) and are summed over all main crops (Eq.25). When crop yields are increasing, the uptakes of nitrogen are increasing in the same proportions. For the other land uses in PEM, as the potential changes at the intensive margin are not modelled, the uptake rate per ha is fixed, with a coefficient for the average yield (in country or region). Therefore the N uptake only depends on land uses (Eq.26, Eq.27). The sum of uptakes from main crops and from other land uses gives the total nitrogen uptake in the country (Eq.28).

The same approach applies to crop residues removed from soils, the amount depending on quantities for modelled crops (Eq. 29, Eq. 30) and on land use for other outputs (Eq. 31, Eq. 32). The sum of removed residues (Eq. 33) and crop uptakes provide the total nitrogen outputs in the country (Eq. 34).

Nitrogen balances

Nitrogen Use Efficiency (NUE) is the ratio of N outputs divided by N inputs (Eq.35). The Gross Nitrogen Balance (GNB) is the balance inputs minus outputs (Eq.36) and the GNB per hectare is computed from total farmland in the country (Eq.37).

Phosphorous budget

The phosphorous budget is very similar to the nitrogen budget (see equations Eq.38 to Eq.65). The main difference is that there is no biological fixation. Unlike for nitrogen, the excretion coefficient for dairy cows (Kg P/head) is not related to the quantities of milk produced per dairy cow. The Gross Phosphorous Balance (GPP) is the balance of inputs minus outputs (Eq.64) and the GPP per ha is computed from total farmland (Eq.65).

Pesticide use

Pesticides are another farm input modelled in PEM. The input labelled "chemicals" in PEM includes crop growth regulators, in addition to plant protection products (i.e. herbicides, fungicides, insecticides, acaricides, molluscicides, and rodonticides). Analogous to fertilisers, the expenditure on pesticides is computed from crop quantity, supply price and factor cost-shares (Eq.66). With additional information on the baseline price of pesticides used in the arable sector (USD/Kg of active ingredient) and the change in the pesticide price index (endogenously computed in PEM) one can compute the pesticide quantities for the crop (Eq.68). After aggregation, the final indicator is the pesticide use in Kg of active ingredients per ha of crop (Eq.71). Note that this indicator is slightly different than the OECD agri-environmental indicator focused on *pesticide sales* for a given year – including non-agricultural use.

The current environmental module is not yet providing information on pesticide use per ha in other crops or for the whole agricultural sector. As explained above, the model is not taking into account changes at the intensive margin for non-modelled crops: the pesticide application rate is assumed to be fixed for crops such as potatoes (falling in the "other arable land" category) or grapes and apples (both in the "other land use"). To compute aggregate pesticide quantities, one would need to match land use statistics with crop-specific data on active ingredients, but the latter is generally lacking in country statistics.

Greenhouse gas emissions

Methane emissions

The emissions of methane (CH_4) from agriculture include emissions from the enteric fermentation of livestock and the emissions from manure management, i.e. produced during the storage and treatment of manure, and from manure deposited on pasture.

Rice cultivation and the burning of savannahs and agricultural residues are the other main sources of methane emissions (IPCC, 2000). They are not included in the present version of the PEM environmental module. Rice cultivation is of no interest for Switzerland study, but is highly relevant for other countries modelled in PEM, Korea and Japan in particular.

The amount of methane from the enteric fermentation of herbivores depends on the type of digestive system, which results in higher rates of emissions for ruminant livestock, e.g. cattle, goats and sheep, and much lower rates for monogastric animals (e.g. swine). Emissions also depend on the composition of feed and on the gross energy intake, the latter being correlated to production, for example milk production and wool growth (IPCC, 2006). As recommended by the IPCC, for dairy cows, the emission factor for enteric fermentation is related to the quantities of milk produced per animal, with emissions increasing with production intensity (Eq.72). When the functional relationship is not available, a default value is taken. For other cattle, emission factors are assumed to be fixed and default values are used, either from the IPCC Guidelines or from national greenhouse gas inventories. For each cattle category, the emissions are computed from the herd size, obtained from PEM, multiplied by the emission factor (Eq.73). They are subsequently summed together (Eq.74) and then added to the emissions from other livestock (e.g., sheep, goats, swine) in order to provide the total CH_4 emissions from enteric fermentation (Eq.75).

The amount of methane from manure management depends on the amount of manure produced and on how the manure is managed. Significant quantities of CH_4 are produced when manure is stored or treated as a liquid; conversely there are lower emission rates with manure handled as solid or when deposited on pastures and rangelands (IPCC, 2006). In the dairy sector, the emission factor depends on production intensity (i.e. amount of milk per cow), as well as on a management coefficient (Eq.76). The management coefficient is estimated from the proportions of liquid/slurry and solid storage in the manure management system. It generally changes over years reflecting changes in farm management. For other cattle, again, emission factors are always assumed to be fixed. The total CH_4 emissions from manure management are computed in the same manner as those from enteric fermentation (Eq.77 to Eq.79). When summed with the total emissions from enteric fermentation, the total emissions of methane in the country are obtained (Eq.80).

Nitrous oxide emissions

The direct emissions of nitrous oxide (N_2O) occur via combined microbial processes of nitrification and denitrification of nitrogen, whereas indirect emissions result from volatile nitrogen losses that occur primarily in the forms of ammonia and NO_x (IPCC, 2006).

Emissions of N_2O include emissions from manure management (i.e. during the storage and treatment of manure before it is applied to land) and emissions from agricultural soils. In the common reporting format for the national inventories of greenhouse gases, the different sources of N_2O from agricultural soils are classified into four broad items:

- Direct soil emissions of nitrogen: application of inorganic fertilisers, manure applied to soils, fixation by leguminous crops, crop residues returned to soils, and cultivation of histosols (e.g. peat and muck);
- Nitrogen manure excretions on pasture, range and paddock;
- Indirect nitrogen emissions: atmospheric deposition, nitrogen leaching and run-off;
- Miscellaneous emissions, for example use of sewage sludge and compost as fertilisers.

The current PEM environmental module does not take into account the cultivation of histosols and the "miscellaneous" category. The other categories, as well as emissions from manure management are assessed using the nitrogen inputs previously computed for the nutrient balances and applying a series of emission factors. Therefore, the method for assessing nitrogen balance and N_2O emissions are consistent.

Emissions from manure management in cattle are computed from the quantities of manure (expressed in tons of N) multiplied by a manure management emission factor in Kg N_2O per Kg nitrogen (Eq.81). The sum from cattle (Eq.82) and other livestock gives the emissions in the country (Eq.83).

Inorganic fertilisers are the first anthropogenic source of direct soil emissions. Those depend on the quantities of fertilisers used, on the emission factor and on the fraction of nitrogen from fertiliser that volatilizes as NH_3 and NO_x (which is subtracted in the equation) (Eq.84). For manure applied to soils, the emissions depends on the quantities of manure applied, on the emission factor, on the fraction of manure excreted and deposited onto soil during grazing (which is subtracted), and on the fraction of excretion that volatilizes as NH_3 and NO_x (which is also subtracted) (Eq.85).

The emissions from leguminous crops are given by the quantities of nitrogen and the relevant emission factors (Eq.86). For the main crops (e.g. wheat, coarse grains, oilseeds), the quantities of nitrogen in crop residues returned to soils are computed from the crop supply quantities in PEM and a coefficient (Kg N/ton crop) (Eq.87). For other arable land and miscellaneous land (e.g. orchards), the quantities depend on land area and per hectare coefficients (Kg N/ha) using average yields in the country (Eq.89), as there is no information on tonnage of output,. The sum over main crops (Eq.88) and other land uses (Eq.90) gives the total quantities of nitrogen in the country (Eq.91). The multiplication by the emission factor provides the N_2O emissions from residues (Eq.92).

Emissions from manure excretions on pasture, range and paddock depend on the amount of manure produced by the livestock (expressed in 1000 tons of N), on the fraction of manure excreted and deposited onto soil during grazing, and on the emission factor (Eq.93).

Indirect nitrogen emissions from atmospheric deposition are given by the quantities of N and the emission factor (Eq.94). The indirect emissions from nitrogen leaching and run-off are computed from the sum of the fertiliser and manure applied to soils, the fraction that is lost through leaching and run-off and applying an emission factor (Eq.95).

The total N_2O emissions from agricultural soils are the sum of emissions from fertiliser and manure application, leguminous crops, crop residues returned to soils, pasture, range and paddock, atmospheric deposition, leaching and run-off (Eq.96). When added to the emissions from manure management, one obtains the total emissions of nitrous oxide from agriculture in the country (Eq.97).

Finally, the total emissions of methane and nitrous oxide are aggregated into quantities of carbon dioxide equivalents (CO_2eq) using the Global Warming Potentials of the two gas (Eq.98).

Landscape and biodiversity

The proportion of grassland in total agricultural area is directly available from PEM (Eq.99). Using the share of each land use category (Eq.100), it is possible to compute Shannon's Diversity Index (Eq.101). Another landscape-related indicator is the stocking density of cattle, expressed in standardised livestock units. It is interpreted as a proxy of intensification in the cattle sector. The density is the ratio of the sum of the dairy and non-dairy herd, corrected by a livestock unit coefficient, divided by the area in grassland (Eq.102).

Limitations

PEM is an equilibrium displacement model for the agricultural sector. It does not include other land uses and the possibility for farmland conversion, for example by afforestation. Fallow land is currently not integrated into the land structure model (Glebe and Salhofer, 2009; Martini, 2008). As total agricultural land is assumed to be fixed, PEM captures the environmental effects of policy changes, through their impacts at the "intensive margin" (input-use intensity) and at the "extensive margin" (land-use allocation between different agricultural activities) (OECD, 2010). But it does not allow capturing the impacts at the "entry-exit" margin (e.g. land entering or leaving agriculture).

When considering nitrogen balance on a per-hectare basis, two major elements dominate in the arable crop sector: output per hectare (yield), and fertiliser use per hectare. As detailed in the nitrogen balance pilot study (OECD, 2005), changes in input mix are brought about only by changes in relative factor prices. Increased production with constant input prices would result in use of each input increasing by the same percentage as the change in output, and the nitrogen balance per-hectare would not be changed. However, any policy scenario will result in changing input prices. This has to do with cross-effects across commodities generating second-order effects on input prices, even if there is no direct policy shock to input prices (OECD, 2005).

With the relevant elasticities in PEM, a policy shock will generally translate into a percent change in nitrogen application rate (Fertiliser/Land ratio) higher than the percent change in crop yield (Output/Land ratio). This is consistent with diminishing returns in the use of nitrogen in agriculture. However, the percent change may be only slightly higher, depending on the respective magnitude of expansion and substitution effects, i.e. between factors, especially between inorganic fertilisers and land.

In addition, it is important to stress that in the model, there is no explicit functional relationship between crop yields and nitrogen application rates (including from livestock manure). Increasing amounts of N applied to different plots on the same field would result in a response curve showing decreasing returns (Jarvis, 2011). In micro-economic modelling, nitrogen response curves are generally approximated with 'linear with plateau' or 'quadratic with plateau' functions, the plateau allowing for a finite yield maximum[4] (Godard, 2005). In the PEM framework, there is no such agronomic constraint.

Concerning greenhouse gas emissions, according to experiments, nitrous oxide emission factors are supposed to increase with nitrogen surplus (Van Groenigen et al., 2010). The non-linearity is not integrated in the current framework, which followed fixed coefficients (Kg N_2O/kg N), consistent with the IPCC approach.

Finally, as regards landscape and biodiversity, it should be noted that land use in PEM is rather aggregated, with only six categories of agricultural land (i.e. wheat, coarse grains, oilseeds, other arable land, grassland, and miscellaneous land). Moreover, the first four categories are not highly distinguishable with respect to landscape features, whereas the last category should be

4. For example, in the linear with plateau, $r = \min(B, a.N + A)$ where r = crop yield, N = nitrogen per ha, A = yield for $N = 0$, B = maximal yield, a = a parameter (Godard, 2005).

ideally broken down into several categories, e.g. orchards, vineyards, protected vegetables. Shannon's Diversity Index (SDI) therefore provides only a limited basis for drawing conclusions about landscape diversity.

4. Switzerland country module

As a part of *OECD Review of Agricultural Policies: Switzerland 2015* (OECD, 2015) the Swiss module of the model was updated to represent three different geographical regions (plain, hilly and mountain), reflects the differences in production and policy support structure between these regions.

Regional representation of markets

In the renewed Swiss module, many of the markets in Switzerland are assumed to be national markets, with linkages to world markets. All output markets are fully integrated so that the Swiss consumers and producers face the same market price (at the farm level). The purchased inputs (chemicals, fertilizer, energy, interest, insurance and machinery) share common markets in Switzerland so that producers face the same market prices, although the price of machinery is specific to crop and livestock sectors. However, the markets for farm owned inputs (farm-owned capital, cows and land), hired labour, concentrated feed and miscellaneous inputs are assumed to be specific to the region. Figure A.1 provides a graphical representation of outputs and inputs markets in new Swiss module. Land use and cattle numbers come from the regional agricultural survey by the Swiss Federal Office of Statistics (OFS, 2014a). Quantities of production are disaggregated based on the regional accounts for agriculture data (OFS, 2014b) (Tables A.8, 9 and 10). Factor cost shares are differentiated by region, making use of farm accountancy data taken from "Rapport de base" published by Agroscope (2014) (Table A.13). The cost allocation of milk production makes use of Lips (2014). The elasticities of demand, elasticities of substitution between inputs, supply elasticities of inputs are assumed to be the same in the three regions due to lack of sufficient information to disaggregate them.

Regional representation of payments

Policy representation in the model is differentiated between three geographical regions for all policy categories except for payments in category A1, Market Price Support, and consumer subsidies in the CSE. The integrated market structure of the model prohibits the separation of these forms of support by region. Other policies are represented separately between the regions to take into account differences due to payment levels by region. The annual report on agriculture by the Federal Office of Agriculture (FOAG) provides information on the distribution of payments by geographical regions up to 2012 (See Table A.17 for the amount of payments disaggregated to three regions for 1986-2012). The expected distribution of payments in 2014-17 is based on the estimation provided by the FOAG. The provisional PSE categorization is made based on the available information (Table A.18).

For commodity markets there is a single domestic price that holds for Switzerland, but separate producer prices could differ according to the level of payments in category A2, payments based on commodity output. For markets for purchased inputs, there is a common supply price, and demand prices for factors of production could differ between three regions according to the level of payments in B1: Payments based on variable input use. However, the amount of payments based on commodity output and variable input use are allocated based on the quantity and value of production by region, respectively, so that the unit rate of payments are common across three regions.

For land, both the supply and demand is differentiated between regions, as land is not a tradable good. Policies that affect land are those in category C with the label based on "area", Payments based on non-current A/An/R/I, production either required (category D) or not (category E). Payments in category C that are based on revenue or income affect both the land market and the market for farm-owned capital (Figure A.2).

It is important to note that not all categories of the PSE are included in the OECD PEM. The model covers only five aggregate commodities (wheat, coarse grain, oilseeds, milk and beef) and excludes payments based on non-commodity criteria, payment based on variable input use with input constraints, and certain payments based on current area/animal number whose commodity or commodity group are not covered by the PEM. In particular, the PSE data in Switzerland record a variety of payments based on current A/An/R/I. However, among the payments based on current A/An/R/I for certain commodity groups (GCT payments), only certain commodity group payments, for which PEM covers all the commodities in the group, are modelled in the PEM as a default; all crops (GCT1), cereal (GCT3) and ruminants (GCT8). However, payments based on animal numbers of all livestock (GCT7) account for a significant part of Swiss payment and some payments are estimated to be paid to cattle predominantly. Therefore, the payments for "holding of livestock under difficult conditions" and "regularly keeping animals outdoors" are included assuming that the payments are made only based on the number of cattle. Moreover, the payments based on the current area of production of grain and oilseeds (GCT 10) and all crops except wine (GCT11) are assumed to be paid based on the area of production of all crops (GCT1).[5]

In the prospective agricultural policy framework (AP 2014-17) proposes a new type of payment based on the area of pasture in geographically disadvantaged area such as "Grass based production of milk and meat". The revised PEM introduces the representation of this type of payment.

Environmental assessment

In the Switzerland country module, the nitrogen excretion coefficient for dairy cows depends on the intensity of production and this is represented with a specific adjustment formula[6]. Likewise, methane emissions from enteric fermentation are calculated using an emission factor for dairy cows that is adjusted for the intensity of production. The reference for those adjustments is a template from Agroscope based on IPCC guidelines (Bretscher, 2014a). It takes into account numerous factors, such as the feed energy density and the methane conversion factor. Finally, the emission factor for emissions from manure management depends on production intensity and on the management coefficient which changes over years depending on the proportion of liquid/slurry and solid systems. The aforementioned template is also used (Bretscher, 2014a).

The different parameter and their data source are detailed in Tables A.6 and A.7 (Appendix). The main data are available in tables A.19 and following. The baseline nominal prices of N and P fertiliser and their share in total inorganic fertiliser cost come from the annual report on gross margins in arable crops published by the Swiss farm extension service (Agridea, 2013). Prices for each year in the 1994-2012 period are then backward-extrapolated from input price indexes (USP, 2014a). The same approach is used for pesticides. The percentage of marketed milk by Swiss region comes from the USP dairy report (USP, 2010).

To compute several environmental parameters consistent with the activities in PEM, disaggregation and re-aggregation of land uses and livestock of Swiss statistics are needed. For example, to generate nitrogen uptakes per hectare for 'other arable land', 'pastures' or 'miscellaneous land', the composition of each land category by year and region is needed, e.g. the

5 Specifically, these two payments are included as a GCT1 payments: "Payment for Extensive Cultivation: Grains, Rapeseed" (GCT10) and "Payments for Farming on Steep Slopes" (GCT11).

6 In Switzerland, the emission is estimated to be 115 kg of nitrogen for a dairy cow producing 6 500 kg of milk annually. From this reference point, the correction to apply is +2% for a 1 000 kg increase, and -10% for a 1 000 kg reduction (Sinaj et al., 2009).

percentage of potatoes, sugar beet, peas and other crops in the ‘other arable land’ category, for plain region and hilly region. For livestock other than cattle, which are not modelled in PEM, the number of animals per year and region are needed, to assign them with the relevant nutrient excretions and methane emissions coefficients. The numbers derive from the 1990-2012 regional agricultural survey by the Swiss Federal Office of Statistics (OFS, 2014a).

For the main arable crops, nutrients from atmospheric deposition, nitrogen fixations, as well as nutrient uptakes per ton of crop come from the OFS’s Nutrient Budget dataset (OFS, 2013). For other land uses, the application rates and uptakes per hectare are reported in the agronomic technical literature (Agridea, 2013; Agroscope, 2013; Bertschinger et al., 2003; Sinaj et al., 2009; Spring et al., 2003). In the case of pastures, nitrogen uptakes per ha take into account the estimated distribution of different intensities of grazing between regions, as reported by Kohler for the 1996-2012 period (Kohler, 2014). Nutrient excretions from cattle and livestock other than cattle derive from the Nutrient Budget dataset (OFS, 2013).

As regards to greenhouse gas emissions, CH_4 and N_2O emissions for non-dairy cattle and other livestock come from the national inventory (OFEN, 2012). This is also the case for the N_2O emission factors (Kg N_2O/kg N) and the different fractions of nitrogen used in the formulas, for example the fraction of inorganic fertiliser applied to soils that volatilizes as NH_3 and NO_x. The dataset on nitrogen in crop residues returned to soils is also provided by Agroscope (Bretscher, 2014b). Global Warming Potentials of atmospheric gas are reported by UNFCCC (2014).

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APPENDIX

Table A.1. Representative country module in PEM

Endogenous variable symbol	***Stands for***
q_i^d, q_i^s, q_i^t	Demand, supply and trade quantities
p_i^d, p_i^s, p_i^w	Domestic demand, supply and world price of commodities
x_j^d, x_j^s	Input demand and supply quantities
r_j^d, r_j^s	Input demand and supply prices
Policy variable symbol	***Stands for rate of***
m_i	market price support
o_i	Payments based on commodity output
a_i	Payments based on current area
h	Payments based on non-current A/An/R/I, percent of land value
s_j	Payments based on variable input use, percent of purchased input value
f	Payments based on current revenue or income, percent of farm owned input and land value
G1	Payments based on current area paid to all crops (GCT 1)
G3	Payments based on current area paid to cereals (GCT 3)
G8	Payments based on current animal numbers paid to all livestock (GCT 8)
Parameter symbol	***Stands for***
n_{ij}	Elasticity of demand for crop i with respect to price of commodity j
c_{ji}	Cost share of input j used in producing commodity i
e_j	Elasticity of supply for input j
$\sigma^S{}_{ij}$	Elasticity of substitution between factor i and j
$\sigma^T{}_{ij}$	Elasticity of transformation between land use i and j
Equations (dot above variable indicates percentage change)	
$\dot{q}_i^d = \sum_{j=1}^{4} n_{ij}\dot{p}_i^d$	Domestic consumption demands for i=1 to 6 commodities
$\dot{x}_{j,i}^d = \sum_{j=1}^{m} c_{ji}\sigma_{ji}\dot{r}_j^d + \dot{q}_i^s$	Input demands for j=1 to m inputs, i=1 to 6 commodities
$p_i^s \cdot q^s{}_i = \sum_{j=1}^{m} x^d{}_{ij} r_j^d$	Zero profit conditions for i=1 to 6 commodities (input cost exhausts revenue)
$\dot{r}_n^s = \sum_{j=1}^{z} \frac{sr_j}{sr_n} \cdot \dot{r}_j^s$	Land price for land nest n containing z land sub-types, n=pasture & cropland, pasture land, cereal and oilseed land

Equations (dot above variable indicates percentage change) (*cont.*)	
$\dot{x}_i^s = \sum_{j=1}^{z} \sigma_n \frac{sr_j}{sr_n} \cdot \dot{r}_j^s$	Demand for land producing commodity i in nest n. z=number of land uses in subgroup and may include aggregate land groupings.
$\dot{x}_j^s = e_j \dot{r}_j^s$	non-land input supplies for non-land inputs
$\dot{x}_{j,i}^d = \sum_{j=1}^{4} c_{ji} \sigma_{ji} \dot{p}_j^d + \dot{x}_{cfi}^s$	Demand for grains, oilseeds, and capital in production of concentrated feed, i=milk, beef; c_{ji}=cost share of input j in production of feed for livestock production i; p_j^d =consumer price of grains or oilseeds or cost of capital in feed production
$\dot{r}_{cfi}^s = \sum_{j=1}^{z} c_{ji} \dot{p}_j^d$	Zero profit condition in feed market (concentrated feed price equals unit average cost of production)
$x_j^s = x_j^d$	Input market clearing
$r_j^s = r_j^d + r_j^{s0}(h + f) + a_j + G1$	land supply prices for j=1 to 7 categories of land. A_j=0 for beef pasture, *G1*=0 for dairy and beef pasture and “other arable” land, *f*=0 for “other arable” land
$r_j^s = r_j^d + r_j^{s0} \cdot f$	Supply price for “farm-owned” input for j=6 commodities
$r_j^s = r_j^d + r_j^{s0} \cdot s_j$	Non-land supply price for input j, aggregated over commodities
$p_i^s = p_i^d + o_i$	Supply prices for i=1 to 6 commodities
$p_i^d = p_i^w + m_i$	Demand prices for i=1 to 6 commodities

Source: Martini (2011).

Table A.2. Definitions of indices

Index	Sets	Notation
i	Commodity	w=wheat, c=coarse grain, o=oilseeds, mk=milk, bk=beef
j	Input	fz=fertilizer, ch=chemical, la=land, co=cow
z	Land use type	a=other arable land, p=pasture, x=miscellaneous land, w=wheat, c=coarse grain, o=oilseeds, mk=milk, bk=beef

Table A.3. Agri-environmental indicators in PEM

Output symbol	Stands for	Unit
UCH	Chemical use on main crops	Kg active ingredient/ha
$GNBH$	Gross Nitrogen Balance per hectare of land	Kg N/ha
$GPBH$	Gross Phosphorous Balance per hectare of land	Kg P/ha
GWP	GHG emissions weighted by Global Warming Potential	1000 tons eqCO2
P_z	Proportion of land covered by land use	%
$SHDI$	Shannon Diversity Index	
□□	Share of grassland in agricultural area	%
LD	Density of cattle on grassland	Livestock Unit/ha

Table A.4. Components of agri-environmental indicators

Output symbol	Stands for	Unit
Y_i	Yield of commodity *i*	Ton/ha
$Y_{i=wco}$	Yield (average of main crops: wheat, coarse grain and oilseeds)	Ton/ha
$QH_{i=mk}$	Quantity of milk production	Kg/head
ECH_i	Chemical expenditures of commodity *i*	Million USD
$ECH_{i=wco}$	Chemical expenditures (main crops: wheat, coarse grain and oilseeds)	Million USD
QCH_i	Chemical quantities of commodity *i*	1000 tons active ingredients
$QCH_{i=wco}$	Chemical quantities (main crops)	1000 tons active ingredients
$CHU_{,i}$	Chemical use of commodity *i*	Kg active ingredient/ha
$E_{fz,i}$	Nitrogen (N) inorganic fertiliser expenditures of commodity *i*	Million USD
$E_{fz,i=wco}$	N inorganic fertiliser expenditures (main crops)	Million USD
$QN_{fz,i}$	N inorganic fertiliser quantities of commodity *i*	1000 tons N
$QN_{fz,i=wco}$	N inorganic fertiliser quantities (main crops)	1000 tons N
$UN_{fz,i}$	N inorganic fertiliser use	Kg N/ha
$UN_{fz,i=wco}$	N inorganic fertiliser use (main crops: wheat, coarse grain and oilseeds)	Kg N/ha
$QN_{fz,j}$	N inorganic fertiliser quantities of land use *j*	1000 tons N
$QN_{fz,z=apx}$	N inorganic fertiliser quantities ofother arable land; pastures; miscellaneous land.	1000 tons N
QN_{fz}	N inorganic fertiliser quantities (total)	1000 tons N
UN_{fz}	N inorganic fertiliser use	Kg N/ha
$QN_{leguminous,z}$	N fixation by N-fixing of land use *z i*	1000 tons N
$QN_{leguminous}$	N fixation by N-fixing crops (total)	1000 tons N
$QN_{free\ living,z}$	N fixation by free living organisms of land use *z*	1000 tons N
$QN_{free\ living}$	N fixation by free living organisms (total)	1000 tons N
$QN_{biological}$	N biological fixation	1000 tons N
$QN_{deposition}$	N atmospheric deposition	1000 tons N
nim_{mk}	N excretions from dairy cattle	Kg N/head
$QN_{manure,i}$	N manure from cattle from commodity *i*	1000 tons N
QN_{manure}	N manure from cattle (all)	1000 tons N
QN_{manure}	N manure (total)	1000 tons N
$QN_{uptakes,i}$	N uptakes from commodity i	1000 tons N
$QN_{uptakes,i=wco}$	N uptakes (main crops: wheat, coarse grain and oilseeds)	1000 tons N
$QN_{uptakes,z}$	N uptakes of land use *j*	1000 tons N
$QN_{uptakes,z=apx}$	N uptakes (other arable land; pastures; miscellaneous land)	1000 tons N
$QN_{uptakes}$	N uptakes (total)	1000 tons N
QN_{inputs}	N inputs	1000 tons N

Output symbol	Stands for	Unit
$N_{intensity}$	N intensity	Kg N/ha
NUE	Nitrogen Use Efficiency	%
GNB	Gross Nitrogen Balance	1000 tons N
$QP_{fz,i}$	Phosphorus (P) inorganic fertiliser quantities of commodity i	1000 tons P
$QP_{fz,i=wco}$	P inorganic fertiliser quantities (main crops: wheat, coarse grain and oilseeds)	1000 tons P
$UP_{fz,i}$	P inorganic fertiliser use of commodity *i*	Kg P/ha
$UP_{fz,i=wco}$	P inorganic fertiliser use (main crops: wheat, coarse grain and oilseeds)	Kg P/ha
$QP_{fz,j}$	P inorganic fertiliser quantities of land use *j*	1000 tons P
$QP_{fz,z=apx}$	P inorganic fertiliser quantities (other arable land; pastures; miscellaneous land)	1000 tons P
QP_{fz}	P inorganic fertiliser quantities (total)	1000 tons P
UP_{fz}	P inorganic fertiliser use	Kg P/ha
$QP_{deposition}$	P atmospheric deposition	1000 tons P
$QP_{manure,}$	P manure from cattle (all)	1000 tons P
QP_{manure}	P manure	1000 tons P
$QP_{uptakes,i}$	P uptakes of commodity *i*	1000 tons P
$QP_{uptakes,i=wco}$	P uptakes (main crops: wheat, coarse grain and oilseeds)	1000 tons P
$QP_{uptakes,z=apx}$	P uptakes (other arable land; pastures; miscellaneous land)	1000 tons P
$QP_{uptakes}$	P uptakes (total)	1000 tons P
QP_{inputs}	P inputs	1000 tons P
$P_{intensity}$	P intensity	Kg P/ha
PUE	Phosphorous Use Efficiency	%
GPB	Gross Phosphorous Balance	1000 tons P
$ef_{enteric,i=mk}$	CH4 emission factor, enteric fermentation, dairy cows	Kg CH4/head
$QM_{enteric,i}$	CH4 from enteric fermentation of commodity *i*	1000 tons CH4
$QM_{enteric}$	CH4 from enteric fermentation, all cattle	1000 tons CH4
$QM_{enteric,other\ livestock}$	CH4 from enteric fermentation, other livestock	1000 tons CH4
$QM_{enteric}$	CH4 from enteric fermentation (total)	1000 tons CH4
$ef_{manure,i=mk}$	CH4 emission factor, manure management, dairy cows	Kg CH4/head
$QM_{manure,i}$	CH4 from manure management of commodity *i*	1000 tons CH4
QM_{manure}	CH4 from manure management (total)	1000 tons CH4
QM	CH4 emissions (total)	1000 tons CH4
$QNO_{management,i}$	N2O from manure management of commodity *i*	1000 tons N2O
$QNO_{management}$	N2O from manure management (total)	1000 tons N2O
$QNO_{soil,j=\ fz}$	N2O from agricultural soils: N input from application of inorganic fertilisers	1000 tons N2O

Output symbol	Stands for	Unit
$QNO_{soil,manure}$	N2O from agricultural soils: N input from manure applied to soils	1000 tons N2O
$QNO_{soil,leguminous}$	N2O from agricultural soils: N fixed by N-fixing crops	1000 tons N2O
$QN_{residues,i}$	N crop residues returned to soils of commodity *i*	1000 tons N
$QN_{residues,wco}$	N crop residues returned to soils (main crops)	1000 tons N
$QN_{residues,z=apx}$	N crop residues returned to soils (other arable land; pastures; miscellaneous land)	1000 tons N
$QN_{residues}$	N crop residues returned to soils (total)	1000 tons N
$QNO_{soil,residues}$	N2O from agricultural soils: N in crop residues returned to soils	1000 tons N2O
$QNO_{soil,z=p}$	N2O from agricultural soils: N excretion on pasture, range and paddock	1000 tons N2O
$QNO_{soil,deposition}$	N2O from agricultural soils: N from atmospheric deposition	1000 tons N2O
$QNO_{soil,leaching}$	N2O from agricultural soils : N from fertilisers and manure that is lost through leaching and run-off	1000 tons N2O
QNO_{soil}	N2O from agricultural soils (total)	1000 tons N2O
QNO	N2O emissions (total)	1000 tons N2O

Table A.5. Equations in PEM environmental module

Equation	Number (Eq.)
$E_{fz,i} = q_i^s \cdot p_i^s \cdot c_{fz,i}$	1
$E_{fz} = \sum_{i=1}^{3} E_{fz,i}$	2
$QN_{fz,i} = \frac{nis_i \cdot E_{fz,i}}{nip \cdot r_{fz,i}^d}$	3
$QN_{fz,wco} = \sum_{i=1}^{3} QN_{fz,i}$	4
$UN_{fz,i} = \frac{QN_{fz,i}}{x_{la,i}^s}$	5
$UN_{fz,wco} = \frac{\sum_{i=1}^{3} QN_{fz,i}}{\sum_{i=1}^{3} x_{la,i}^s}$	6
$QN_{fz,z} = niq_z \cdot x_{la,z}^s$	7
$QN_{fz,apx} = \sum_{z=1}^{3} QN_{fz,z}$	8
$QN_{fz} = QN_{fz,wco} + QN_{fz,apx}$	9
$UN_{fz} = \frac{QN_{fz}}{\sum_{z=1}^{6} x_{la,z}^s}$	10
$QN_{leguminous,z} = nil_z \cdot x_{la,z}^s$	11
$QN_{leguminous} = \sum_{j=1}^{6} QN_{leguminous,z}$	12
$QN_{free\ living,z} = nif_z \cdot x_{la,z}^s$	13
$QN_{free\ living} = \sum_{z=1}^{6} QN_{free\ livingzj}$	14
$QN_{biological} = QN_{leguminous} + QN_{free\ living}$	15
$QN_{deposition} = nia \cdot x_{la}^s$	16
$QN_{manure,i} = nim_i \cdot x_{co,i}^s$	17
$nim_{mk} = \varphi\ (QH_{mk})$	18
$QH_{mk} = nik \cdot \frac{q_{mk}^s}{x_{co,mk}^s}$	19
$QN_{manure,cattle} = \sum_{i=\ mk,bf} nim_i \cdot x_{co,i}^s$	20
$QN_{manure} = QN_{manure,cattle} + QN_{manure,other\ livestock}$	21
$QN_{inputs} = QN_{fz} + QN_{biological} + QN_{deposition} + QN_{manure}$	22
$N_{intensity} = \frac{QN_{inputs}}{\sum_{z=1}^{6} x_{la,z}^s}$	23

Equation	Number (Eq.)
$QN_{uptakes,i} = niu_i \cdot q_i^s$	24
$QN_{uptakes,wco} = \sum_{i=1}^{3} QN_{uptakes,i}$	25
$QN_{uptakes,z} = nih_z \cdot x_{la,z}^s$	26
$QN_{uptakes,apx} = \sum_{z=1}^{3} QN_{uptakes,z}$	27
$QN_{uptakes} = QN_{uptakes,wco} + QN_{uptakes,apx}$	28
$QN_{removed\ residues,i} = nir_i \cdot q_i^s$	29
$QN_{removed\ residues,wco} = \sum_{i=1}^{3} QN_{removed\ residues,i}$	30
$QN_{removed\ residues,z} = nid_j \cdot x_{laz}^s$	31
$QN_{removed\ residues,apx} = \sum_{z=1}^{3} QN_{removed\ residues,z}$	32
$QN_{removed\ residues} = QN_{removed\ residues,wco} + QN_{removed\ residues,apx}$	33
$QN_{outputs} = QN_{uptakes} + QN_{removed\ residues}$	34
$NUE = \frac{QN_{outputs}}{QN_{inputs}}$	35
$GNB = QN_{inputs} - QN_{outputs}$	36
$GNBH = \frac{GNB}{\sum_{z=1}^{6} x_{la,z}^s}$	37
$QP_{fz,i} = \frac{phs_i \cdot E_{fz,i}}{php \cdot r_{fz,i}^d}$	38
$QP_{fz,wco} = \sum_{i=1}^{3} QP_{ch,i}$	39
$UP_{fz,i} = \frac{QP_{fz,i}}{x_{la,i}^s}$	40
$UP_{fz,wco} = \frac{\sum_{i=1}^{3} QP_{fz,i}}{\sum_{i=1}^{3} x_{la,i}^s}$	41
$QP_{fz,z} = phq_z \cdot x_{laz}^s$	42
$QP_{fz,apx} = \sum_{z=1}^{3} QP_{fz,z}$	43
$QP_{fz} = QP_{fz,wco} + QP_{fz,apx}$	44
$UP_{fz} = \frac{QP_{fz}}{\sum_{z=1}^{6} x_{la,z}^s}$	45
$QP_{deposition} = pha \cdot x_{la}^s$	46
$QP_{manure,i} = phm_i \cdot r_{co,i}^s$	47

Equation	Number (Eq.)
$QP_{manure,cattle} = \sum_{i=mk,bf} phm_i \cdot x^s_{co,i}$	48
$QP_{manure} = QP_{manure,cattle} + QP_{manure,other\ livestock}$	49
$QP_{inputs} = QP_{fz} + QP_{deposition} + QP_{manure}$	50
$P_{intensity} = \frac{QP_{inputs}}{\sum_{z=1}^{6} x^s_{la,z}}$	51
$QP_{uptakes,i} = phu_i \cdot q^s_i$	52
$QP_{uptakes,wco} = \sum_{i=1}^{3} QP_{uptakes,i}$	53
$QP_{uptakes,z} = phh_z \cdot x^s_{la,z}$	54
$QP_{uptakes,apx} = \sum_{z=1}^{3} QP_{uptakes,z}$	55
$QP_{uptakes} = QP_{uptakes,wco} + QP_{uptakes,apx}$	56
$QP_{removed\ residues,i} = phr_i \cdot q^s_i$	57
$QP_{removed\ residues,wco} = \sum_{i=1}^{3} QP_{removed\ residues,i}$	58
$QP_{removed\ residues,j} = phd_z \cdot x^s_{la,z}$	59
$QP_{removed\ residues,apx} = \sum_{z=1}^{3} QP_{removed\ residues,z}$	60
$QP_{removed\ residues} = QP_{removed\ residues,wco} + QP_{removed\ residues,apx}$	61
$QP_{outputs} = QP_{uptakes} + QP_{removed\ residues}$	62
$PUE = \frac{QP_{inputs}}{QP_{outputs}}$	63
$GPB = QP_{inputs} - QP_{outputs}$	64
$GPBH = \frac{GPB}{\sum_{z=1}^{6} x^s_{la,z}}$	65
$ECH_i = q^s_i \cdot p^s_i \cdot c_{ch,i}$	66
$ECH = \sum_{i=1}^{3} ECH_i$	67
$QCH_i = \frac{ECH_i}{chp \cdot r^d_{ch,i}}$	68
$QCH_{wco} = \sum_{i=1}^{3} QCH_i$	69
$UCH_i = \frac{QCH_i}{x^s_{la,i}}$	70

Equation	Number (Eq.)
$UCH = \frac{\sum_{i=1}^{3} QCH_i}{\sum_{i=1}^{3} x_{la,i}^{s}}$	71
$ef_{enteric,mk} = \varphi\ (QH_{mk})$	72
$QM_{enteric,i} = ef_{enteric,i} \cdot x_{co,i}^{s}$	73
$QM_{enteric,cattle} = \sum_{i=\ mk,bf} ef_{enteric,i} \cdot x_{co,i}^{s}$	74
$QM_{enteric} = QM_{enteric,cattle} + QM_{enteric,other\ livestock}$	75
$ef_{manure,mk} = \varphi\ (mes_{mk}, QH_{mk})$	76
$QM_{manure,i} = ef_{manure,i} \cdot x_{co,i}^{s}$	77
$QM_{manure,cattle} = \sum_{i=\ mk,bf} ef_{manure,i} \cdot x_{co,i}^{s}$	78
$QM_{manure} = QM_{manure,cattle} + QM_{manure,other\ livestock}$	79
$QM = QM_{enteric} + QM_{manure}$	80
$QNO_{management,i} = nom_i \cdot QN_{manure,i}$	81
$QNO_{management,cattle} = \sum_{i=\ mk,bf} nom_i \cdot QN_{manure,i}$	82
$QNO_{management}\ QNO_{management,cattle} +\ QNO_{management,other\ livestock}$	83
$QNO_{soil,fz} = ef_{soil,fz} \cdot (1 - nof) \cdot QN_{fz}$	84
$QNO_{soil,manure} = ef_{soil,manure} \cdot (1 - nop) \cdot (1 - noa) \cdot QN_{manure}$	85
$QNO_{soil,leguminous} = ef_{soil,leguminous} \cdot QN_{leguminous}$	86
$QN_{residues,i} = noc_i \cdot q_i^{s}$	87
$QN_{residues,wco} = \sum_{i=1}^{3} QN_{residues,i}$	88
$QN_{\ residues,z} = noh_j \cdot x_{la,z}^{s}$	89
$QN_{residues,apx} = \sum_{j=1}^{3} QN_{residues,z}$	90
$QN_{residues} = QN_{residues,wco} + QN_{residues,apx}$	91
$QNO_{soil,residues} = ef_{soil,residues} \cdot QN_{residues}$	92
$QNO_{soil,pasture} = ef_{pasture} \cdot nop \cdot QN_{manure}$	93
$QNO_{soil,deposition} = ef_{deposition} \cdot QN_{deposition}$	94
$QNO_{soil,leaching} = ef_{leaching} \cdot nol \cdot (QN_{fz} + QN_{manure})$	95
$QNO_{soil} = QNO_{soil,fz} + QNO_{soil,manure} + QNO_{soil,leguminous} + QNO_{soil,residues} + QNO_{soil,pastures} + QNO_{soil,deposition} + QNO_{soil,leaching}$	96
$QNO = QNO_{management} + QNO_{soil}$	97
$GWP = gwp_{CH4} \cdot QM + gwp_{NO2} \cdot QNO$	98

Equation	Number (Eq.)
$GR = \frac{\sum_{z=mk,bf} x^{s}_{la,z}}{\sum_{z=1}^{n} x^{s}_{la,z}}$	99
$P_j = \frac{x^{s}_{la,z}}{\sum_{z=1}^{n} x^{s}_{la,z}}$	100
$SDI = -\sum_{j=1}^{n} (P_j \cdot lnP_j)$	101
$LD = \frac{\sum_{i=mk,bf} (lsu_i \cdot r^{s}_{co,i})}{\sum_{i=mk,bf} x^{s}_{z=p,i}}$	102

Table A.6. Nutrient budgets: Parameters and data sources for Switzerland

Parameter symbol	Stands for	Unit	Year	Region	Data sources
nik	Percentage of marketed milk	%			USP (2010)
$niq_{\mathrm{z=apx}}$	N inorganic fertiliser use (other arable land; pastures; miscellaneous land)	Kg N/ha	x	x	Agridea (2013); Agroscope (2013); Bertschinger et al (2003); Sinaj et al (2009); Spring et al (2003); OFS (2014a)
nil_z	N fixation by N-fixing crops	Kg N/ha	x	x	OFS (2013); OFS (2014a); Kohler (2014)
nia	N from atmospheric deposition	Kg N/ha	x		OFS (2013)
$QN_{manure,other\ livestock}$	N excretions from livestock other than cattle	1000 tons N	x	x	OFS (2013); OFS (2014a)
niu_i	N uptake coefficient (main crops)	Kg N / ton	x	x	OFS (2013); OFS (2014a)
$nih_{\mathrm{z=apx}}$	N uptakes (other arable land; pastures; miscellaneous land)	Kg N / ha	x	x	Agridea (2013); Bertschinger et al (2003); Sinaj et al (2009); Spring et al (2003); Kohler (2014); OFS (2014a)
nip	N inorganic fertiliser price	USD/kg N	x		Agridea (2013), USP (2014a)
nis_i	Share of N in inorganic fertiliser cost	%	x		Agridea (2013)
nim_{bf}	N manure from beef cattle	Kg N/head	x		OFS (2013)
nif_z	N biological fixation from free-living organisms	Kg N/ha			OFS (2013)
$phq_{\mathrm{z=apx}}$	P inorganic fertiliser use (other arable land; pastures; miscellaneous land)	Kg P/ha	x	x	Agridea (2013); Bertschinger et al (2003); Sinaj et al (2009); Spring et al (2003); OFS (2014a)
pha	P atmospheric deposition	Kg P/ha	x		OFS (2013)
$QP_{manure,other\ livestock}$	P excretions from livestock other than cattle	1000 tons P	x	x	OFS (2013); OFS (2014a)
phu_i	P uptake coefficient (main crops)	Kg P / ton	x	x	OFS (2013); OFS (2014a)
$phh_{\mathrm{z=apx}}$	P uptakes (other arable land; pastures; miscellaneous land)	Kg P / ha	x	x	Agridea (2013); Bertschinger et al (2003); Sinaj et al (2009); Spring et al (2003); Kohler (2014); OFS (2014a)
php	P inorganic fertiliser price	USD/kg P	x		Agridea (2013), USP (2014a)
phs_i	Share of P in inorganic fertiliser cost	%	x		Agridea (2013)
phm_i	P manure from cattle	Kg P/head	x		OFS (2013)

Table A.7. Greenhouse gas emissions: parameters and data sources for Switzerland

Parameter symbol	Stands for	Unit	Year	Region	Data sources
$QM_{enteric,other\ livestock}$	CH4 enteric emissions from other livestock	1000 tons CH4	x	x	OFEN (2012); OFS (2014a)
$QM_{manure,other\ livestock}$	CH4 manure emissions from other livestock	1000 tons CH4	x	x	OFEN (2012); OFS (2014a)
$ef_{enteric,i}$	CH4 emission factor, cattle enteric fermentation	Kg CH4/head	x		OFEN (2012); OFS (2014a)
mes_{mk}	CH4 manure management coefficient (dairy cows)		x		Bretscher (2014a)
nom_i	N2O emission factor, manure management	Kg N2O/kg N	x		OFEN (2012); OFS (2014a)
$QNO_{management,other\ livestock}$	N2O emissions from manure management, livestock other than cattle	1000 tons N2O	x	x	OFEN (2012); OFS (2014a)
nof	Fraction of inorganic fertiliser N applied to soils that volatilizes as NH3 and NOx	%	x		OFEN (2012)
nop	Fraction of livestock N excreted and deposited onto soil during grazing	%	x		OFEN (2012)
noa	Fraction of livestock N excretion that volatilizes as NH3 and NOx	%	x		OFEN (2012)
noc_i	N in crop residues returned to soils (main crops)	Kg N/ton	x		Bretscher (2014b)
$noh_{z=apx}$	N in crop residues returned to soils (other arable land; miscellaneous land)	Kg N/ha	x		Bretscher (2014b), OFS (2014b)
nol	Fraction of fertiliser and manure applied to soils that is lost through leaching and run-off	%	x		Bretscher (2014b)
$ef_{soil,fz}$	N2O emission factor: N input from application of inorganic fertilisers	Kg N2O/kg N			OFEN (2012)
$ef_{soil,manure}$	N2O emission factor: N input from manure applied to soils	Kg N2O/kg N			OFEN (2012)
$ef_{soil,leguminous}$	N2O emission factor: N fixed by N-fixing crops	Kg N2O/kg N			OFEN (2012)
$ef_{soil,residues}$	N2O emission factor: N in crop residues returned to soils	Kg N2O/kg N			OFEN (2012)
$ef_{z=p}$	N2O emission factor: N excretion on pasture range and paddock	Kg N2O/kg N			OFEN (2012)
$ef_{deposition}$	N2O emission factor: N from atmospheric deposition	Kg N2O/kg N			OFEN (2012)
$ef_{leaching}$	N2O emission factor: N from fertilisers, animal manures and other that is lost through leaching and run-off	Kg N2O/kg N			OFEN (2012)
gwp_{CH4}	CH4 global warming potential	CO2 equivalent			UNFCCC (2014)
gwp_{NO2}	N2O global warming potential	CO2 equivalent			UNFCCC (2014)

Figure A.1. New PEM Switzerland module structure

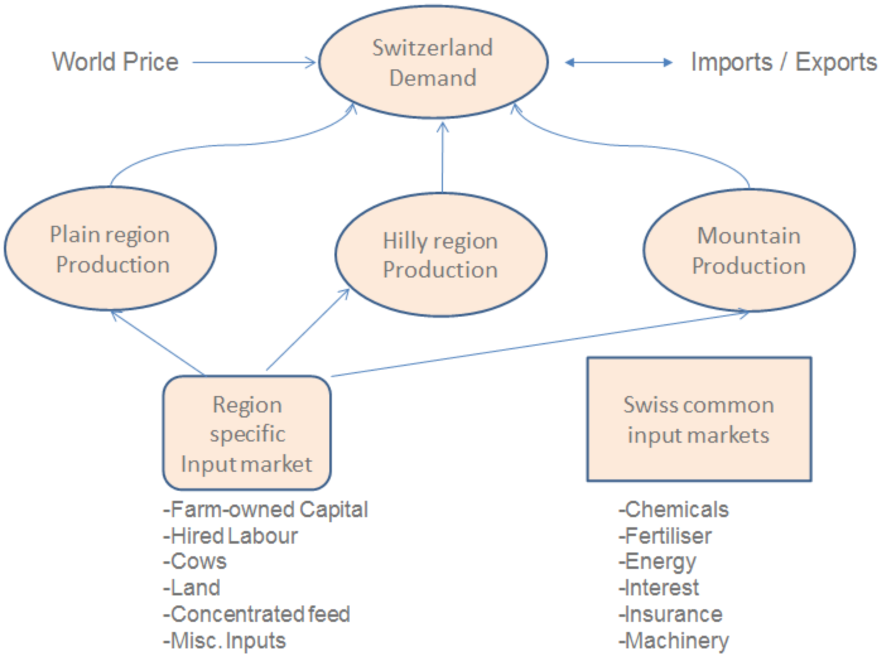

Figure A.2. First incidence of policies in PEM Switzerland

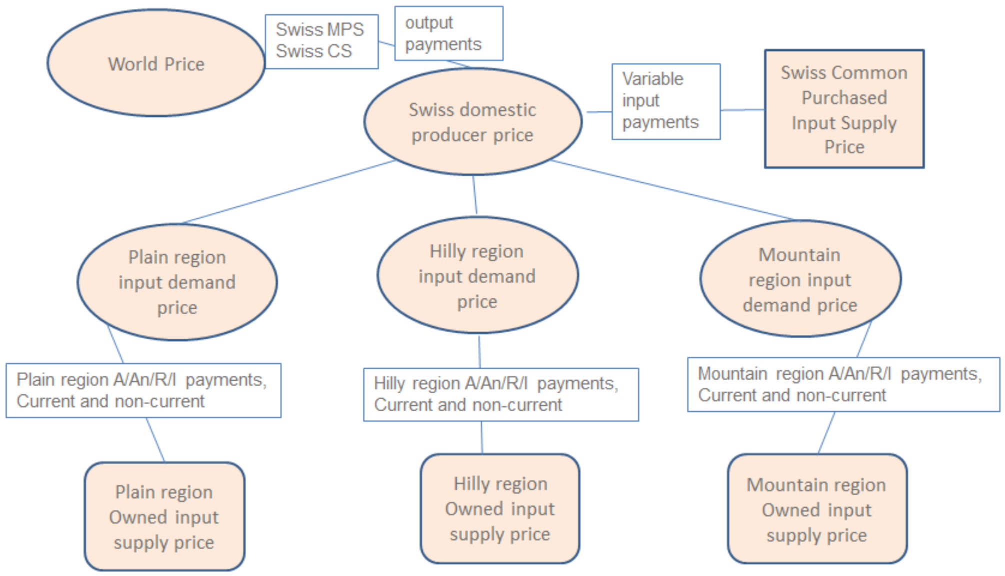

Table A.8. Commodity production by region, from 1986 to 2012

	thousand tonnes	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Switzerland	Wheat	478	449	550	633	551	592	537	584	574	618	657	584	594	490	561	496	509	428	528	516	534	534	537	537	508	534	510
	of which for feed use	*53*	*39*	*50*	*44*	*75*	*81*	*56*	*65*	*58*	*81*	*106*	*87*	*79*	*79*	*48*	*16*	*38*	*20*	*32*	*38*	*43*	*47*	*40*	*37*	*43*	*33*	*36*
	Coarse grains	404	385	539	614	576	583	551	572	551	528	535	507	532	458	487	463	436	309	438	433	382	388	371	372	318	335	321
	of which for feed use	*201*	*195*	*271*	*311*	*291*	*295*	*279*	*289*	*278*	*264*	*268*	*256*	*264*	*224*	*419*	*394*	*374*	*270*	*371*	*366*	*322*	*325*	*319*	*313*	*268*	*297*	*297*
	Oil-seeds	40	49	50	54	43	51	45	50	35	45	44	50	47	38	43	39	49	45	59	59	56	65	59	66	68	78	69
	Milk	3228	3121	3175	3251	3155	3233	3169	3195	3251	3262	3210	3231	3248	3196	3301	3334	3316	3300	3337	3328	3330	3385	3550	3540	3563	3597	3595
	Beef	169	172	154	157	165	173	165	155	142	147	159	152	148	147	128	138	140	137	134	132	136	133	135	142	143	144	143
of which plain	Wheat	409	384	471	542	471	506	460	499	491	529	562	500	508	419	480	427	438	368	456	443	460	461	464	464	438	461	440
	Coarse grains	315	300	421	479	449	455	430	446	430	412	418	396	415	357	384	372	349	239	356	354	310	322	308	310	264	277	266
	Oil-seeds	36.2	44.3	45.1	49.0	39.0	45.5	40.2	44.7	31.2	40.7	40.0	45.1	42.6	34.6	38.3	35.4	43.9	40.7	52.8	52.4	50.1	57.6	52.2	58.9	60.1	69.0	60.7
	Milk	1552	1501	1526	1563	1517	1554	1524	1536	1563	1568	1543	1553	1562	1537	1585	1592	1581	1569	1591	1569	1577	1615	1694	1677	1692	1708	1702
	Beef	73.3	74.3	66.5	67.7	71.1	74.8	71.2	67.2	61.4	63.7	68.7	65.8	63.8	63.5	55.9	59.9	59.8	57.5	55.9	53.6	55.6	53.8	52.9	57.6	58.5	58.7	58.0
of which hilly	Wheat	67.3	63.3	77.5	89.2	77.6	83.4	75.7	82.3	80.9	87.1	92.6	82.4	83.7	69.0	78.8	68.1	69.2	59.0	71.1	71.8	72.1	71.0	71.6	71.8	67.9	71.8	68.8
	Coarse grains	76.5	72.8	102.0	116.2	109.0	110.2	104.2	108.1	104.2	100.0	101.3	96.0	100.7	86.6	88.5	79.0	76.7	62.1	73.9	70.4	65.1	60.8	58.0	56.8	49.0	52.5	50.4
	Oil-seeds	3.2	4.0	4.0	4.4	3.5	4.1	3.6	4.0	2.8	3.6	3.6	4.0	3.8	3.1	3.7	3.4	3.9	3.8	4.7	4.6	4.7	5.4	4.9	5.6	5.8	6.7	6.0
	Milk	1040	1005	1023	1047	1016	1041	1021	1029	1047	1051	1034	1041	1046	1029	1063	1077	1076	1072	1082	1089	1084	1099	1152	1148	1155	1166	1166
	Beef	49	50	44	45	47	50	48	45	41	43	46	44	43	42	37	40	40	40	39	40	40	39	41	42	42	43	43
of which mountain	Wheat	1.7	1.6	1.9	2.2	1.9	2.1	1.9	2.0	2.0	2.2	2.3	2.1	2.1	1.7	1.9	1.5	1.6	1.2	1.5	1.5	1.4	1.4	1.5	1.5	1.4	1.4	1.4
	Coarse grains	12.4	11.8	16.5	18.8	17.7	17.9	16.9	17.5	16.9	16.2	16.4	15.6	16.3	14.0	13.7	11.6	10.5	8.0	8.0	7.9	6.9	5.6	5.4	5.4	4.6	4.9	4.6
	Oil-seeds	0.7	0.9	0.9	1.0	0.8	0.9	0.8	0.9	0.6	0.8	0.8	0.9	0.8	0.7	0.6	0.7	1.1	0.9	1.6	1.7	1.5	1.8	1.7	1.9	2.0	2.3	2.0
	Milk	636	615	626	641	622	637	625	630	641	643	633	637	640	630	652	665	659	659	664	670	669	670	704	715	715	723	727
	Beef	47.3	48.0	43.0	43.7	45.9	48.3	46.0	43.4	39.6	41.2	44.4	42.5	41.2	41.0	35.8	37.9	39.4	39.3	38.6	39.1	40.2	39.8	41.3	41.9	42.0	42.2	42.1

Table A.9. Land use by regions, from 1986 to 2012

	thousand hectares	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Switzerland	Beef	319.0	319.0	319.0	319.0	319.0	319.0	319.0	319.0	319.0	319.0	313.8	306.5	309.4	354.3	341.6	349.5	352.7	360.9	366.5	369.8	374.4	378.6	378.2	380.3	382.4	381.9	378.4
	Milk	406.1	406.1	406.1	406.1	406.1	406.1	406.1	406.1	406.1	406.1	426.3	434.8	436.1	388.4	403.3	396.4	393.4	388.1	382.4	374.4	370.4	367.0	366.6	364.1	361.3	364.1	366.4
	Wheat	100.7	100.7	100.7	100.7	100.7	100.7	100.7	100.7	100.7	100.7	100.3	99.1	99.7	96.5	97.7	93.0	92.6	87.6	88.9	93.6	94.6	91.7	91.9	91.3	90.2	86.7	88.7
	Coarse Grain	99.8	99.8	99.8	99.8	99.8	99.8	99.8	99.8	99.8	99.8	83.8	78.3	79.0	78.3	74.8	74.1	65.6	67.0	61.3	63.3	61.7	56.6	54.3	51.1	49.1	47.1	47.8
	Oil-seeds	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	19.0	20.8	22.1	21.3	19.6	18.8	22.9	25.0	25.3	25.2	26.3	27.2	27.0	27.3	27.6	27.8	27.9
	Arable land	100.3	100.3	100.3	100.3	100.3	100.3	100.3	100.3	100.3	100.3	112.6	109.2	105.4	104.1	106.8	110.3	113.5	110.3	112.0	110.7	109.7	110.7	111.5	111.8	111.0	113.7	111.1
	Other land	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	35.1	34.9	34.7	36.7	35.7	35.7	35.7	35.0	35.1	35.2	35.4	35.6	35.8	36.5	36.7	37.0	37.4
of which plain	*Beef*	109.0	109.0	109.0	109.0	109.0	109.0	109.0	109.0	109.0	109.0	108.4	106.6	106.9	119.5	116.1	118.3	118.5	121.5	123.9	122.5	124.1	125.9	126.4	124.7	126.1	125.7	124.6
	Milk	131.8	131.8	131.8	131.8	131.8	131.8	131.8	131.8	131.8	131.8	133.9	139.8	140.1	128.8	130.1	126.1	125.2	123.1	123.4	119.0	117.7	117.3	116.4	119.5	119.2	119.8	120.4
	Wheat	84.4	84.4	84.4	84.4	84.4	84.4	84.4	84.4	84.4	84.4	83.0	82.1	82.3	79.6	81.0	77.5	77.4	72.9	74.3	77.3	78.3	76.0	75.7	75.4	74.8	71.8	72.9
	Coarse Grair	73.0	73.0	73.0	73.0	73.0	73.0	73.0	73.0	73.0	73.0	61.4	57.0	58.0	58.2	56.2	56.5	49.9	51.0	47.0	48.7	47.6	43.7	42.4	40.0	39.0	37.2	37.7
	Oil-seeds	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	16.4	18.0	19.2	18.5	16.9	16.3	19.8	21.6	21.8	21.7	22.5	23.2	23.0	23.3	23.5	23.8	23.7
	Arable land	77.6	77.6	77.6	77.6	77.6	77.6	77.6	77.6	77.6	77.6	88.5	86.9	83.7	83.3	85.5	88.3	90.8	89.0	90.7	89.3	89.0	90.3	90.7	91.2	90.1	92.8	90.7
	Other land	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	25.0	24.6	24.9	25.5	25.2	25.0	25.0	24.3	24.5	24.3	24.3	24.3	24.4	24.9	25.1	25.3	25.5
of which hilly	*Beef*	91.3	91.3	91.3	91.3	91.3	91.3	91.3	91.3	91.3	91.3	89.6	87.5	88.0	100.1	95.3	98.7	99.8	102.5	104.4	106.4	107.4	109.4	109.0	110.3	110.4	109.5	108.4
	Milk	129.5	129.5	129.5	129.5	129.5	129.5	129.5	129.5	129.5	129.5	134.9	137.1	137.1	123.5	128.7	126.1	125.5	123.8	122.0	119.1	117.7	117.4	117.0	115.7	114.8	116.6	116.7
	Wheat	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	13.3	13.1	13.4	13.0	12.8	11.9	11.7	11.3	11.3	12.5	12.5	12.1	12.4	12.2	11.8	11.4	12.1
	Coarse Grair	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	17.2	16.4	16.1	15.5	14.3	13.6	12.1	12.3	11.0	11.3	10.8	9.9	9.1	8.6	7.8	7.6	7.7
	Oil-seeds	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.8	2.0	2.1	2.0	1.9	1.8	2.2	2.4	2.5	2.5	2.7	2.8	2.8	2.9	2.9	2.8	2.9
	Arable land	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	21.7	20.3	19.7	19.0	19.4	20.3	21.0	19.8	19.8	19.9	19.4	19.0	19.4	19.2	19.6	19.5	19.0
	Other land	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	4.1	4.3	4.3	4.9	4.7	4.8	4.8	4.9	4.9	4.9	5.0	5.1	5.1	5.2	5.2	5.2	5.3
of which mountain	*Beef*	118.7	118.7	118.7	118.7	118.7	118.7	118.7	118.7	118.7	118.7	115.9	112.4	114.5	134.7	130.2	132.5	134.3	136.9	138.1	140.9	142.9	143.3	142.8	145.3	145.8	146.7	145.4
	Milk	144.8	144.8	144.8	144.8	144.8	144.8	144.8	144.8	144.8	144.8	157.4	157.9	158.9	136.1	144.5	144.2	142.7	141.2	136.9	136.3	135.1	132.3	133.1	128.9	127.3	127.7	129.2
	Wheat	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	4.0	3.9	4.0	3.9	3.9	3.6	3.5	3.4	3.4	3.7	3.8	3.6	3.7	3.7	3.5	3.4	3.6
	Coarse Grair	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	5.2	4.9	4.8	4.6	4.3	4.1	3.6	3.7	3.3	3.4	3.2	3.0	2.7	2.6	2.3	2.3	2.3
	Oil-seeds	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.7	0.9	1.0	1.0	1.0	1.1	1.1	1.1	1.2	1.1	1.1	1.2
	Arable land	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.3	2.0	2.0	1.8	1.8	1.7	1.7	1.5	1.5	1.5	1.4	1.3	1.4	1.3	1.3	1.4	1.4
	Other land	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	6.0	6.1	5.6	6.4	5.7	5.9	5.9	5.8	5.7	6.0	6.1	6.2	6.2	6.4	6.5	6.5	6.6

Table A.10. Beef and dairy herd size by regions, from 1986 to 2012

thousand heads	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Milk																											
Switzerland	790.9	790.9	790.9	790.9	790.9	790.9	790.9	790.9	790.9	790.9	764.0	743.6	737.3	683.5	669.4	669.4	657.9	638.3	621.0	620.7	618.1	614.8	628.5	599.4	589.0	589.2	591.2
Plain	*358.2*	*358.2*	*358.2*	*358.2*	*358.2*	*358.2*	*358.2*	*358.2*	*358.2*	*358.2*	*336.3*	*328.1*	*322.6*	*301.1*	*297.0*	*294.3*	*287.5*	*277.3*	*270.7*	*268.4*	*268.3*	*268.4*	*274.0*	*262.5*	*260.1*	*261.7*	*260.2*
Hilly	*244.2*	*244.2*	*244.2*	*244.2*	*244.2*	*244.2*	*244.2*	*244.2*	*244.2*	*244.2*	*237.3*	*230.1*	*228.3*	*212.9*	*209.5*	*210.2*	*207.1*	*200.7*	*195.7*	*196.6*	*195.0*	*193.8*	*198.8*	*189.4*	*184.5*	*185.6*	*186.8*
Mountain	*188.5*	*188.5*	*188.5*	*188.5*	*188.5*	*188.5*	*188.5*	*188.5*	*188.5*	*188.5*	*190.4*	*185.4*	*186.5*	*169.5*	*162.8*	*164.9*	*163.3*	*160.4*	*154.7*	*155.7*	*154.7*	*152.6*	*155.7*	*147.5*	*144.4*	*141.9*	*144.2*
Beef																											
Switzerland	622.9	622.9	622.9	622.9	622.9	622.9	622.9	622.9	622.9	622.9	569.8	528.9	527.2	619.7	567.0	592.3	590.7	595.2	595.2	612.8	624.6	633.8	649.7	620.6	618.2	611.9	605.0
Plain	*296.4*	*296.4*	*296.4*	*296.4*	*296.4*	*296.4*	*296.4*	*296.4*	*296.4*	*296.4*	*272.0*	*250.0*	*246.3*	*279.3*	*265.0*	*276.3*	*272.3*	*273.6*	*271.8*	*276.2*	*282.8*	*287.9*	*297.5*	*273.8*	*275.3*	*274.6*	*269.3*
Hilly	*172.1*	*172.1*	*172.1*	*172.1*	*172.1*	*172.1*	*172.1*	*172.1*	*172.1*	*172.1*	*157.7*	*146.9*	*146.5*	*172.6*	*155.2*	*164.4*	*164.7*	*166.1*	*167.3*	*175.6*	*178.1*	*180.6*	*185.2*	*180.5*	*177.5*	*174.4*	*173.4*
Mountain	*154.5*	*154.5*	*154.5*	*154.5*	*154.5*	*154.5*	*154.5*	*154.5*	*154.5*	*154.5*	*140.1*	*132.0*	*134.3*	*167.8*	*146.8*	*151.6*	*153.7*	*155.5*	*156.1*	*161.0*	*163.7*	*165.3*	*167.0*	*166.2*	*165.4*	*163.0*	*162.3*

Table A.11. Carcass weight of cattle, from 1986 to 2012

kg/animal	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Switzerland	204	200	199	203	209	207	202	202	199	200	196	195	197	197	195	202	203	205	210	215	204	204	204	205	206	208	208

Table A.12. Demand elasticity for Switzerland

Change in price →

Change in quantity ↓

	Wheat	Coarse Grains	Oilseeds	Rice	Fluid milk	Mfg. milk	Beef
Wheat	**-0.400**	0.500	0.100	-0.257	0	0	0
Coarse Grains	0.580	**-1.000**	0.100	0	0	0	0
Oilseeds	0.010	0.100	**-1.000**	0	0	0	0
Rice	0	0	0.004	**-0.240**	0	0	0
Fluid milk	0	0	0	0	**-0.100**	0	0
Mfg. milk	0	0	0	0	0	**-0.275**	0
Beef	0	0	0	0	0	0	**-1.000**

Table A.13. Factor cost shares by regions

	Beef	Milk			Wheat	Coarse grains	Oil-seeds
Shares	All regions	Plain region	Hilly region	Mountain region	All regions	All regions	All regions
Farm-owned capital	0.492	0.456	0.48	0.49	0.282	0.238	0.239
Land	0.100	0.080	0.04	0.01	0.092	0.083	0.096
Cows	0.040	0.130	0.14	0.14	0.000	0.000	0.000
Hired labour	0.033	0.038	0.04	0.04	0.050	0.050	0.050
Other purchased inputs	0.168	0.094	0.098	0.10	0.166	0.225	0.171
Concentrated feeds	0.067	0.058	0.06	0.06	0.000	0.000	0.000
Chemicals	0.000	0.000	0.00	0.00	0.039	0.032	0.076
Energy	0.028	0.028	0.03	0.03	0.040	0.040	0.040
Fertiliser	0.000	0.000	0.00	0.00	0.059	0.051	0.079
Insurance	0.000	0.000	0.00	0.00	0.036	0.036	0.036
Interest	0.000	0.000	0.00	0.00	0.033	0.033	0.033
Machinery and equipment	0.073	0.116	0.12	0.12	0.203	0.212	0.180

Table A.14. Elasticity of factor substitution for Switzerland

	Among purchased inputs	Between land and other farm owned factors	Between land and purchased inputs	Between purchased and other farm owned	Between land and feed
Crops	**0.5**	**0.4**	**0.5**	**0.9**	**-**
Milk and Beef	**0.15**	**0.15**	**0.15**	**0.15**	**0.5**

Table A.15. Elasticity of factor supply for Switzerland

Purchased inputs	2
Cow	0.5
Other farm own factor	0.5

Table A.16 Coefficient of transformation between land use

	Plain region	Hilly region	Mountain region
σ1	0.05	0.05	0.05
σ2	0.107	0.093	0.137
σ3	0.33	0.33	0.33
σ4	0.33	0.33	0.33

Table A.17. Regional disaggregation of Swiss payments from 1986 to 2012

	Million CHF	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Market price support	**Switzerland**	4592.3	4541.9	4758.0	4057.9	4381.3	4363.9	3585.5	3888.0	3865.0	3145.2	3133.7	3103.1	3180.7	2985.3	2328.0	1923.2	2096.8	1865.4	2005.8	1771.2	1771.7	850.5	1209.7	1289.4	568.4	765.9	874.0
	of which wheat	*377.7*	*365.0*	*446.8*	*466.3*	*387.8*	*404.4*	*387.8*	*411.2*	*381.4*	*381.9*	*264.8*	*288.5*	*295.0*	*220.6*	*204.8*	*100.8*	*130.6*	*98.9*	*94.3*	*90.3*	*114.2*	*82.5*	*48.2*	*37.7*	*87.7*	*44.1*	*57.9*
	of which coarse grain	*218.6*	*226.6*	*315.9*	*324.2*	*269.9*	*303.3*	*260.1*	*269.0*	*217.7*	*204.9*	*145.7*	*143.4*	*159.2*	*128.8*	*131.1*	*88.3*	*100.3*	*77.2*	*86.6*	*81.8*	*74.4*	*33.8*	*8.7*	*39.7*	*41.7*	*17.9*	*25.1*
	of which oilseeds	*66.7*	*89.2*	*84.9*	*90.6*	*76.3*	*88.8*	*78.2*	*74.0*	*43.3*	*59.0*	*56.6*	*54.6*	*50.4*	*45.2*	*44.2*	*33.9*	*45.1*	*41.6*	*52.4*	*55.5*	*49.3*	*48.2*	*53.5*	*45.0*	*21.4*	*25.9*	*21.2*
	of which milk	*2593.0*	*2628.8*	*2722.9*	*1978.8*	*2363.3*	*2296.0*	*2034.1*	*2181.1*	*2124.0*	*1650.9*	*2150.9*	*2044.6*	*2096.4*	*2041.4*	*1175.6*	*1062.4*	*1242.8*	*995.0*	*991.1*	*825.1*	*771.2*	*-23.1*	*484.4*	*680.6*	*-8.9*	*229.0*	*377.9*
	of which beef	*1336.3*	*1232.2*	*1187.5*	*1198.0*	*1284.0*	*1271.4*	*825.3*	*952.7*	*1098.5*	*848.5*	*515.7*	*571.9*	*579.8*	*549.2*	*772.4*	*637.9*	*577.8*	*652.7*	*781.4*	*718.5*	*762.6*	*709.2*	*615.0*	*486.5*	*426.5*	*449.1*	*391.9*
Payments based on commodity output	**Switzerland**	42.2	42.2	42.2	42.2	45.3	44.8	55.9	57.8	61.5	63.5	87.1	99.5	116.6	260.7	330.8	380.5	363.4	349.2	331.7	330.4	341.6	289.6	295.0	279.7	289.0	292.0	298.0
	Plain region	20.3	20.3	20.3	20.3	21.8	21.5	26.9	27.8	29.6	30.5	41.9	47.8	56.0	125.3	158.9	181.7	173.3	166.0	158.1	155.8	161.8	138.2	140.8	132.5	137.2	138.7	141.1
	Hilly region	13.6	13.6	13.6	13.6	14.6	14.4	18.0	18.6	19.8	20.5	28.0	32.0	37.5	84.0	106.6	122.9	117.9	113.4	107.6	108.1	111.2	94.1	95.7	90.7	93.7	94.7	96.6
	Mountain region	8.3	8.3	8.3	8.3	8.9	8.8	11.0	11.4	12.1	12.5	17.2	19.6	23.0	51.4	65.4	75.9	72.2	69.7	66.0	66.5	68.7	57.3	58.5	56.5	58.0	58.7	60.2
Consumer support	**Switzerland**	680.7	686.4	714.9	780.4	851.9	870.9	900.4	891.0	795.1	845.8	904.8	792.5	835.1	610.3	194.9	178.5	162.0	148.1	129.4	104.3	67.9	63.2	47.6	13.3	0.0	0.0	0.0
	of which wheat	*20.8*	*22.5*	*14.6*	*23.5*	*34.3*	*10.1*	*15.2*	*20.3*	*29.7*	*25.8*	*15.3*	*17.1*	*13.3*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	of which oilseeds	*32.2*	*40.0*	*40.1*	*41.4*	*42.6*	*52.9*	*50.5*	*40.5*	*35.5*	*30.0*	*28.9*	*37.7*	*38.5*	*36.8*	*1.5*	*4.3*	*8.5*	*8.5*	*8.4*	*2.6*	*4.1*	*4.2*	*4.2*	*2.1*	*0.0*	*0.0*	*0.0*
	of which milk	*627.7*	*623.8*	*660.2*	*715.5*	*775.0*	*807.9*	*834.7*	*830.2*	*729.9*	*790.0*	*860.6*	*737.7*	*783.3*	*573.5*	*193.4*	*174.2*	*153.5*	*139.6*	*121.0*	*101.7*	*63.8*	*59.0*	*43.4*	*11.2*	*0.0*	*0.0*	*0.0*
Payments based on variable input use	**Switzerland**	47.0	46.8	46.9	47.0	47.0	68.0	68.0	67.6	66.8	69.5	70.5	68.3	68.1	68.2	68.2	68.7	68.3	68.3	67.7	67.2	67.3	67.3	65.8	67.4	67.0	67.0	67.1
	Plain region	29.8	29.8	29.8	29.9	29.8	43.2	43.2	42.9	42.4	44.1	44.8	43.4	43.3	43.3	43.5	43.2	43.3	42.9	42.7	42.5	42.7	42.5	41.4	43.2	43.0	43.4	43.1
	Hilly region	10.1	10.1	10.1	10.1	10.1	14.7	14.7	14.6	14.4	15.0	15.2	14.7	14.7	14.7	14.7	15.1	14.9	15.0	14.7	14.5	14.4	14.6	14.4	14.2	14.1	14.0	14.1
	Mountain region	7.0	7.0	7.0	7.0	7.0	10.2	10.2	10.1	10.0	10.4	10.5	10.2	10.2	10.2	10.0	10.4	10.1	10.4	10.3	10.2	10.3	10.2	9.9	10.0	9.9	9.6	9.9
Payment based on current area	**Switzerland**	20.6	20.6	20.6	20.6	0.0	0.0	13.7	35.3	28.7	22.9	18.4	24.3	23.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	of which wheat	*20.6*	*20.6*	*20.6*	*20.6*	*0.0*	*0.0*	*13.7*	*35.3*	*28.7*	*22.9*	*18.4*	*22.1*	*21.5*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	of which oilseeds	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*2.2*	*2.4*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	Plain region	17.6	17.6	17.6	17.6	0.0	0.0	11.7	30.2	24.6	19.6	15.7	20.9	20.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	of which wheat	*17.6*	*17.6*	*17.6*	*17.6*	*0.0*	*0.0*	*11.7*	*30.2*	*24.6*	*19.6*	*15.7*	*18.9*	*18.4*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	of which oilseeds	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*2.0*	*2.2*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	Hilly region	2.9	2.9	2.9	2.9	0.0	0.0	1.9	5.0	4.0	3.2	2.6	3.3	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	of which wheat	*2.9*	*2.9*	*2.9*	*2.9*	*0.0*	*0.0*	*1.9*	*5.0*	*4.0*	*3.2*	*2.6*	*3.1*	*3.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	of which oilseeds	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.2*	*0.2*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	Mountain region	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	of which wheat	*0.1*	*0.1*	*0.1*	*0.1*	*0.0*	*0.0*	*0.0*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	of which oilseeds	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Payments based on animal number	**Switzerland**	144.3	145.3	141.3	149.9	159.6	254.3	177.6	145.1	116.5	106.7	100.0	93.1	88.0														
	of which milk	*79.2*	*83.8*	*89.4*	*94.7*	*101.0*	*194.1*	*121.3*	*121.9*	*105.0*	*105.5*	*100.0*	*93.1*	*88.0*														
	of which beef	*65.1*	*61.5*	*51.9*	*55.2*	*58.6*	*60.2*	*56.3*	*23.2*	*11.5*	*1.2*	*0.0*	*0.0*	*0.0*														
	Plain region	66.2	66.9	65.4	69.4	73.9	119.3	82.7	68.6	55.5	51.2	48.1	44.8	42.3														
	of which milk	*38.1*	*40.3*	*43.0*	*45.5*	*48.6*	*93.3*	*58.3*	*58.6*	*50.5*	*50.7*	*48.1*	*44.8*	*42.3*														
	of which beef	*28.1*	*26.6*	*22.4*	*23.9*	*25.3*	*26.0*	*24.3*	*10.0*	*5.0*	*0.5*	*0.0*	*0.0*	*0.0*														
	Hilly region	44.3	44.7	43.8	46.4	49.4	79.9	55.3	46.0	37.1	34.3	32.2	30.0	28.3														
	of which milk	*25.5*	*27.0*	*28.8*	*30.5*	*32.5*	*62.5*	*39.1*	*39.3*	*33.8*	*34.0*	*32.2*	*30.0*	*28.3*														
	of which beef	*18.8*	*17.7*	*15.0*	*15.9*	*16.9*	*17.4*	*16.2*	*6.7*	*3.3*	*0.3*	*0.0*	*0.0*	*0.0*														
	Mountain region	33.8	33.7	32.1	34.1	36.3	55.1	39.6	30.5	23.9	21.1	19.7	18.4	17.3														
	of which milk	*15.6*	*16.5*	*17.6*	*18.7*	*19.9*	*38.3*	*23.9*	*24.0*	*20.7*	*20.8*	*19.7*	*18.4*	*17.3*														
	of which beef	*18.2*	*17.2*	*14.5*	*15.4*	*16.4*	*16.8*	*15.7*	*6.5*	*3.2*	*0.3*	*0.0*	*0.0*	*0.0*														
Payment based on current area paid to all crops (GCT 1)	**Switzerland**	0.0	0.0	100.7	100.8	103.8	106.7	120.4	279.2	298.6	431.2	826.3	913.5	828.6	236.5	251.1	169.1	171.1	172.3	173.3	174.3	171.9	172.9	168.3	166.2	183.3	181.3	184.3
	Plain region	0.0	0.0	17.8	17.8	18.4	18.9	21.3	65.7	68.3	96.3	180.1	193.0	171.7	41.9	46.8	36.6	36.8	37.9	39.1	40.5	41.1	46.9	46.0	48.4	53.4	53.1	54.0
	Hilly region	0.0	0.0	25.3	25.3	26.1	26.8	30.2	75.6	80.2	115.0	218.9	239.9	216.5	59.4	62.7	46.1	47.6	47.6	47.9	48.3	47.6	48.9	47.6	49.7	54.6	54.1	55.0
	Mountain region	0.0	0.0	57.6	57.7	59.3	61.0	68.8	137.9	150.1	219.9	427.4	480.6	440.4	135.2	141.6	86.4	86.8	86.7	86.3	85.5	83.3	77.1	74.6	68.1	75.3	74.1	75.3
Payment based on current area paid to all cereals (GCT 3)	**Switzerland**	138.8	143.9	168.2	181.5	180.4	172.4	120.5	84.4	92.8	80.9	73.8	75.0	73.8	48.9	25.0	0.2											
	Plain region	108.3	112.3	131.2	141.6	140.7	134.5	94.0	65.8	72.4	63.1	57.6	58.5	57.6	38.1	19.7	0.2											
	Hilly region	26.3	27.2	31.8	34.3	34.1	32.6	22.8	16.0	17.6	15.3	14.0	14.2	14.0	9.3	4.5	0.0											
	Mountain region	4.3	4.4	5.2	5.6	5.5	5.3	3.7	2.6	2.8	2.5	2.3	2.3	2.3	1.5	0.7	0.0											
Payment based on current animal numbers paid to all livestock (GCT 8)	**Switzerland**														510.5	510.1	518.6	453.6	453.7	447.4	449.1	447.6	528.8	682.7	862.1	864.6	860.6	854.9
	Plain region														91.4	95.0	52.1	59.3	60.3	59.1	59.1	59.6	71.9	72.7	92.3	92.3	99.0	104.1
	Hilly region														160.5	158.4	168.8	181.8	182.1	180.5	182.2	181.8	214.8	214.8	270.3	270.2	268.2	264.6
	Mountain region														258.5	256.7	297.7	212.6	211.4	207.7	207.8	206.1	242.1	395.2	499.5	502.1	493.4	486.2
Payments based on current revenue or income	**Switzerland**	70.3	69.5	70.6	82.1	95.1	102.5	106.5	92.2	85.8	84.3	77.3	72.9	74.7	76.9	81.8	87.9	91.6	95.5	99.7	102.8	106.2	108.9	111.3	113.4	115.7	116.3	10.1
	Plain region	44.7	44.2	44.9	52.2	60.4	65.1	67.7	58.6	54.5	53.6	49.1	46.3	47.4	48.8	52.1	55.3	58.1	60.0	62.8	65.0	67.3	68.8	70.1	72.6	74.3	75.3	6.5
	Hilly region	15.2	15.0	15.2	17.7	20.5	22.1	23.0	19.9	18.5	18.2	16.7	15.7	16.1	16.6	17.7	19.3	19.9	21.0	21.7	22.2	22.6	23.7	24.4	23.9	24.4	24.3	2.1
	Mountain region	10.5	10.4	10.5	12.3	14.2	15.3	15.9	13.8	12.8	12.6	11.5	10.9	11.1	11.5	12.0	13.3	13.6	14.5	15.2	15.6	16.2	16.5	16.8	16.9	17.0	16.6	1.5
Payment based on historical area	**Switzerland**	26.2	26.1	30.4	31.2	33.8	34.2	34.5	429.7	556.5	557.9	574.2	574.8	573.6	1230.7	1268.0	1384.4	1406.2	1409.4	1409.1	1411.2	1411.0	1374.4	1292.6	1323.5	1322.5	1319.1	1289.3
	Plain region	8.6	8.6	10.0	10.3	11.1	11.2	11.3	197.1	254.3	254.8	260.1	260.1	259.5	567.4	579.6	670.0	679.5	680.3	680.9	682.9	683.6	672.7	634.6	669.7	668.2	665.8	654.4
	Hilly region	7.9	7.9	9.2	9.4	10.2	10.3	10.4	112.2	145.6	146.1	151.0	151.2	150.9	320.5	330.0	350.2	354.9	354.7	354.2	354.4	353.2	341.4	320.1	322.0	322.0	321.4	315.5
	Mountain region	9.7	9.6	11.2	11.5	12.5	12.6	12.7	120.4	156.5	157.0	163.1	163.5	163.2	342.8	358.4	364.2	371.8	374.5	374.0	373.9	374.2	360.3	337.9	331.7	332.3	331.9	319.4

Table A.18. Regional disaggregation of Swiss payments under AP 2014-17

		2012	2014	2015	2016	2017
Market price support		874.0	874.0	874.0	874.0	874.0
Payments based on commodity output		298.0	298.0	298.0	298.0	298.0
Payments based on variable input use		67.1	67.1	67.1	67.1	67.1
Payment based on current area paid to all crops (GCT 1)	All region	184.3	555.1	596.9	610.7	662.5
	Plain region	54.0	157.8	183.9	190.4	214.2
	Hilly region	55.0	138.7	148.3	152.3	164.1
	Mountain region	75.3	258.6	264.6	268.0	284.2
Payment based on current animal numbers paid to all livestock (GCT 8)	All region	854.9	17.5	17.8	18.1	18.3
	Plain region	104.1	9.4	9.6	9.8	9.9
	Hilly region	264.6	4.1	4.2	4.3	4.3
	Mountain region	486.2	3.9	4.0	4.1	4.1
Payments based on current revenue or income	All region	10.1	10.1	10.1	10.1	10.1
	Plain region	6.5	6.5	6.5	6.5	6.5
	Hilly region	2.1	2.1	2.1	2.1	2.1
	Mountain region	1.5	1.5	1.5	1.5	1.5
Payments based on historical area	All region	1289.3	1362.2	1235.7	1180.6	1096.4
	Plain region	654.4	620.9	563.7	538.9	501.2
	Hilly region	315.5	361.9	328.0	313.1	290.4
	Mountain region	319.4	379.3	344.0	328.5	304.8
Payments based on pasture	All region	0.0	350.8	356.1	361.4	366.7
	Plain region	0.0	47.9	49.6	51.4	53.1
	Hilly region	0.0	112.7	114.3	116.0	117.6
	Mountain region	0.0	190.2	192.1	194.1	196.0
Total		3577.7	3534.7	3455.6	3420.0	3393.2

Table A.19. Inorganic fertiliser price and nutrient share

Fertiliser	Price (CHF/kg)	Cost (CHF/ha)	Nutrient share
Nitrogen (N)	1.77	265	0.68
Phosphorous (P)	3.76	94	0.24
K2O	1.11	8	0.02
Mg	2.65	22	0.06
Total		389	1.00

Table A.20. Price index of purchased inputs

Input	1993-98	1999-03	2004-07	2008-12
Fertilisers	74	72	79	109
Pesticides	111	104	103	99

(December 2010=100)

Table A.21. Nitrogen uptakes of main crops (Kg N / Kg crop)

Land use	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Wheat	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Coarse	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Oilseeds	28	28	28	28	28	28	29	29	30	29	29	30	30	31	29	28	30	30	30	29	28	28	28	28	28	28	28

Table A.22. Nitrogen uptakes of other crops and pastures (Kg N / ha)

Region	Land use	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Plain region	Arable land	190	190	190	190	190	190	190	190	190	190	187	188	188	191	190	187	184	187	188	189	190	193	193	192	190	191	192
	Other land	92	92	92	92	92	92	92	92	92	92	92	92	92	66	66	67	67	67	68	67	67	68	68	68	68	68	69
	Pastures	206	206	206	206	206	206	206	206	206	206	211	208	205	201	200	200	200	201	201	199	199	200	201	201	201	201	200
Hilly region	Arable land	169	169	169	169	169	169	169	169	169	169	170	174	172	172	170	167	164	167	168	168	169	170	170	171	169	170	170
	Other land	92	92	92	92	92	92	92	92	92	92	92	92	92	75	76	77	77	76	77	77	77	78	79	79	79	80	81
	Pastures	158	158	158	158	158	158	158	158	158	158	162	162	161	160	159	160	160	160	160	160	160	161	160	160	160	160	159
Mountain region	Pastures	90	90	90	90	90	90	90	90	90	90	92	92	91	91	91	91	91	91	91	90	90	90	90	90	90	89	89

Table A.23. Fertiliser use on other crops and pastures (Kg N / ha)

Region	Land use	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Plain region	Arable land	104	104	104	104	104	104	104	104	104	104	100	97	97	98	99	98	96	95	96	96	96	96	97	99	99	99	99
	Other land	50	50	50	50	50	50	50	50	50	50	50	50	50	54	54	54	54	53	53	53	53	53	53	53	53	53	53
	Pastures	24	24	24	24	24	24	24	24	24	24	27	28	27	28	28	28	28	29	30	29	29	30	30	31	32	32	32
Hilly region	Arable land	104	104	104	104	104	104	104	104	104	104	102	101	100	101	101	100	99	99	100	100	100	100	101	102	102	102	102
	Other land	50	50	50	50	50	50	50	50	50	50	50	50	50	52	52	52	52	52	52	52	52	52	52	52	52	52	52
	Pastures	13	13	13	13	13	13	13	13	13	13	16	17	17	17	17	18	18	18	18	18	18	19	19	20	20	20	20
Mountain region	Pastures	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Table A.24. Biological fixation of nitrogen by leguminous (Kg N / ha)

Region	Land use	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Plain region	Oilseeds	9	9	9	9	9	9	9	9	9	9	15	17	20	16	7	3	11	15	15	9	7	6	6	6	6	6	6
	Arable land	4	4	4	4	4	4	4	4	4	4	4	6	5	5	5	6	7	10	9	10	11	10	8	7	7	7	7
	Pastures	56	56	56	56	56	56	56	56	56	56	59	59	58	57	57	57	57	58	58	57	57	58	58	59	59	59	59
Hilly region	Oilseeds	4	4	4	4	4	4	4	4	4	4	4	5	5	3	2	1	2	4	4	3	2	1	1	2	2	2	2
	Arable land	2	2	2	2	2	2	2	2	2	2	3	4	4	4	5	4	6	8	6	6	7	6	5	5	4	4	4
	Pastures	40	40	40	40	40	40	40	40	40	40	42	42	42	42	42	42	42	43	43	42	43	43	43	43	43	43	43
Mountain region	Pastures	21	21	21	21	21	21	21	21	21	21	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	21	21

Table A.25. Atmospheric deposition of nitrogen (Kg N / ha)

Region	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Plain region	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Hilly region	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Mountain region	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Table A.26. Excretion and GHG emission factors: Beef cattle

Factor	Unit	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Manure nitrogen excretions	Kg N per head	33.6	33.6	33.6	33.6	33.6	33.7	34.0	34.0	34.2	34.4	34.6	35.1	35.1	35.5	35.8	35.8	36.2	36.5	36.9	37.2	37.7	37.9	38.1	38.4	38.7	38.7	38.7
Manure phosphorous excretions	Kg P per head	4.8	4.8	4.8	4.8	4.8	4.9	4.9	4.9	4.9	5.0	5.0	5.1	5.1	5.2	5.3	5.3	5.3	5.4	5.5	5.5	5.5	5.6	5.6	5.6	5.7	5.7	5.7
Methane from enteric fermentation	Kg CH4 per head	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.3	35.5	35.7	35.4	35.5	35.1	36.4	37.2	36.9	37.2	37.4	37.6	38.0	38.6	38.8	39.0	39.2	39.3	39.3	39.5
Methane from manure management	Kg CH4 per head	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.5	4.4	4.4	4.3	4.6	4.5	4.4	4.4	4.5	4.6	4.8	4.9	5.0	5.0	5.1	5.1	5.1	5.1
Nitrous oxide from manure management	kg N2O/kg N	0.0121	0.0121	0.0121	0.0121	0.0121	0.0121	0.0120	0.0120	0.0120	0.0119	0.0116	0.0113	0.0111	0.0108	0.0103	0.0100	0.0097	0.0095	0.0095	0.0093	0.0092	0.0091	0.0091	0.0090	0.0090	0.0090	0.0090

Table A.27. Excretions and GHG emissions from other livestock

Production (1000 Tons)	Region	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Manure nitrogen excretions (N)	Plain region	22.5	22.5	22.5	22.5	22.5	22.5	22.3	22.2	22.1	21.8	17.2	17.7	18.2	18.3	18.2	17.8	17.9	17.6	18.1	18.5	18.7	18.3	18.2	18.5	19.1	18.8	18.8
	Hilly region	10.6	10.6	10.6	10.6	10.6	10.6	10.5	10.5	10.5	10.3	8.5	8.8	8.9	8.8	8.9	9.0	8.9	8.9	8.8	9.3	9.1	9.1	9.0	9.0	9.2	9.3	9.0
	Mountain region	5.4	5.4	5.4	5.4	5.4	5.4	5.3	5.3	5.4	5.3	4.7	4.9	5.1	5.9	5.9	5.8	5.8	5.9	5.7	5.9	5.8	5.6	5.7	5.7	5.7	5.5	5.4
Manure phosphorous excretions (P)	Plain region	5.6	5.6	5.6	5.6	5.6	5.5	5.4	5.3	5.2	5.1	4.1	4.2	4.3	4.5	4.5	4.5	4.6	4.6	4.8	4.9	5.0	4.9	4.9	4.9	5.1	5.0	5.0
	Hilly region	2.9	2.9	2.9	2.9	2.9	2.8	2.8	2.7	2.7	2.6	2.2	2.3	2.3	2.4	2.4	2.5	2.5	2.5	2.5	2.7	2.7	2.7	2.6	2.6	2.7	2.7	2.6
	Mountain region	2.2	2.2	2.2	2.2	2.2	2.2	2.1	2.1	2.1	2.1	2.0	2.1	2.1	2.3	2.2	2.2	2.3	2.3	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.1	2.1
Methane from enteric fermentation (CH4)	Plain region	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.4	3.7	3.1	3.2	3.2	3.4	3.4	3.5	3.5	3.6	3.7	3.7	3.8	3.8	3.8	3.7	3.9	3.8	3.7
	Hilly region	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.1	2.2	2.0	2.0	2.1	2.1	2.1	2.2	2.3	2.3	2.3	2.4	2.4	2.4	2.4	2.3	2.4	2.4	2.3
	Mountain region	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.7	2.8	2.8	2.8	2.9	3.0	2.9	3.0	3.0	3.0	3.1	3.1	2.9	2.9	3.0	2.9	2.9	2.9	2.9
Methane from manure management (CH4)	Plain region	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	5.4	5.5	5.8	5.8	6.0	6.1	6.2	6.1	6.3	6.5	6.6	6.4	6.3	6.4	6.5	6.5	6.4
	Hilly region	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	2.5	2.6	2.7	2.6	2.7	2.8	2.8	2.8	2.8	2.9	2.9	2.9	2.8	2.8	2.9	2.9	2.8
	Mountain region	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Nitrous oxide from manure management (N2O)	Plain region	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.16	0.17	0.16	0.17	0.17	0.18	0.18	0.18	0.19	0.19	0.19	0.20	0.20	0.20
	Hilly region	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
	Mountain region	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09

Table A.28. Fractions of nitrogen

Fraction	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Fraction of synthetic fertilizer N applied to soils that volatilizes as NH3 and NOx	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Fraction of livestock N excretion that volatilizes as NH3 and NOx	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.33	0.32	0.32	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Fraction of livestock N excreted and deposited onto soil during grazing	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.12	0.13	0.14	0.15	0.17	0.18	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Fraction of N input to soils that is lost through leaching and run-off	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

Table A.29. Nitrous oxide emission factors

Emission factor	Kg N2O-N / kg N	Kg N2O / kg N
N input from application of inorganic fertilisers	0.0125	0.0196
N input from manure applied to soils	0.0125	0.0196
N fixed by N-fixing crops	0.0125	0.0196
N in crop residues returned to soils	0.0125	0.0196
N excretion on pasture range and paddock	0.0200	0.0314
N from atmospheric deposition	0.0100	0.0157
N from fertilisers, animal manures and other that	0.0250	0.0393