Reading Material for Training Session

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Version Star 2.4, September 2019

Content

Introduction

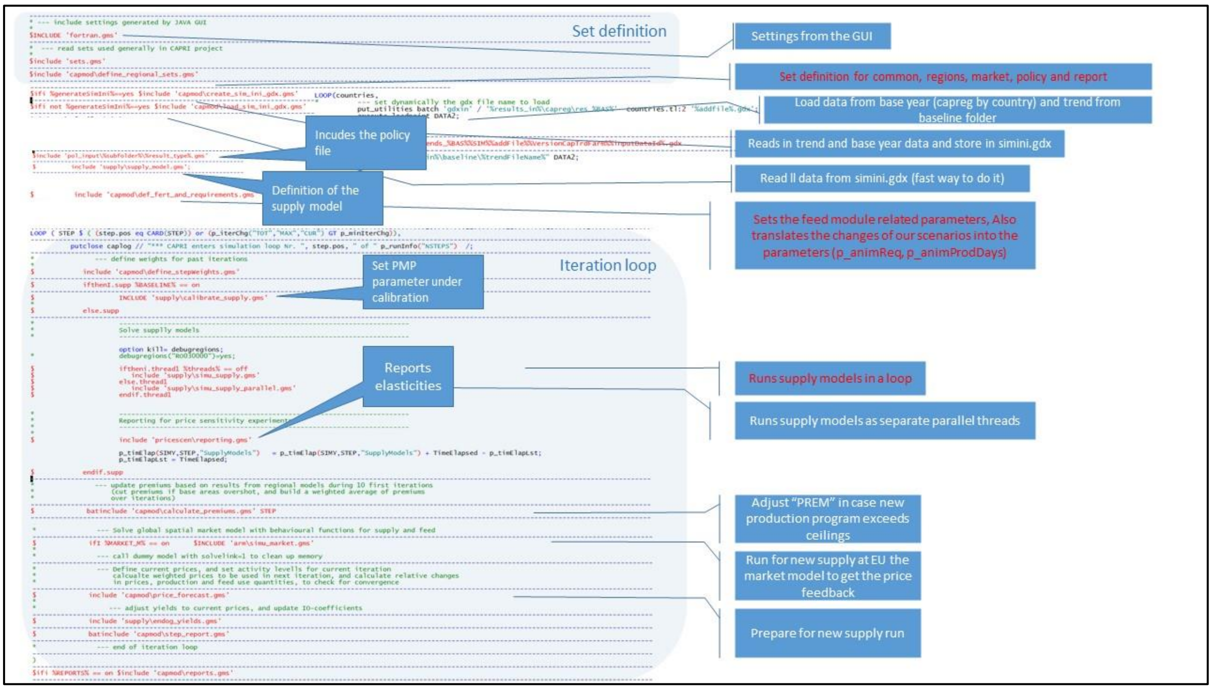
The aim of this document is to present the core supply model in CAPRI. Before we introduce the objective function and the restrictions, or equations, we shortly present the structure of the capmod.gms file as it is running when the simulation task "" is selected. Afterwards the structure of the objective function in CAPRI as well as important parameters, variables and equations are described. In the next part important modules in the supply model are shown and exemplified by different scenarios[1]. The last part demonstrates how scenarios can be defined and examples are shown to improve the understanding of the computation of scenarios in CAPRI.

The supply model in CAPRI

In figure 1 the most important sections and key files of '\gams\capmod.gms' are depicted. In general there are two options to run capmod.gms, with and without the market model which can be selected in the GUI. First the settings from the GUI ($include 'fortran.gms') and the sets ($include 'sets.gms'; 'capmod\define_regional_sets.gms') are included.

[1] In order run all the scenarios with the policy editor in the GUI correctly, the user has to download and use the recent trunk version of CAPRI.

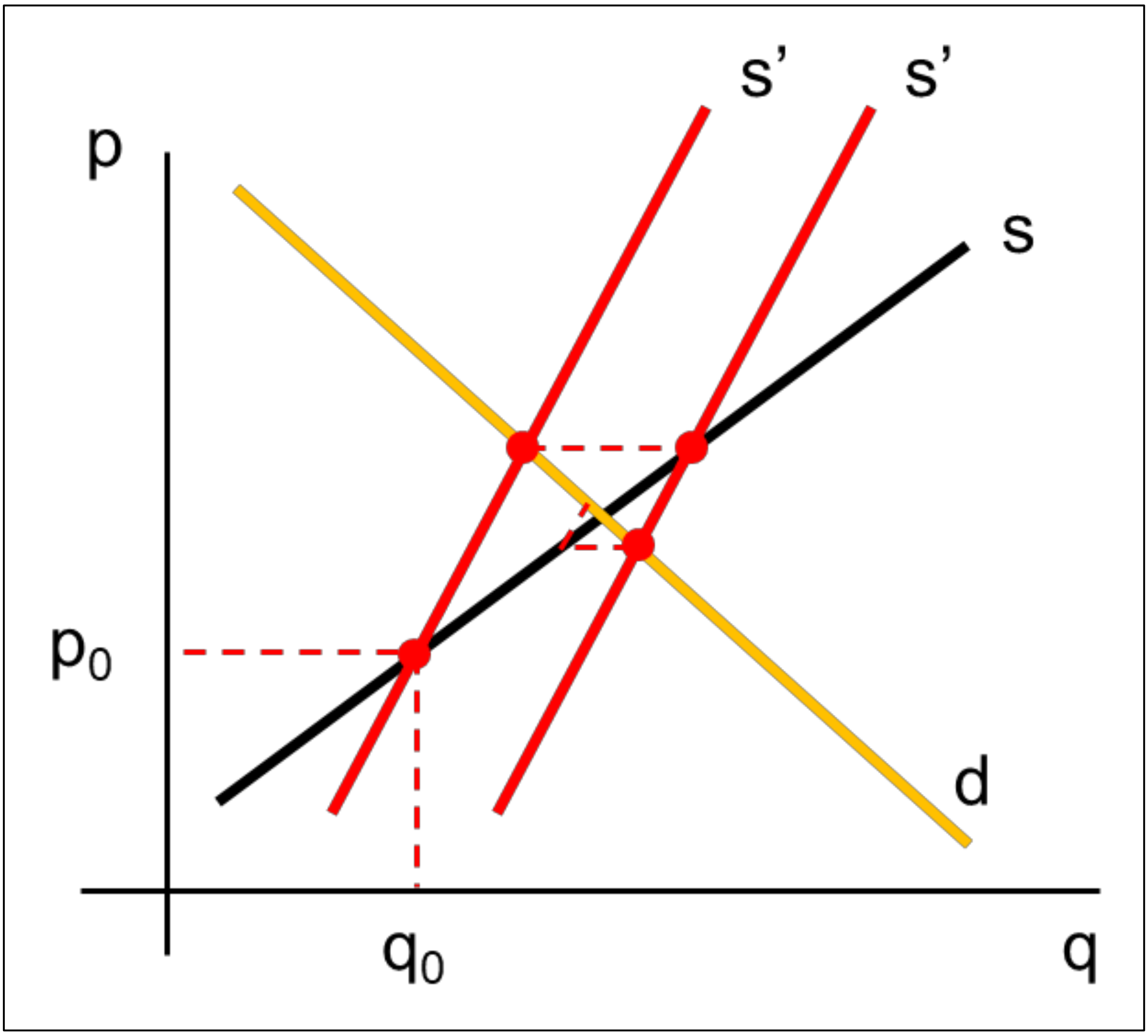
Figure 1: Structure of the capmod.gms during task run simulation with and without market model



Then the data from the base year by country and the trends from the baseline folder are loaded and stored in 'simini.gdx'. Afterwards the policy file, the definition of the supply model ($include 'supply\supply_model.gms') are included and the feed module related parameters are set ($in-clude 'capmod\def_fert_and_requirements.gms').In the iteration loop the PMP parameters under calibration and the reporting of elasticities are included. If the market model is activated in the GUI (ifi %MARKET_M% = on) there is a run for the new supply ($include 'arm\simu_market.gms') to get the price feedback from the market model which is further explained in figure 2.

As CAPRI is a comparative static equilibrium model and the supply models are solved independently at fixed prices, the link between the supply and market modules is based on an iterative procedure (see figure 2). The supply function of FT models is unknown (black). First any supply function can be assumed (red). Starting with some price, the supply is simulated with models and the assumed supply function is calibrated to that point. Then the supply and demand in the market model is solved simultaneously for a new price. After each iteration, during which the supply module works with fixed prices, the constant terms of the behavioural functions for supply and feed demand are calibrated to the results of the regional aggregate programming models aggregated to Member State level. Solving the market modules then delivers new prices. A weighted average of the prices from past iterations then defines the prices used in the next itera-tion of the supply module. This is repeated until convergence is achieved.

Figure 2: Comparative Static equilibrium in CAPRI



The most important parameters and model variables in the supply model are shown and described in figure 3.

Figure 3: Parameters and variables of the supply model in CAPRI

```
$include 'supply\def_supply_model_par.gms';

 @purpose  : Define sets, parameters, variables etc. used in supply model
-------------------------------------------------------------------------------------------
   PARAMETER

-------------------------------------------------------------------------------------------
   p_linObjeCont(RALL,PACT,A)               "Costs and revenues for activities not covered by constraints"
   p_nitrBalance(*,*)                       "Nitrogen balance parameter"
   p_nitrFact                               "Nitrogen balance parameter"
   p_NVZshare(Rall,*)                       "Shares of NVZ area in total and implementation shares for balanced fertilisation"

   p_maxFeedShare(RALL,PACT,A,FEED %addtimedim_ast%)       "Maximum shares dry matter intake for each feedingstuff"
   p_minFeedShare(RALL,PACT,A,FEED %addtimedim_ast%)       "Minimum shares dry matter intake for each feedingstuff"
   p_animProdDays                           "Days per year in production system for animal activities"

   p_minShareMinFert(RALL,PACT,*,FNUT)      "Minimum share of mineral on total fertilizer input"
   p_maxShareMinFert(RALL,PACT,*,FNUT)      "Maximum share of mineral on total fertilizer input"
   p_nutContCropOutput(O,FNUT)              "Nutrient retention from harvested material"

   p_feedQuant(*,* %addtimedim_ast%)                        "Ammount of feed use in current aggregate to trim"

TJ TREND
   p_PMPStep1                               "If set to 1, allow LEVL.up = LEVL.lo in first PMP step"


   p_pmpCnst(RALL,COLS,A)                   "PMP parameter for linear own area cost effect"
   p_pmpQuadPact(RALL,COLS,COLS)            "PMP parameter for cross-crop-groups quadratic PMP effects"
   p_pmpQuadLandTypes(RALL,COLS,COLS)       "PMP parameter for land markets"
   p_pmpQuadTechn(RALL,COLS,A,A)            "PMP parameter for own area v_sumOfPmpTermsLevlstic cost effect"
-------------------------------------------------------------------------------------------
                     model variables
-------------------------------------------------------------------------------------------
   VARIABLES

      v_obje                                 "Objective value"
      v_actLevl(RALL,COLS,*)                 "Level of production activities in 1000 ha or 1000 heads"
-------------------------------------------------------------------------------------------
      v_youngAnimUse(RALL,OM)                "Intrasectoral use of young animals in 1000 heads"
      v_feedQuantReg(RALL,* %addtimedim_ast%)            "Regional feed use in 1000 t per year and herd"
      v_feedInpCoeff(RALL,MAACT,A,* %addtimedim_ast%)    "Feeding per head and year in kg"
      v_pmpCostFeedPerAnim(RALL,MAACT,A)     "Per unit PMP feed cost"
      v_netPutQuant(RALL,*)                  "Selling and buying activities in 1000 t"

      v_lossQuant(RALL,ROWS %addtimedim_ast%)            "Losses of straw and organic fertiliser in 1000 t"
      v_nutAvailFactExcr(RALL,FOUT,A)        "Nutrient availability factor in manure"
      v_nutAvailFactCRes(RALL,FOUT,A)        "Nutrient availability factor for crop residues"
      v_cropNutNeedMultFact(RALL,FNUT,*)     "Multiplative Nutrient need factor for crops, per region and technology"
      v_cropNutNeedAddFact(RALL,FNUT)        "Constant nutrient need factor for crops, per region"

      v_animReq (RALL,*,A,* %addtimedim_ast%)            "Requirements per head and day"
      v_linObjePart(RALL)                    "Linear part of objective"
      v_sumOfPmpTermsLevls                   "Objective contribution of PMP terms activities"
      v_sumOfPmpTermsFeed                    "Objective contribution of PMP terms feeding"
      v_pmpCostLandMarket                    "Objective contribution of land market"
      v_landSupCost(RALL)                    "Cost for supplying land to agriculture"
      v_labCap(RALL)

      v_CO2EquEmis(RALL,*)                   "Global warming emissions"
      v_nutSurPlus(Rall,Fnut)                "Nutrient surpluses in 1000 tons"
      v_minShareMinFertCorr(RALL,NGRP,FNUT)  "Correction of minimum application rates of mineral fertilizer"

      v_fertDist(RALL,*,FNUT,*)              "Distribution of organic and mineral N to groups of crops"
      v_ManureNPK(RALL,*)                    "Total N,P,K at tail net of gaseous losses"

      v_watUse(RALL,*)                       "Regional water use in 1000 m3"
      v_watCos(RALL,*)                       "Regional water cost in 1000 euros"

      v_SIGMSugb(RALL,A)                     "Sales multiplied with VCOEF (??)"
      v_cdfSugb(RALL,A,Qut_A_AB)             "Cummulative probability for the production to be lower then A or A+B quotas"
      v_pdfSugb(RALL,A,Qut_A_AB)             "point probability for production being equal to A res. A+B quota"
      v_sugbRev(RALL,A)                      "Revenues from sugar beet A,B,C sales"
      v_salesSugb(RALL,A)                    "Sugar beet sales per technology"
      v_fixCosts(RALL)                       "Fix costs and premiums to generate compensated supply response"

      v_nonfSlack(RALL,A)                    "Slack which allows to turn non-food into a unequality"
      v_corfSetr(RALL)                       "Correction factor to render set-aside binding"
```

In figure 4 the linear part of the model including the equations (constraints) for animal feed requirements (feeding block, see table 1), the constraints relating to fertilisation such as the nutrient need balance for group of crops (NUTNED_), minimum use of mineral fertilizer (NUTMIN_), distribution of total nutrients from crop residues and atmospheric deposition to crop groups (fertDistCres), distribution of mineral fertilizer to crop groups (fertDistMine_), distribution of nutrients from manure to crop groups (fertDistExcr_) and the total manure output of animals (ManureNPK_). In addition constraints relating to the cost function and set-aside are included.

Figure 4: Linear part of the supply model in CAPRI

```
    MODEL m_capMod/LINEAR_,OBJEQF_,
                SUPBAL_,INPANI_,
*
*     --- feeding block
*
                REQSE_,REQSN_,
                MAXSHR_,MINSHR_,
                FEDUSE_,
*
*     --- fertilization block
*
                NUTNED_,NUTMIN_,
                fertDistExcr_,
                fertDistMine_,
                fertDistCres_,
                ManureNPK_,
*
*     --- cost function
*
                GRPLEVL_,QUADRA_
------------------------------------------------------------------
*     --- set-aside
*
                SETA_
                SETAN_
                MXSETA_
                NONF_
                sumEntl_
                overShotEntl_
                greenOverShot_
------------------------------------------------------------------
                fixTechfShares_
------------------------------------------------------------------
                nGrpLevl_,
                nMax_,
                lsDensMax_,
------------------------------------------------------------------
                SalesSugb_,SIGMSugb_,cdfSugb_,pdfSugb_,SugbRev_,
                netPutQuantSugb_
                winterCover_
                ecoSetAside_
                cropDivGreening_
                /;
*
```

In Figure 5 the non-linear part (PMP) of the supply model is depicted. The non-linear cost function allows for a calibration of the models and a smooth simulation response rooted in observed behaviour. Here the cost function terms for feeding including the PMP per feed and head (QUADRF) and PMP for feed use per region, activity and technology (QUADRF_1) as well as for the land market (LandMarket_), land balance (LandBal_) and a non-linear cost function which captures the effects of labour and capital on farmers' decisions (labCap_) are included.

Figure 5: Non-linear part of the supply model in CAPRI

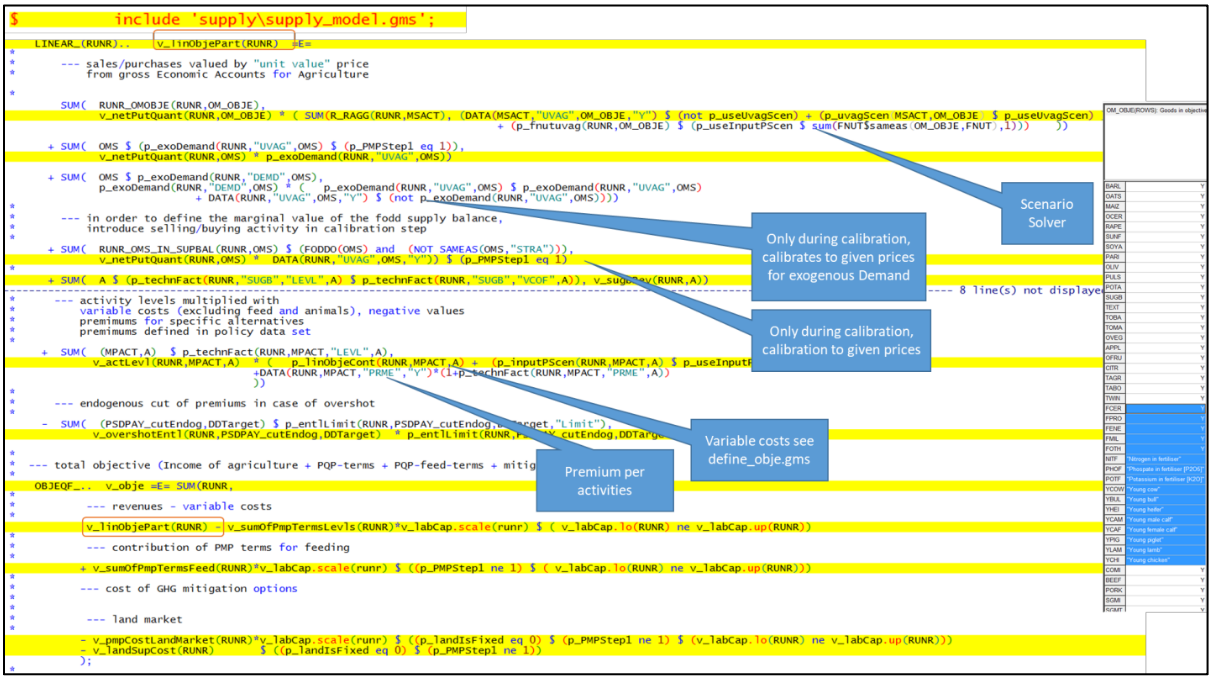
```
* ---------- same model as m_capMod, with pmp s and land constraint included ---------------------
*
*

    MODEL m_capModQ/m_capMod,
*                   --- add the cost function terms for feeding
                    QUADRF_
                    QUADRF1_
*                   --- add the obligatory set-aside constraints, missing in calibration to obtain expert dual
*                   --- add land balances, missing in calibration to obtain expert dual
                    LandMarket_
                    LandBal_
                    labCap_
                    e_uaar
                    e_asym
                    e_landSupCost
                    permGrasGreening_
----------------------------------------------------------------------------------------------------
                     /;
```

Objective function in the supply model of CAPRI

The supply side models of the CAPRI simulation tool are programming models with an objective function. In general there are two sources for interactions between activities in simulation: the objective function and constraints. In CAPRI, the objective function does solve interactivity terms for groups of arable crops, so that the major interplay is due to constraints.

The objective function is split up into the linear part and the one relating to the quadratic cost function for activities and the quadratic cost function relating to the feed mix costs. The linear part (LINEAR_) comprises the revenues from sales and the costs of purchases valued by "unit value" price from EAA, minus the variable costs of allocated inputs not explicitly covered by constraints (i.e. all inputs with the exemptions of fertilisers, feed and young animals) plus premiums and minus endogenous cut of premiums in case of overshot of entitlements. The objective function (OBJEQF_) sums up the linear and quadratic costs for activities. The target variable is v_obje in OBJEQF_.

Figure 6: Objective function in the supply module



In Table 1 detailed information about the relevant equations, variables and parameters or scalars needed to understand the working principle of the objective function is provided. The exact meaning of the abrevations in this table is shown in figure 3.

Table 1: Equations, variables and paramters or scalars for the objective function and the feeding block in CAPRI

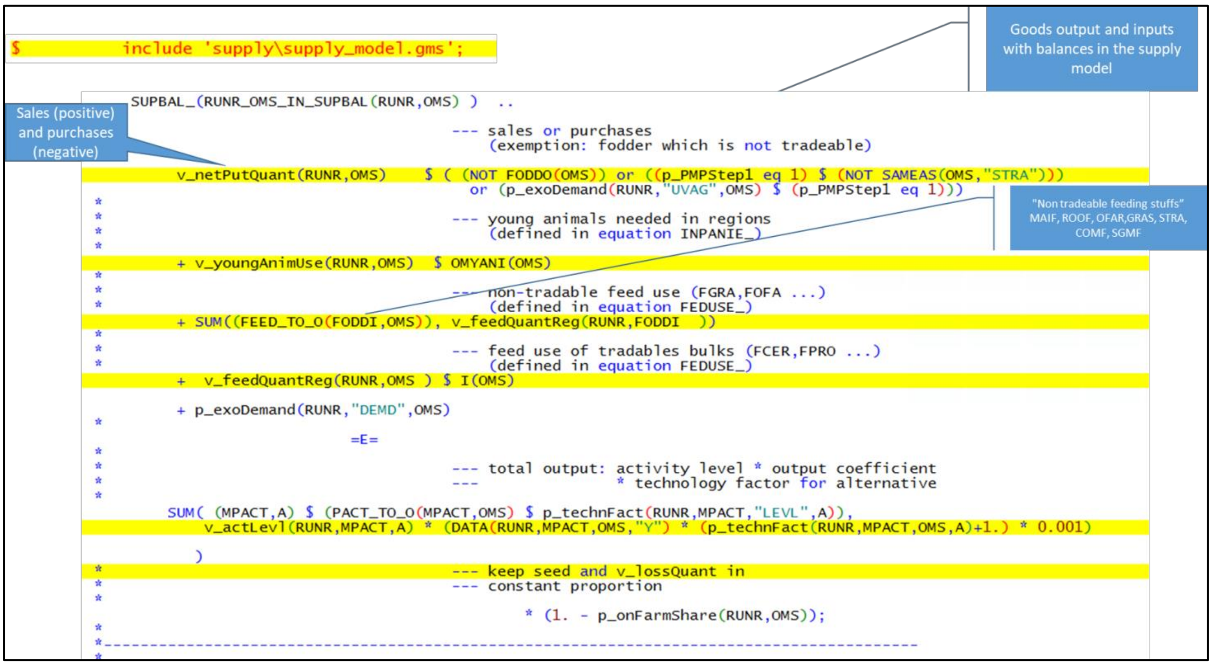
Area	Equations	Variables	Parameters or scalars
Objective Function	LINEAR_,	v_linObjePart v_overshotEntl v_actLevl v_netPutQuant	Premium: DATA(RUNR,MPACT,"PRME","Y") Premium loss when overshot: p_entlLimit(RUNR,PSDPAY_cutEndog, DDTarget,"Cut") Price: DATA(MSACT,"UVAG",OM_OBJE,"Y") Switch for scenario solver: p_useUvagScen:
	OBJEQF_	v_linObjePart v_sumOfPmpTermsLevls v_labCap v_sumOfPmpTermsFeed v_pmpCostLandMarket v_landSupCost	

Important modules in the supply model exemplified by different scenarios

Supply balance

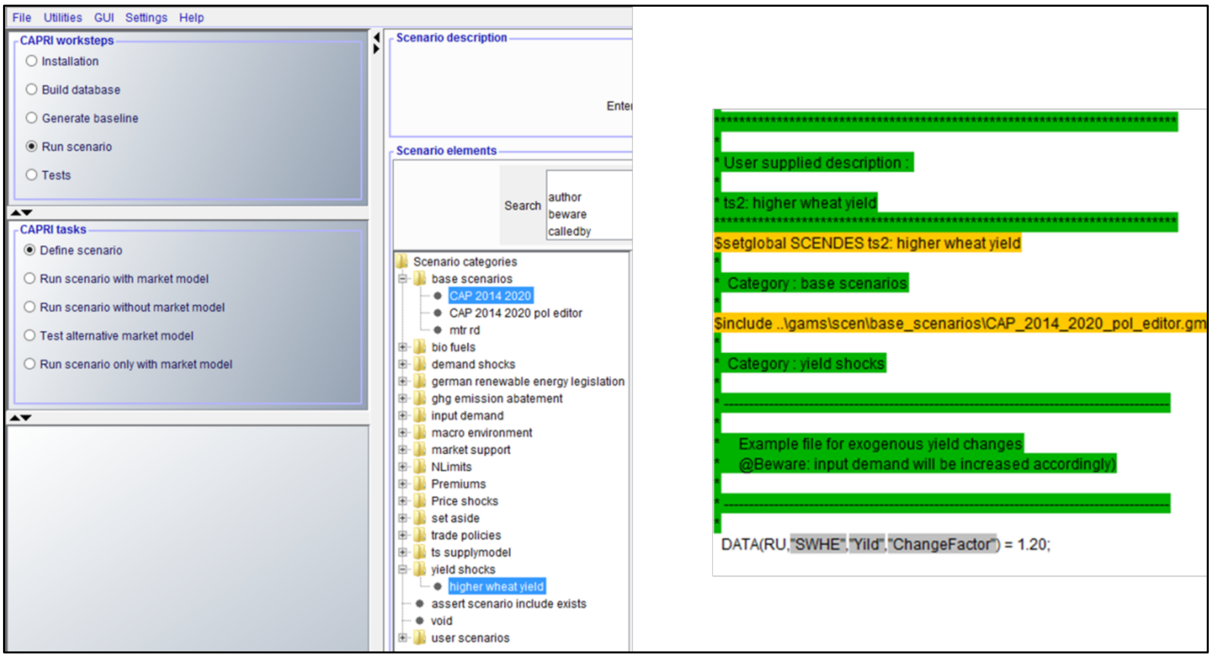
One important module in CAPRI is the supply balance for final outputs. Here the sales and purchases (v_netPutQuant) plus the young animals needed in the regions, the tradeable and non-tradeable feeding stuffs and exogenous demand (e.g. bio energy production) have to be equal to the total output which is calculated by multiplying the activity level with the output coefficient and the technology factor (see figure 7).

Figure 7: Supply balance for final outputs in CAPRI



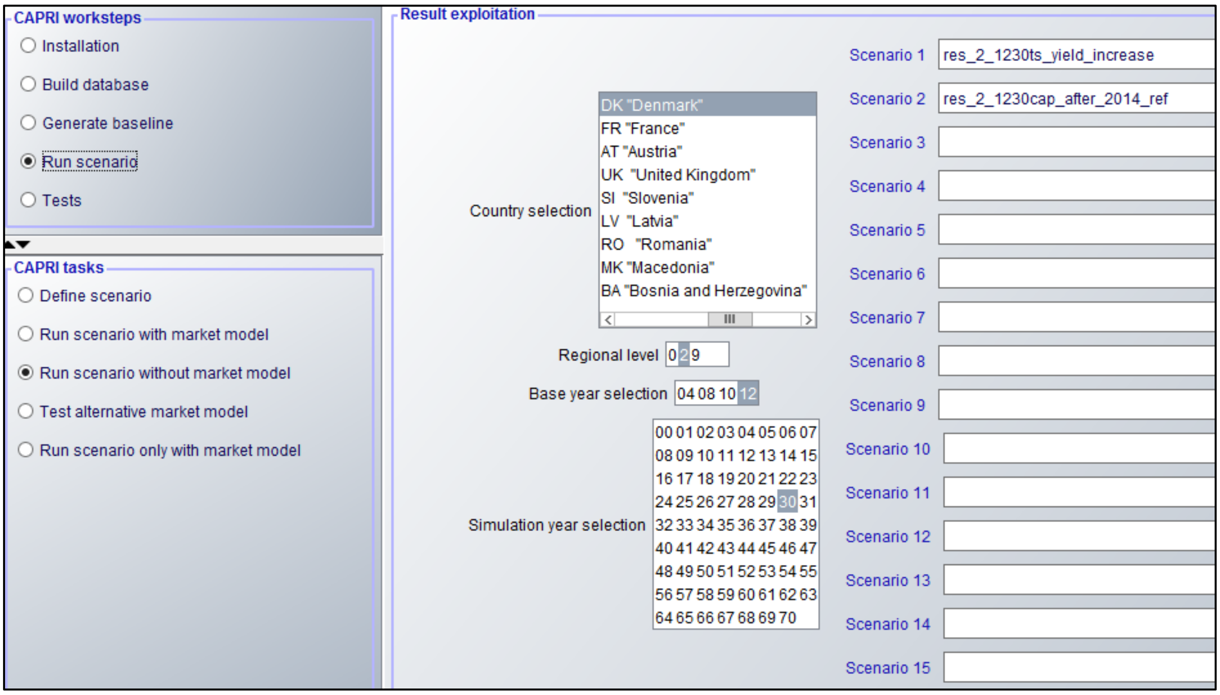
One possible scenario relating to the supply balance for final outputs is to modify the yield for a specific production activity. This can be done by modifying the parameter DATA(RUNR,MPACT,OMS,"Y") (see figure 7 and table 2). Here an increase of wheat yield about 20% is simulated Data(RU,"SWHE","Yild",ChangeFactor")=1.20;) which shown in figure 8.

Figure 8: Scenario – Wheat yield increase by 20%



Using the exploiter in the GUI (see figure 9) the results of the scenario (res_2_1230useScens_ts2) can now be compared to the baseline (re_2_1230userScens_nochange).

Figure 9: Selection of baseline scenario (nochange) and yield increase scenario (ts2)



Looking at the results in the CAPRI exploiter (see figure 10) shows that the yield increase about 10% for cereals Denmark and a resulting higher income for this crop group.

Figure 10: Yield an income changes for wheat yield increase by 20%

Supply details [0] — Region: Denmark — Year: 2030

	ts_yield_increase			cap_after_2014_ref		
	Income [Euro/ha or head]	Hectares or herd size [1000 ha or hds]	Yield [kg, Const EU or 1/1000 head/ha]	Income [Euro/ha or head]	Hectares or herd size [1000 ha or hds]	Yield [kg, Const EU or 1/1000 head/ha]
Cereals	-206.08 1.54%	1250.20 -0.47%	1180.79 7.17%	-209.31	1256.13	1101.84
Soft wheat	-327.95 1.15%	429.81 -3.39%	8776.77 18.52%	-331.77	444.87	7405.09
Oilseeds	-238.06 -0.19%	160.05 0.42%	1537.29 0.06%	-237.61	159.38	1536.44
Other arable crops	-26.93 -25.69%	100.30 0.65%	4159.64 -0.06%	-21.43	99.66	4162.02
Vegetables and Permanent crops	26655.41 -0.01%	20.70 0.01%	38736.21 -0.01%	26657.46	20.70	38738.23
Fodder activities	96.72 -0.94%	904.80 0.22%	1058.17 0.05%	97.64	902.80	1057.68
Set aside and fallow land	321.69 0.01%	160.65 1.65%		321.66	158.04	
All cattle activities	712.64 0.16%	2008.36 0.03%	2101.22 -0.01%	711.47	2007.84	2101.50
Beef meat activities	-298.71 0.31%	540.84 0.05%	698.68 -0.03%	-299.63	540.58	698.89
All Dairy	1085.37 0.13%	1467.52 0.02%	2618.12 -0.01%	1083.99	1467.26	2618.26
Other animals	295.12 0.00%	3103.16 -0.00%	1788.73 0.00%	295.12	3103.16	1788.73

Young animal balance

Another important module is the young animal balance (see figute 11). Here the sum of young animals needed by the respective region have to be equal to the total need added over activities and alternatives. The EAA requires a distinction between young animals as inputs and outputs, where only the net trade is valued in the EAA on the output side. Consequently, demand for young animals (e.g piglets for pig fattening activity) must be covered by young animals produced from other production activities like sows or are imported from other regions. In Table 2 the corresponding equations, variables and parameters or scalars are shown.

Figure 11: Young animal balance

```
$          include 'supply\supply_model.gms';

* ---------- adding up use of young animals --------------------------------------------------
*
  INPANI_(RUNR,IYANI) $ SUM ( O_TO_YANI(OMYANI,IYANI) $ (v_youngAnimUse.lo(RUNR,OMYANI) ne v_youngAnimUse.up(RUNR,OMYANI)),1) ..
*
*                                   --- young animals needed by
*                                   --- region RUNR
*
    SUM ( O_TO_YANI(OMYANI,IYANI), v_youngAnimUse(RUNR,OMYANI) )
*
         =E=
*                                   --- total need added over activities
*                                   --- and alternatives
*
    0.001 * SUM( MAACT $ (p_technFact(RUNR,MAACT,"LEVL","T") $ PACT_TO_I(MAACT,IYANI)),
*
                v_actLevl(RUNR,MAACT,"T") * DATA(RUNR,MAACT,IYANI,"Y") * (p_technFact(RUNR,MAACT,IYANI,"T")+1.)
                );
*
```

Table 2: Equations, variables and parameters or scalars for the balance of products and young animals in CAPRI

Area	Equations	Variables	Parameters or scalars	Exercise from the policy editor
Balance of products and young animals	---- EQU SUPBAL_ Supply balances for final outputs ---- EQU INPANI_ Input balances for young animals regional	v_netputQunt v_YoungAnimUse V_feedQuantReg V_actLevl	Yields DATA(RUNR,MPACT,OMS,"Y") young animal requirements DATA(RUNR,MAACT,IYANI,"Y") p_exoDemand	Yield, Young animal input p_exoDemand

Land balance

A central role in the CAPRI supply model plays the land balance. Its shadow price appears as a cost in all crop activities including fodder producing ones, so that animals are indirectly affected as well. The second major link is the availability of not-marketable feeding stuff, and finally, less important organic fertiliser. The model comprises a land use module with two major components:

- Imperfect substitution between arable and grass lands depending on returns to the two types of agricultural land uses.
- A land supply curve which determines the land available to agriculture as a function to the returns to land.

If the land endowment is fixed or not meaning if arable land can be substituted with grass land depends on p_landIsFixed (see figure 12). If land is fixed, so no substitution between arable and grassland, the parameter p_landIsFixed = 1.

Figure 12: Fixed land endowment

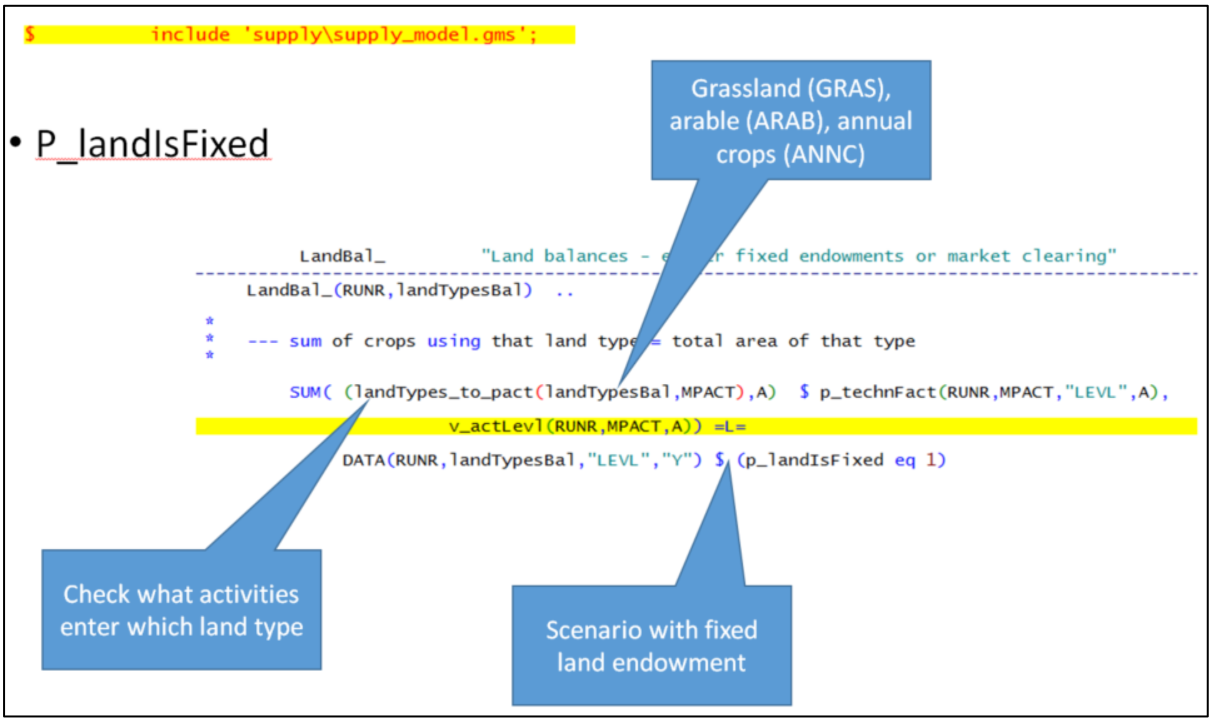
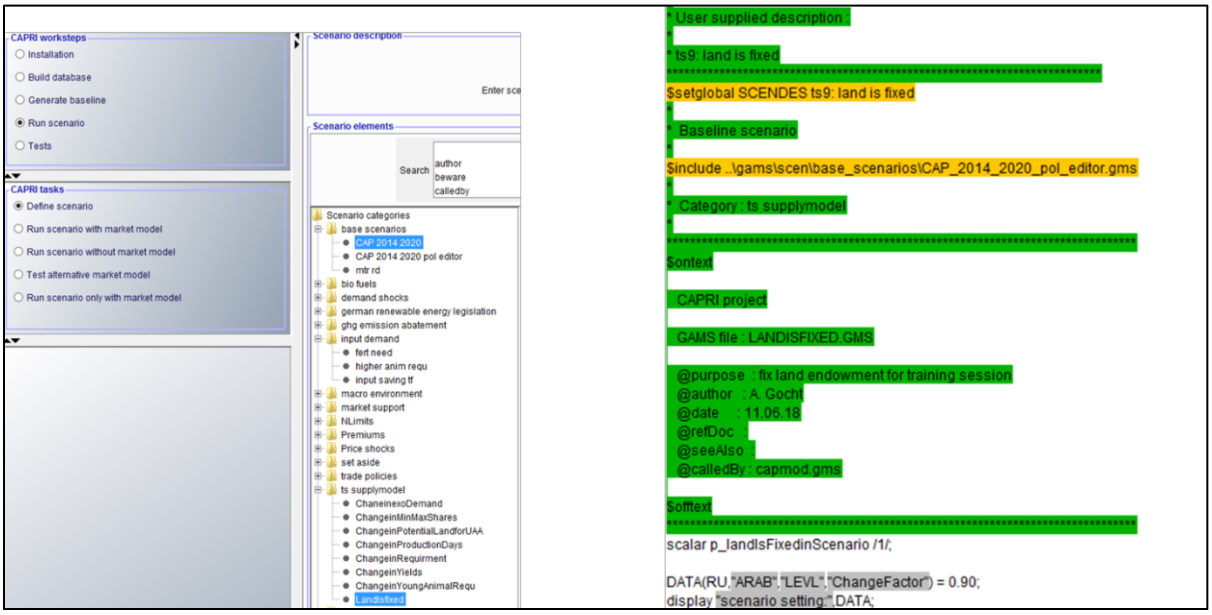


Table 3: Equations, variables and parameters or scalars for the land balance in CAPRI

Area	Equations	Variables	Parameters or scalars
Land Balance	LandBal_ Fixed endowment of market clearing	v_actLevl(Landtypes,"LEVL")	p_landisfixed DATA (RU, landtypes, "Levl","Y")

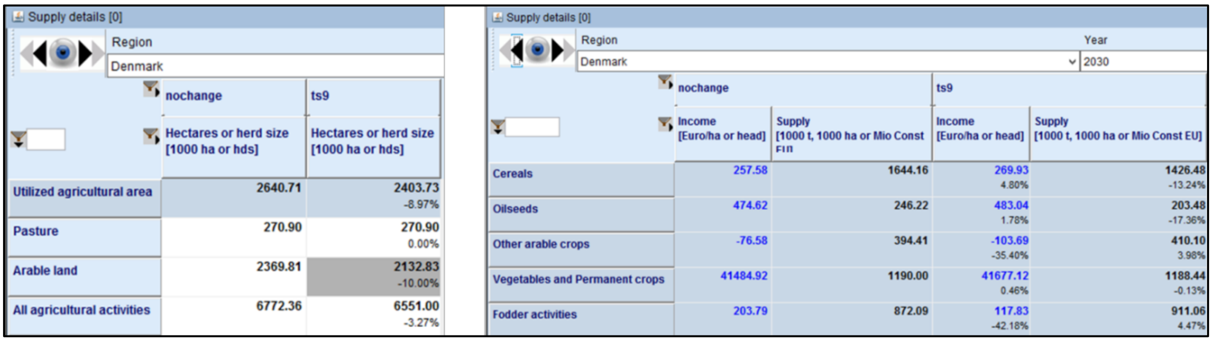
A possible scenario for the land balance module is the change of available arable land. Here the arable land availabe is reduced by 10%. This is achieved through DATA(RU,"ARAB","LEVL","ChangeFactor") =0.90; (see figure 13).

Figure 13: Scenario - Reduction of available arable land by 10%



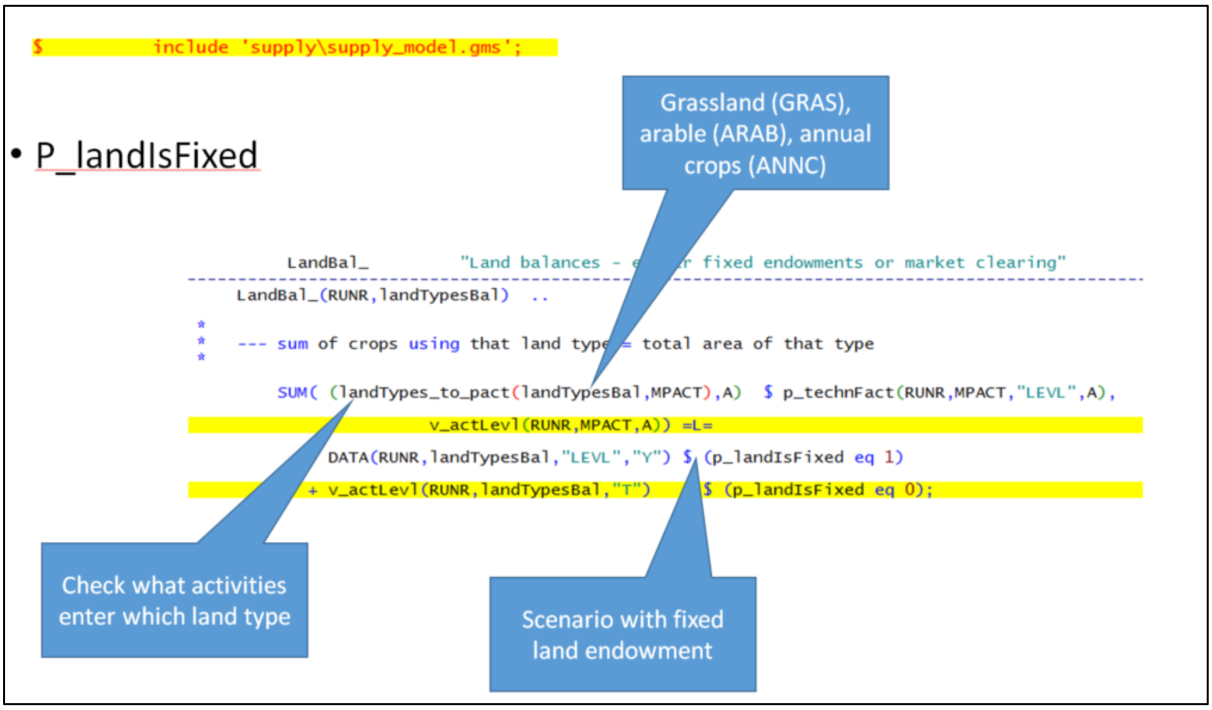
The results of this scenario are shown in figure 14. It can be seen that the scenario (ts9) results in lower total UAA, lower arable land and reduced agricultural activities. In addition the income and supply effects for arable crops are shown for different crop groups. This scenario is only working with the recent trunk version and yet with STAR 2.4.

Figure 14: Scenario results for the reduction of arable land by 10%



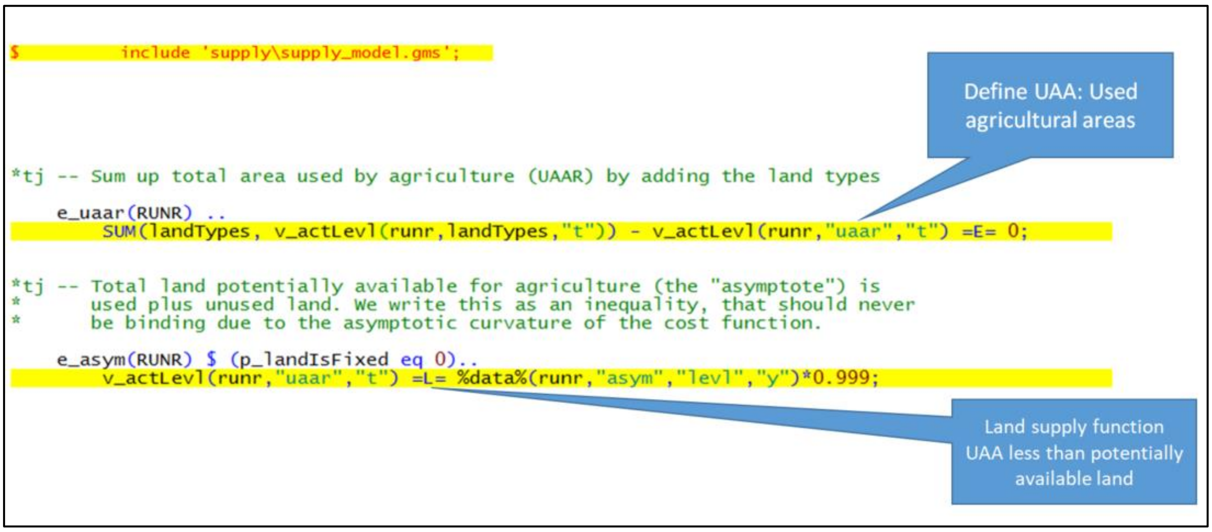
If the land endowment is not fixed (p_landIsFixed = 0) this results in market clearing (see figure 15). For more detailed information see "\doc\landSupplyCAPRI_v5.pdf". This means that the land potentially be used by agriculture is allocated between agriculture and other land uses. At the second level the regional representative farm decides how to allocate total land supplied to: arable and grass land {arab, gras}. The heterogeneity of land is reflected in a concave cost curve for increasing the allocation to the two land types (see figure 16). The representative farm optimizes the land allocation by maximizing the total land rent across land types minus the cost of allocating it to each land type.

Figure 15: Market clearing in the land balance module of CAPRI



In Figure 16 "asym" is the land asymptote i.e. the maximal amount of economically usable agricultural area in a region. In the first equation (e_uaar(RUNR)) the total area used by agriculture for a region is defined and the second equation (e_asym(RUNR)) ensures that the land supply for UAA is less than the potential availabe land.

Figure 16: Constraints to potentially used land for agriculture



It is clear that changes in land allocation also generates costs for the farmer. The costs can stem from the supply of UAA and the transformation of land (e.g. grass land to arable land). In figure 17 the costs calculation for the supply of land and in figure 18 (see also table 4) the costs for transforming land types are showed (see "\doc\landSupplyCAPRI_v5.pdf" for further details).

Figure 17: Costs for supply of land in CAPRI

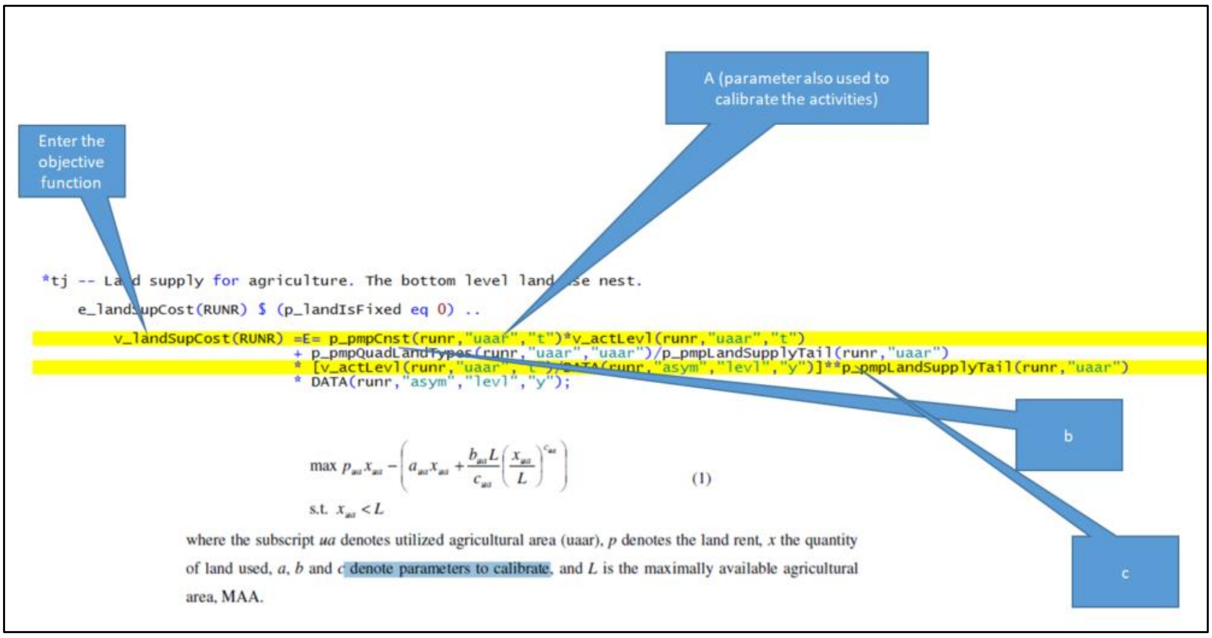


Figure 18: Costs for transforming land types in CAPRI

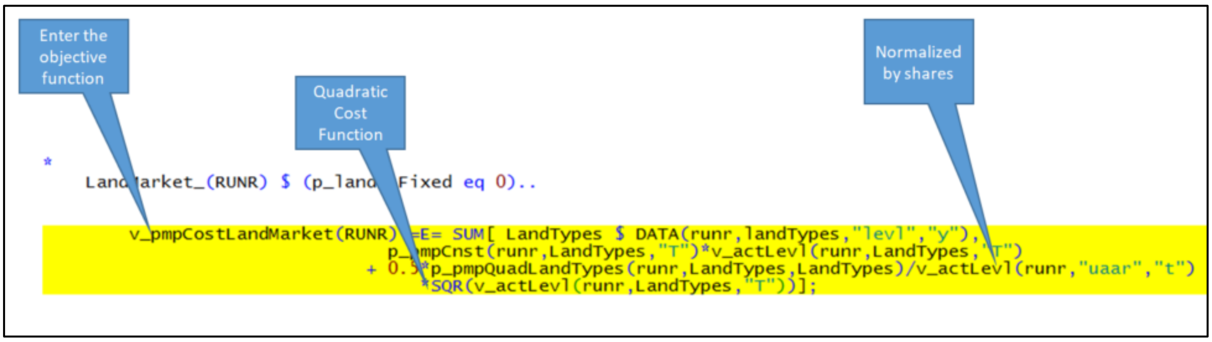
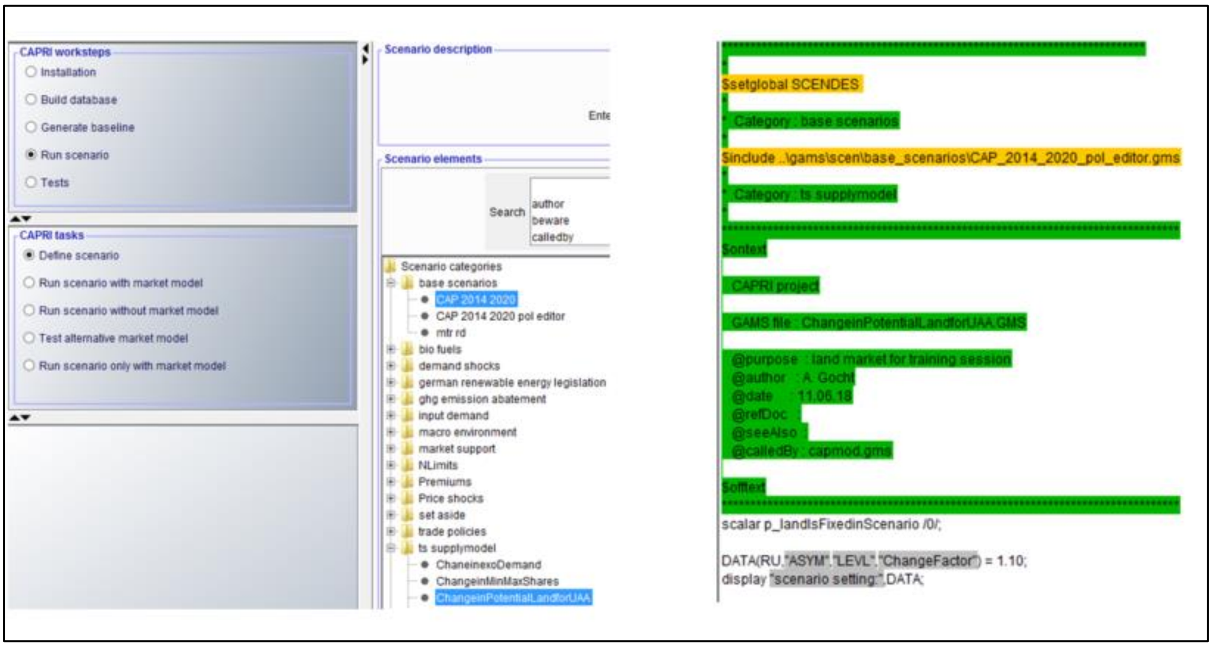


Table 4: Equations, variables and parameters or scalars for the land balance in CAPRI

Area	Equations	Variables	Parameters or scalars
Land Balance	LandMarket_ see also OBJEQF_	V_actLevel(landtypes) V_actLevel("UAA")	p_landisfixed=1 DATA (RU, "Asym", "Levl","Y") p_pmpCnst(LandTypes) p_pmpQuadLandTypes(landtypes)

One potential scenario for market clearing is an increase in available land for UAA by 10% which is depicted in figure 19. As mentioned before "asym" is the land asymptote hence the maximal amount of economically usable agricultural area in a region which has to be increased DATA(RU,"ASYM","LEVL","ChangeFactor")=1.10, here by 10%.

Figure 19: Scenario: Change in available land for UAA (+10%)



The income and supply effects on land are shown in figure 20.

Figure 20: Results: Change in available land for UAA (+10%)

Supply details [0]

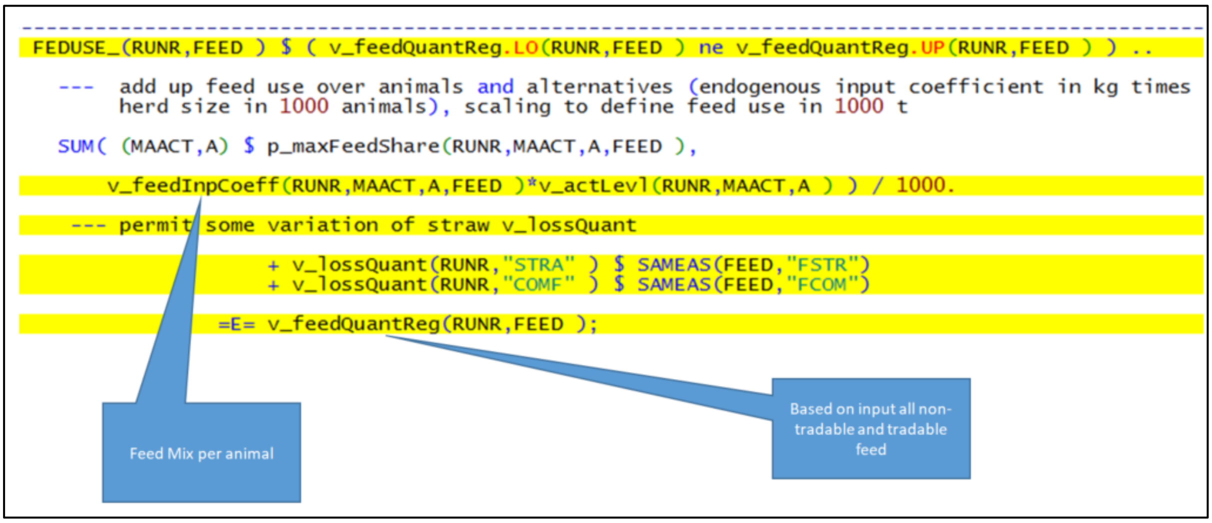
Region: Denmark | Year: 2030

	ts_Reduction_UAA		cap_after_2014_ref	
	Income [Euro/ha or head]	Hectares or herd size [1000 ha or hds]	Income [Euro/ha or head]	Hectares or herd size [1000 ha or hds]
Oilseeds	-267.19	173.47	-237.61 11.07%	159.38 -8.12%
Other arable crops	-21.66	97.44	-21.43 1.06%	99.66 2.27%
Vegetables and Permanent crops	26571.63	20.75	26657.46 0.32%	20.70 -0.26%
Fodder activities	60.20	918.93	97.64 62.18%	902.80 -1.76%
Set aside and fallow land	301.24	236.55	321.66 6.78%	158.04 -33.19%
All cattle activities	718.32	2007.12	711.47 -0.95%	2007.84 0.04%
Beef meat activities	-293.84	540.20	-299.63 -1.97%	540.58 0.07%
All Dairy	1091.06	1466.91	1083.99 -0.65%	1467.26 0.02%
Other animals	295.15	3103.12	295.12 -0.01%	3103.16 0.00%

Feed balance

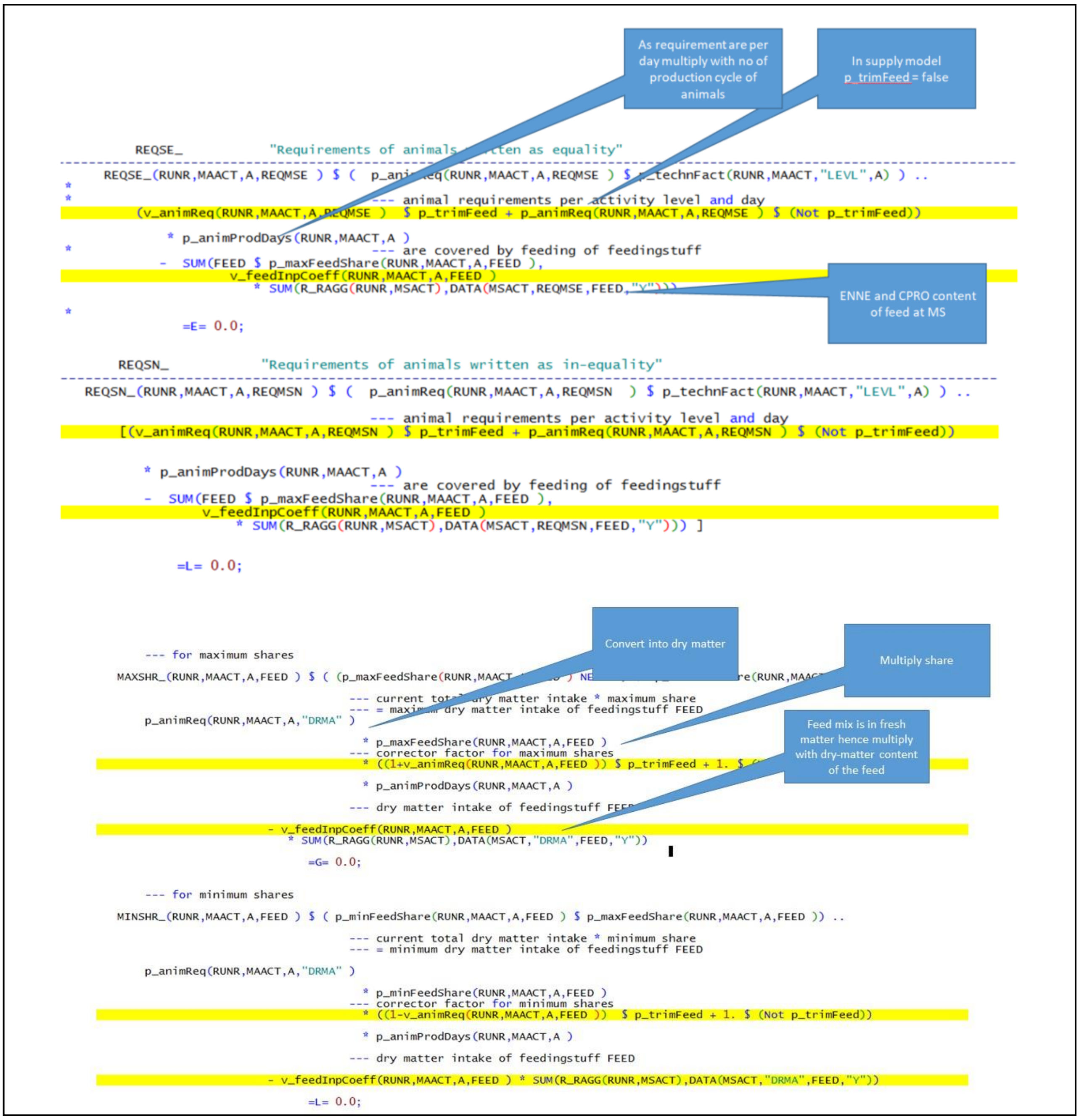
The feed module for animals is another important module for the supply model as it ensures that the requirements of the animal processes are met that these are linked to the markets and crop production decisions. In figure 21 it is shown that the feeding mix per head and kg (v_feedInpCoeff) has to be equal to the regional feed use in 1000t per year and hectar (V_feedQuantReg) based on ainput of all non-tradable and tradable feed.

Figure 21: Feed module in CAPRI



In figure 22 the animal requirements e.g. crude protein(CRPR), dry matter (DRMA), energy re-quired for net lactation (ENNE) which are covered by cost minimised feeding combination are shown.

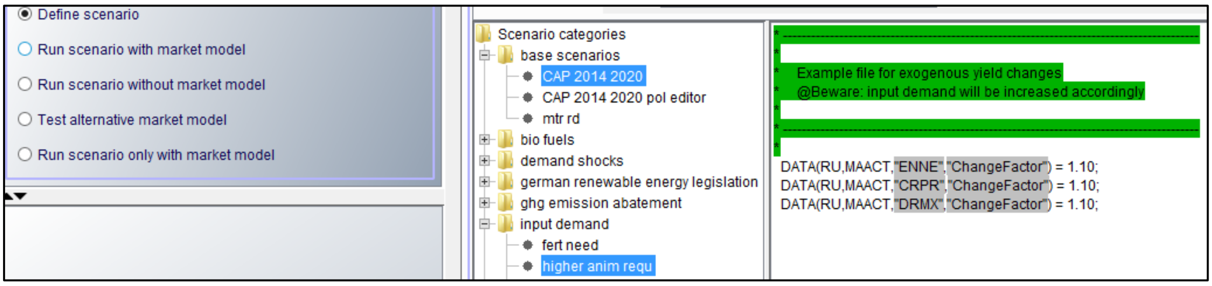
Figure 22: Animal feed requirements in the supply module



Here the net energy requirements (per unit of activity level) for maintenance, daily activity, growth, lactation and pregnancy are calculated and the gross energy intake is derived from the energy requirements and digestibility factors. For more detaqiled information see \docs\Docu_CH4ENT.docx and \docs\capri_documentation.pdf ,pages 123-124.

Regarding animal feed requirements a potential scenario would be the increase of the animal feed requirements by 10% for net energy lactation ("ENNE"), crude protein ("CRPR"), and dry matter max ("DRMX"). The necessary changes in the policy editor are demonstrated in figure 23.

Figure 23: Scenario - Higher animal feed requirements +10% (for net energy lactation ("ENNE"), crude protein ("CRPR"), dry matter max ("DRMX")



As expected the scenario results in figure 24 show an increase in the necessary feed requirements for animals (feed cereals, protein, energy, fodder maize). In addition the herd sizes decrease, the income for animal production decreases and the income for fodder crops increase due to the increased feeding requirements of animals.

Figure 24: Results: Higher animal feed requirements (+10%)

Feed Distribution [0]

Region: Denmark — Year: 2030

	ts_feed_requirements				cap_after_2014_ref			
	Feed cereals [kg/head]	Feed rich protein [kg/head]	Feed rich energy [kg/head]	Fodder maize [kg/head]	Feed cereals [kg/head]	Feed rich protein [kg/head]	Feed rich energy [kg/head]	Fodder maize [kg/head]
All cattle activities	949.85	406.06	5.35	8261.59	810.61 -14.66%	341.59 -15.88%	5.27 -1.50%	7362.29 -10.89%
All Dairy	1107.88	472.87	5.14	8836.59	957.84 -13.54%	404.68 -14.42%	5.08 -1.13%	7895.29 -10.65%
Other animals	2278.06	907.49	18.60	36.33	2070.68 -9.10%	825.39 -9.05%	18.48 -0.65%	33.64 -7.42%

Supply details [0]

Region: Denmark — Year: 2030

	ts_feed_requirements		cap_after_2014_ref	
	Income [Euro/ha or head]	Hectares or herd size [1000 ha or hds]	Income [Euro/ha or head]	Hectares or herd size [1000 ha or hds]
Oilseeds	-237.40	159.03	-237.61 -0.09%	159.38 0.22%
Other arable crops	-24.70	100.04	-21.43 13.26%	99.66 -0.38%
Vegetables and Permanent crops	26656.12	20.70	26657.46 0.01%	20.70 -0.01%
Fodder activities	120.75	909.60	97.64 -19.14%	902.80 -0.75%
Set aside and fallow land	321.71	159.76	321.66 -0.01%	158.04 -1.07%
All cattle activities	610.09	1856.13	711.47 16.62%	2007.84 8.17%
Beef meat activities	-393.02	466.15	-299.63 23.76%	540.58 15.97%
All Dairy	946.50	1389.98	1083.99 14.53%	1467.26 5.56%
Other animals	198.66	2845.37	295.12 48.55%	3103.16 9.06%

Fertilizer balance

The fertilizer balance is the last module of the supply model presented in this document. In CAPRI, fertilisers are available from three different sources, namely from purchased mineral fertiliser, animal manure and crop residues. Fertilisers in animal manure produced per animal per head per year depend on the type of animal, the raising period in number of days and the kg live weight at the start and the end of the raising period. The nitrogen emission factors from animal activities are coupled to crude protein intake. As shown in figure 25 the total nutrient need of plants (NUTNED_) –minus biological fixation for pulses– multiplied with a factor describing fertilisation beyond exports must be covered by: (1) inorganic fertiliser, corrected by ammonia losses during application in case of N, (2) atmospheric deposition, taking into account a crop specific loss factor in form of ammonia, and (3) nutrient content in manure, corrected by ammonia losses in case of N, and a specific availability factor. The relevant equations variables, parameters or scalars are depicted in Table 5.

Figure 25: The fertilizer balance in the supply module of CAPRI

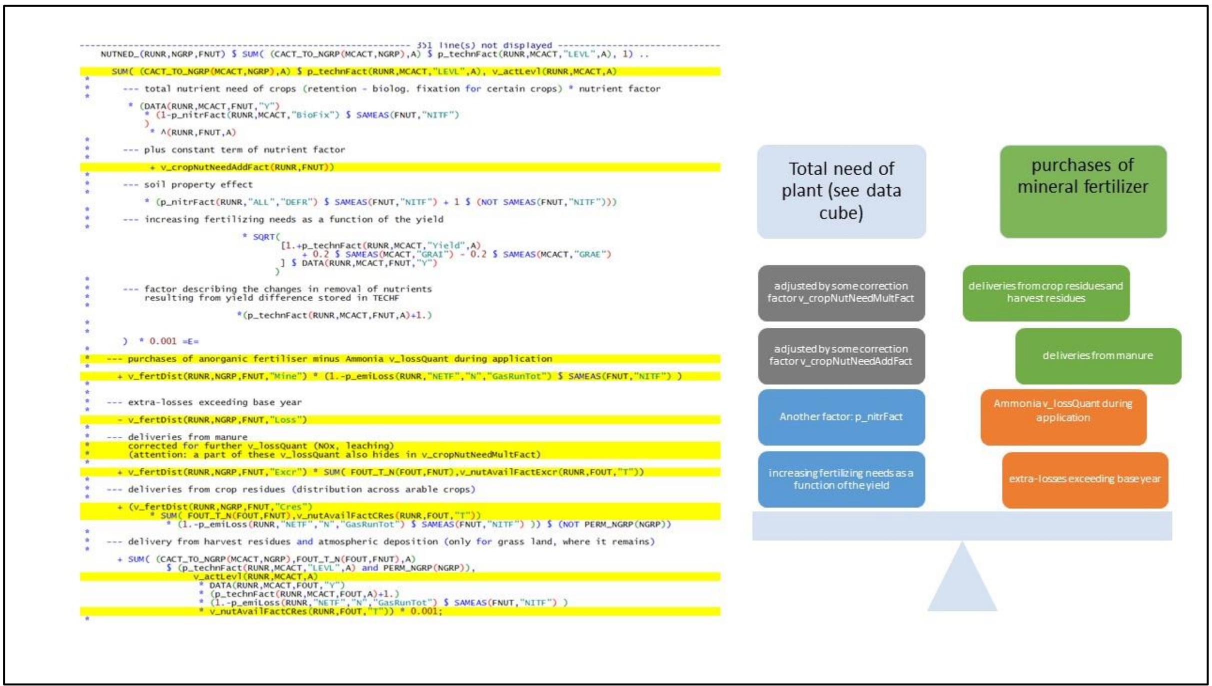


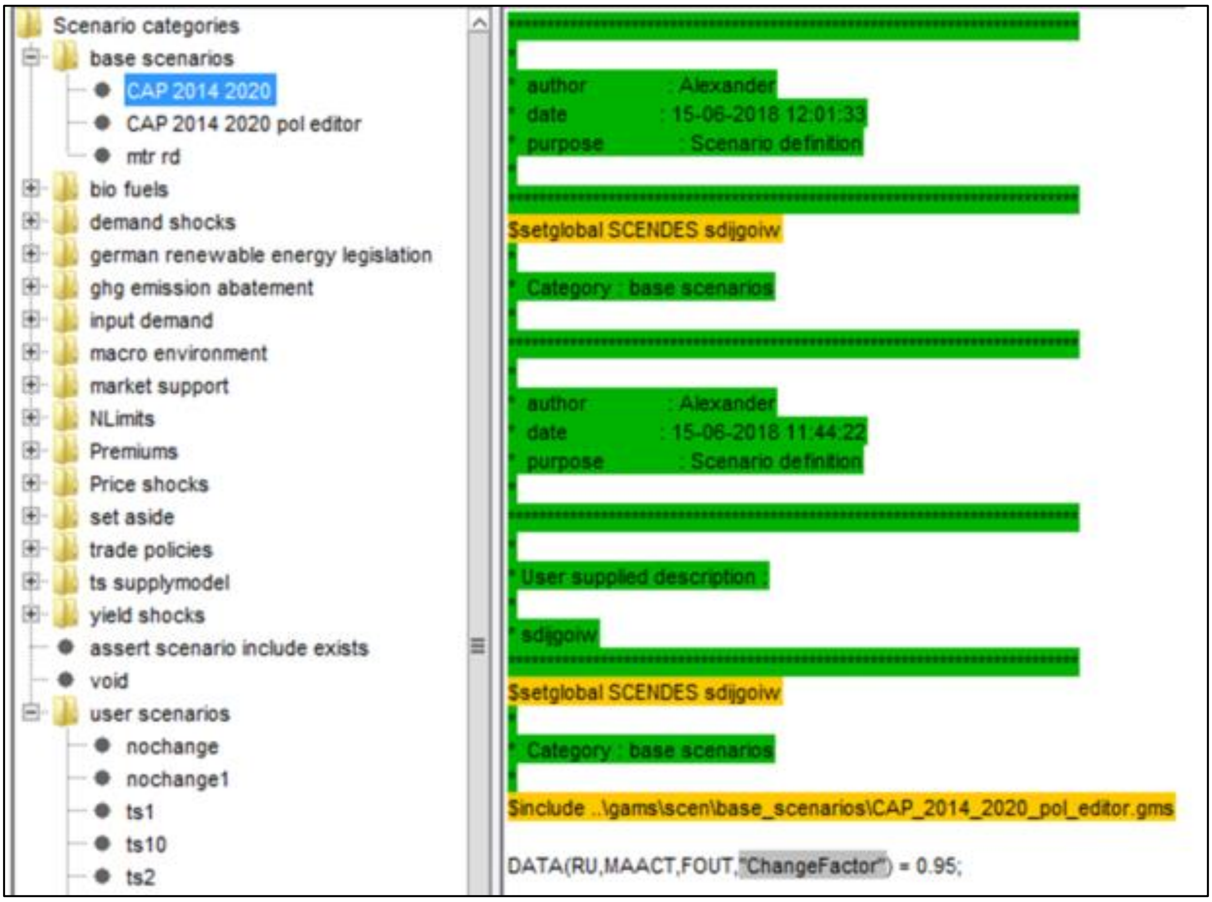
Table 5: Equations, variables and parameters or scalars for the fertilizer balance in CAPRI

Area	Equations	Variables	Parameters or scalars
Distribution of mineral and organic fertilizer to crops	fertDistMine_ ineral fertilizer distributed to group of crops must exhaust total mineral N sales	v_fertDist(RUNR,NGRP,FNUT,"Mine") v_netPutQuant(RUNR,FNUT)	No
	NUTNED_ nutrient need balance for group of crops		Nutrient factors: p_nitrFact v_cropNutNeedAddFact v_cropNutNeedMultFact Nutrient need of crop: DATA(RUNR,MCACT,FNUT,"Y")
	NUTMIN_ Minimum use of mineral fertilizer	v_actLevl(MCACT) v_fertDist(RUNR,NGRP,FNUT,"Mine")	p_minShareMinFert(MSACT,MCACT,A,FNUT) v_minShareMinFertCorr DATA(RUNR,MCACT,FNUT,"Y") p_nitrFact

mapping	fertDistExcr_ Total crop available nutrients from manure must be distributed to different crop groups	excrements distributed summed up over crop groups	
mapping	fertDistCres_ Total nutrients from crop resiudes and atmosperic deposition must be distributed to different crop groups	Only non permanent v_actLevl(nonPermAct)	DATA(RUNR,noPermCact,FOUT,"Y")
mapping	ManureNPK_ Definition of total manure output of animals	v_ManureNPK v_actLevl(RUNR,MAACT	v_ManureNPKintraTrade DATA(RUNR,MAACT,FOUT,"Y") p_emiLoss

One thinkable sceanrio would be the reduction of manure output from animals by 5%. The necessary changes in the policy editor are shown in figure 26. MAACT are the animal production ac-tivities and FOUT is the output of N,P2O,K2O from animals which is reduced by 5%.

Figure 26: Scenario - Reduction of manure output from animals by 5%



The results in figure 27 show that CH4, N2O emissions and ammonium output is reduced and the EAA value of manure and related nutrients is reduced. This scenario is only working with the recent trunk version and not with STAR 2.4.

Figure 27: Results - Reduction of manure output from animals by 5%