A manual on DynMod model conversion from Excel to GAMS

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1. Background

DynMod is a simple herd growth model spreadsheet that simulates the population dynamics of ruminant livestock herds (Lesnoff 2008). Based on a series of calculations specified using Microsoft Office Excel, Dynmod can be used to derive the number of animals produced over a given period (e.g. a year), population-specific animal live weights, and the production of various livestock products, e.g. meat, milk, hides and skin and manure. These are derived based on user-specified characteristics of the herd (such as fertility and mortality rates) and can be further linked to resource use indicators such as herd-level feed requirements and costs and financial indicators such as production costs. DynMod has a robust history of use at the International Livestock Research Institute (ILRI) in integrated/bio-economic assessments relevant to ruminant livestock systems, including recent applications at sector (e.g. Toye et al. 2020) and value chain (e.g. Rich and Wane 2021) levels.

Specification of DynMod in Excel, while making the model relatively simple to use and thus widely accessible to specialists and non-specialists alike, presents considerable challenges, particularly in its application to livestock system modeling and policy and investment planning. Most notable of these is the limited ability to incorporate dynamic economic considerations (e.g. changing prices) in management decisions such as offtakes that influence overall herd dynamics. Also of note is the cumbersome process of manipulating numerous lines and pages of formula in Excel to execute the herd dynamics, which makes it difficult to implement appropriate scenario analysis, and lends itself to multiple data and specification errors. Re-specifying the model using flexible mathematical programming software such as GAMS is a preliminary step to addressing these challenges.

A model converting DynMod's original specification in Excel to GAMS is reported following. The accompanying model specifications and data files to execute this process are made available on ILRI's open data portal.[1]

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1   https://data.ilri.org/portal/dataset/integrated-livestock-systems-and-economic-modeling

2. Introduction

The model developed replicates the DynMod methodology of Lesnoff (2008) in a GAMS format, using Tanzania livestock master plan (LMP) data from the livestock sector investment and policy toolkit (LSIPT) (FAO, CIRAD and ILRI 2020). It computes both monthly and annual herd dynamics based on parturition (birth), fecundity, offtake, and mortality rates. The model has been parameterized for ruminant herd dynamics.

The model allows for dynamic exogenous parameters for simulations, i.e. selected parameters can change to different levels during the 20 years. A base GAMS code developed by Karl M. Rich and Sherman Robinson (Version 1.0, 06 November 2019) was extended to include production and financial estimates and implemented for multiple production systems over 20 years to allow for simulations and compiling of a synthesis of the results.

3.   Sequence of files

The model folder in the repository contains one main GAMS (.gms) file, with several files in *include* (.inc) format. The include files are modular and must be run in sequence. However, initial include files can be run without subsequent include files. This allows for more systematic changes and checking of different components of the model. The general files (not country-specific) are numbered to indicate the flow. Country-specific files that give the production systems and data for the base and simulations for Tanzania, all start with *ILRITanzania*. The flow of files is shown in Table 1. In addition, an initial conversion file (0_DynMod_v1) has been included. This file is for reference only and does not run as part of the sequence of other files listed in Table 1.

Table 1: Sequence of DynMod model GAMS files	
File name	**Description**
1DynModProject.gpr	Project file to specify active folder
2Dynmod.gms	Main gms file to specify herd dynamics over 240 months
ILRITanzania-Sets.inc	*Country-specific production systems*
ILRITanzania-input.inc	*Country-specific file to read in data*
ILRITanzania-data.xlsx	*Country-specific data contained in Excel*
ILRITanzania-Sim2.inc	*Country-specific specification of data for simulations for herd growth*
3DynModHerd.inc	Conversion from monthly to annual time steps, and conversion from all age classes to reporting age classes and subtotals
4DynModProducts.inc	Estimation of production of animal products
ILRITanzania-Sim4.inc	*Country-specific specification of data for simulations related to animal products*
5DynModFinance.inc	Estimation of financial impacts
ILRITanzania-Sim5.inc	*Country-specific specification of data for simulations related to financial impacts*
6DynModIndOption2.inc	Estimation of indicators for option 2 (with survey data)
7DynModIndOption1.inc	Estimation of indicators for option 1 (without survey data)
8DynModSynth.inc	Synthesis of results

The main .gms file (**DynMod.gms**) uses, amongst other factors, parturition, mortality, and offtake rates to compute the core herd dynamics over 240 months. Different ruminant production systems are read in via an include file (**ILRITanzania-Sets.inc**). Annual mortality/death and offtake rates are exogenous data. From these two rates, the monthly hazard rates for each are calculated and then the monthly probabilities. The monthly probabilities are used to estimate changes in the herd population.

Herd data for the production systems are read in via an include file (**ILRITanzania-input.inc**) from the *Herddat* worksheet in the country-specific Excel file (**ILRITanzania-data.xlsx**). The Excel file duplicates/initializes the data for each production system's simulation, so at this stage, the base production system and the simulation production system should give the same results over the 240-month period for parameters such as the numbers of births, deaths, offtake, and transitions for different age classes. The model replicates the results from the **Tmp_Projection (Without**)

worksheets in the individual country ECORUM files, which give monthly results[1]. The simulations are discussed in more detail in section 3.

The third file (**3DynModHerd.inc**) converts the estimates in 2DynMod.gms from monthly time steps (240 months) to annual time steps (20 years). It also converts age classes used in calculations to the age classes used for data input and reporting and subtotals for reporting (see section 4.4). No new input data is required for this conversion file. The model results at this point replicate the results from the Ecorum *file Projection (Without)* worksheets section I, section II, and the first part of section III, which give annual results. For the subsequent include files, only annual time steps are used, not monthly time steps.

The fourth file (**4DynModProducts.inc**) extends the herd dynamics module with estimates of the annual production of animal products. It replicates results from the Ecorum *file Projection (Without)* worksheet part of section III on production. It requires additional data, which is read in from the **Proddat worksheet** in the country-specific data file (ILRITanzania-data.xlsx) via an include statement.

The fifth file (**5DynModFinance.inc**) extends the herd dynamics module with estimates of financial impacts. It replicates results from the Ecorum file *Diagnostic* worksheet section I (production costs and general expenses) and section II (income). It requires additional data, which is read in from the **Findat1** and **Findat2** worksheets in the country-specific data file (ILRITanzania-data.xlsx) via an include statement. In this file, each financial parameter is estimated for both the financial and the economic analysis.

The sixth file (**6DynModIndOption2.inc**) estimates indicators for option 2 (with survey data). No new data is required for these calculations. It replicates results from the Ecorum file *Diagnostic* worksheet section III (income and other financial and economic indicators) and section V (calculations of parameters for modules 4, 5, and 6).

The seventh file (**7DynModIndOption1.inc**) estimates indicators for option 1 (without survey data). It replicates results from the Ecorum *file Diagnostic* worksheet section IV (indicators of vulnerability). This is relevant for the financial analysis only (i.e. not for the economic analysis). It requires additional data, which is read in from the *Findat3* worksheet in the country-specific data file (ILRITanzania-data.xlsx) via an include statement.

The eighth and final file (**8DynModSynth.inc**) compares the base (without change) and simulation (with change) results following the Ecorum file *Synthesis* worksheet in the individual files. It should be noted that shared results have already been multiplied by 100 in this file to get percentages. No new input data is required in this include file. Four sets of results are presented. The first two sets are presented for a single year of choice, whereas the next two sets report the comparison of averages over the entire period. The first and third sets present results that are related to herd dynamics, production, and income. The second and fourth sets present results for both the financial and economic analyses. Sets are summarized in Table 2.

Table 2: Description of result sets in synthesis file	
Result sets	**Description**
For a particular year	
RES1	Results related to herd dynamics, production, and income
RES2	Results related to financial and economic analyses
Average over the period	
RES3	Results related to herd dynamics, production, and income
RES4	Results related to financial and economic analyses

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1   The Tmp_Projection (Without) and Tmp_Projection (With) worksheets in the individual country Ecorum files (from the LSIPT datasets) incorrectly use the new years' parturition rate in the base (X0) calculation of the number of births. The base values (X0) represent the last month of the previous year and hence should use the previous year's parturition rate. This causes incorrect transitions between years in the Excel files. This observation is consistent with the motivation to specify the DynMod model a program like GAMS (see Background section).

4. Simulations

The files to produce the baseline estimates of the production systems are discussed in the previous section. Simulation production systems are already declared and initialized at base values in the mentioned files because initially, the same data is read in from the country-specific data file (ILRITanzania-data.xlsx) for both the base production systems and the simulation production systems.

Simulations are activated by changing base values of the simulation production systems in three country-specific simulation files (ILRITanzania-Sim2.inc, ILRITanzania-Sim4.inc, and ILRITanzania-Sim5.inc), with the file sim number indicating in which numbered general file the simulation file is included. Since estimations for the simulation production systems are carried out simultaneously as the base production systems, the simulation data should be read in at the same time as the base data, hence the inclusion of the simulations in different files.

The simulation files currently contain a few examples of how to introduce the simulations, but the analysts should further populate these simulation files. New parameters values should be specified for each production system as required; otherwise, base values are used.

5. Sets

5.1 Sets for production systems

There are two types of production systems: a) production systems for the base, and b) one simulation production system for each base production system, denoted with an s at the end of the name, e.g. B1LG (base) and B1LGs (simulation).

Two sets are defined:

PS: global production system set that includes all possible base and simulation productions systems.

PSCUR: production systems that are included in the current analysis – this set also includes base and simulation production systems.

It is useful to select only the production systems that are the focus of a study or simulation in PSCUR and switch off the other production systems until they are needed to reduce the output for more focused checking and/or reporting. The sets and set elements are included in the file **ILRITanzania**-Sets.inc and called in the main .gms file (**2DynMod.gms**).

5.2 Sets for time periods

The following sets are defined:

YALL   All annual time periods ranging from Y0 to Y20

Y(YALL)   Annual time periods for simulation ranging from Y0 to chosen year

YN(Y)   Annual time periods for simulation excluding Y0

YS(Y)   Reporting year in result synthesis file

P   Probability time steps ranging from 1 to 12

T   Monthly time steps ranging from 1 to 240

T1(T)   First month

TYend(T)   Last month of a year, e.g. 12, 24, etc.

Change only Y when selecting fewer than 20 years for analysis and reporting of base results. The reporting year for synthesis results (comparing base and simulation results) can be set at any year except Y0. The Ecorum files Synthesis worksheet only compares results for Y1.

The annual time periods are set to a maximum of 20 years in YAll. If this needs to increase, then adjustments must be made to monthly time periods (T) and mappings of months to years (in the input include file) and month ends (TYend). Monthly time periods (T) can be set for the entire 20 years regardless of the number of years used in the analysis (Y). However, fewer time periods than the number of years will create errors, so it is advisable to keep T set to 240 months even if the number of years is reduced.

5.3. Mapping sets for time periods

Mapping sets for time periods are used in the calculations to transition between months and years. Three mapping sets are used, and these are specified in the country-specific Excel file (ILRITanzania-data.xlsx):

MTY: The mapping set is used to map specific months (set TYend) to years, e.g. month 12 is mapped to year 1, month 24 to year 2, etc.

MT2Y: The mapping set is used to map months to years, e.g. months 1 to 12 are mapped to year 1, etc.

MY2T: The mapping set is used to map years to months, e.g. year 1 is mapped to months 1 to 12, etc.

5.4. Sets for age classes

One global set and three subsets are used for age classes. The global set A includes the full set of age classes and subtotals for calculations (Table 3), similar to age classes that are used in the Ecorum file *Tmp_Projection* worksheets that estimate monthly results. F and M, which are subsets of A, include the female and male age classes, respectively. AR, which is a subset of A, consists of the age classes for reporting, as well as subtotals for reporting (Table 4), like age classes that are used in the Ecorum file Projection worksheets that report annual results.

Table 3: Full set of age classes and subtotals used in calculations (Set A)	
Age classes and totals (Set A)	**Descriptions**
Females (subset F[A])	
FBIRTH	Female births
FJUV	Female juveniles
FSUB	Female sub-adults
FADULT	Female adults
FCULL	Female culls
Males (subset M[A])	
MBIRTH	Male births
MJUV	Male juveniles
MSUB	Male sub-adults
MADULT	Male adults
MCULL	Male culls
Subtotals	
FEMALE	Female subtotal
MALE	Male subtotal
TOTAL	Total

Table 4: Age classes and subtotals used in data input and reporting (Subset AR)	
Age classes (Subset AR[A])	**Description**
Females	
FJUV	Female juveniles (including births)
FSUB	Female sub-adults
FADULT	Female adults (including culls)
Males	
MJUV	Male juveniles (including births)
MSUB	Male sub-adults
MADULT	Male adults (including culls)
Subtotals	
FEMALE	Female subtotal
MALE	Male subtotal
TOTAL	Total

5.5. Mapping set for age classes

The mapping set for age classes (set MAR) is used in the calculations to transition from the full set of age classes (A), which include births and culls, to the reporting age classes (AR), which exclude births and culls. The mapping set is specified in the country-specific Excel file (ILRITanzania-data.xlsx). When the mapping is implemented, the numbers for births are added to the numbers for juveniles, and those for culls are added to those for adults. Also, all female age class numbers are added together to get the female subtotal, and similarly for males. Finally, all age class numbers are also added together to get the grand total for reporting purposes.

The parameter listing for each of the include files are presented in the Appendix.

6. Applying the model

The users of the DynMod GAMS-based model should populate the simulation files for meaningful results comparison. Thorough checks should be conducted to ensure that intended simulations are implemented correctly. It is recommended that changes are introduced systematically so that results can be checked at each stage of adding a change in a simulation file for a production system. Note that the files are set up such that the data for the simulations should be changed only in the simulation include files and NOT in Excel, because the Excel files do not allow for dynamic changes, and it leaves too much room for errors if changes are implemented in two places. Changes can then unknowingly be overwritten by later data statements.

Initial checks of model results against Ecorum Excel files are advised, but note that the calculation of births should be corrected first in the *Tmp_Project* worksheets by using the previous year's parturition rate for the calculation of births in X0 in each year from year 2 onwards (for both males and females), otherwise results will not be consistent if parturition rates change over time. Also, note that since the Excel Synthesis worksheets only report differences in year 1 between the without change and with change scenarios, changes implemented from year 2 onward cannot be directly compared using the Synthesis worksheets. Still, results can be compared using the annual Projection worksheets.

In order to use the model for another country, the name of the country should be specified in the global set statement in the main .gms file, and then country-specific file names should contain the same name. The general files can thus be used with other country data if country-specific files are compiled following the same layout and patterns as established for Tanzania.

7. References

FAO, CIRAD and ILRI (Food and Agriculture Organization of the United Nations, French Agricultural Research Centre for International Development and International Livestock Research Institute). 2020. *Livestock Sector Investment and Policy Toolkit (LSIPT): Making Responsible Decisions.* Rome, FAO.

Lesnoff, M 2008. *DynMod: A tool for demographic projections of tropical livestock populations under Microsoft Excel, user's manual - Version 1.* CIRAD; ILRI. 29 pp.

Rich, K.M., and Wane, A. 2021. The competitiveness of beef exports from Burkina Faso to Ghana. *Frontiers in Veterinary Science* 8:888.

Toye, P., Kiara, H. Ole-MoiYoi, O., Enahoro, D. and Rich, K. M. 2020. The management and economics of East Coast fever. Pp. 239–73 in *The Impact of the International Livestock Research Institute.* edited by J. McIntire and D. Grace. Nairobi, Kenya: ILRI and Wallingford, UK: CABI: CABI.

8. Appendix:

8.1. Parameters and descriptions of project files

File and parameter names	Descriptions

2DynMod.gms

Data read in per production system

PARY(YALL,PS)	Parturition rate (annual)
PR(T,PS)	Parturition rate (monthly)
NPRY(YALL,PS)	Net prolificacy rate (annual)
NPR(T,PS)	Net prolificacy rate (monthly)
PCTFEM(T,PS)	Percentage female
INITANIM(PS)	Initial number of animals

Data read in per age class and production system

OFFR(A,Y,PS)	Annual offtake rate
MORT(A,Y,PS)	Annual death or mortality rate
INITDIST(A,PS)	Initial age distribution
AGEMOS(A,PS)	Duration or age in months per age class

Rates and probabilities used in calculation of herd population numbers over time

HDEATH(A,T,PS)	Monthly hazard rate for deaths
HDEATHAGE(A,T,PS)	Duration-specified hazard rate for deaths
MHOFF(A,P,T,PS)	Aggregated monthly hazard rate for offtakes
HOFF(A,T,PS)	Monthly hazard rate for offtakes
FVALUE(A,P,T,PS)	Numerical estimation function 1
DERIV(A,P,T,PS)	Derivative 1
PDEATH(A,T,PS)	Monthly probability of deaths by age class
POFFTAKE(A,T,PS)	Monthly probability of offtakes by age class
SURV(A,T,PS)	Probability of survival

Matrix algebra to estimate births, deaths, offtake and transitions from initial period herd numbers to next period herd numbers

GCALC(A,T,PS)	Transitional probability
X0(A,PS)	Initial number of animals per age class

File and parameter names	Descriptions

Matrices used in the calculation of production tables

SMATRIX(A,A,T,PS)	Survival matrix
GMATRIX(A,A,T,PS)	Gamma transitional matrix
ICULLMATRIX(A,A,T,PS)	I-cull matrix
FMATRIX(A,A,T,PS)	Fecundity matrix (total number of animals)

Production tables indicating number of animals in any given month

SPROD(A,T,PS)	Number after death and offtake (survival)
GPROD(A,T,PS)	Number after transition from one age class to next (gamma)
IPROD(A,T,PS)	Number after culling
FPROD(A,T,PS)	Number of animals per age class and month

Number (N) of deaths and offtake (including culling) per month

NDEATH(A,T,PS)	Number of deaths per month
NOFFTAKE(A,T,PS)	Number of offtake per month

3DynModHerd.inc

Annual (indicated with y at the end)

FPRODY(A,Y,PS)	Number of animals (production) per year
NDEATHY(A,Y,PS)	Number of deaths per year
NOFFTAKEY(A,Y,PS)	Number of offtake per year
SVAR(A,TYEND,PS)	Stock variation at months for year end
SVARY(A,Y,PS)	Stock variation per year
SVAROFFTY(A,Y,PS)	Stock variation per year plus net offtake

Reporting (indicated with r at the end)

FPRODYr(*,AR,Y,PS)	Number of animals per year reporting
NDEATHYr(*,AR,Y,PS)	Number of deaths per year reporting
NOFFTAKEYr(*,AR,Y,PS)	Number of offtake per year reporting
SVAROFFTYr(*,A,Y,PS)	Stock variation per year plus net offtake

4DynModProducts.inc

Parameters for loading data

MDAYLEN(PS)	Length of milking period (days)
MOFFDAY(PS)	Milking quantity per day (litre per reproductive female)
DRESSING(PS)	Dressing percentage
LIVEWEIGHT(A,PS)	Live weight (kg per animal)
OFFVAL(A,Y,PS)	Offtake value (financial price per animal) per year
SKIN(A,PS)	Hides and skins (kg per animal)
WOOL(A,PS)	Wool (kg per animal)
ORGMAT(A,PS)	Organic matter (manure) (kg per animal per day)
DRYMATTER(A,PS)	Daily dry matter requirement (% per kg live weight)

Parameters for calculations

File and parameter names	Descriptions
FPRODYA(A,Y,PS)	Average number of animals per year
LIVEWEQ(*,Y,PS)	Live weight equivalent
MEATEQ(*,Y,PS)	Meat equivalent
FINEQ(*,Y,PS)	Financial equivalent
MILK(*,Y,PS)	Milk average and total
SKINS(Y,PS)	Skin and hides
WOOLTOT(Y,PS)	Wool
ORGMATTOT(Y,PS)	Organic material
PRODMEAS(*,Y,PS)	Productivity measures
FEED(Y,PS)	Feed requirements dry matter (kg per year)

5DynModFinance.inc

Parameters for loading data

PFEED(Y,PS,NC)	Digestible dry matter % feed
CONCFADULT(Y,PS,NC)	Concentrates for female adults (kg per day)
CONCJUV(Y,PS,NC)	Concentrates for juveniles (kg per day)
CONCSUB(Y,PS,NC)	Concentrates for sub-adults (kg per day)
CONCMADULT(Y,PS,NC)	Concentrates for male adults (kg per day)
ADDITIVES(Y,PS,NC)	Additives (kg per day)
SALTS(Y,PS,NC)	Salts and minerals (kg per day)
FAREA(Y,PS,NC)	Forage production area
FLABOUR(Y,PS,NC)	Forage production salaried labour
FSEED(Y,PS,NC)	Forage production seed
FFERT(Y,PS,NC)	Forage production fertilizers
FOTREAT(Y,PS,NC)	Forage production other treatments
FOTHER(Y,PS,NC)	Forage production other
GAREA(Y,PS,NC)	Grass land maintenance area
GLABOUR(Y,PS,NC)	Grass land maintenance salaried labour
GFERT(Y,PS,NC)	Grass land maintenance fertilizers
GOTREAT(Y,PS,NC)	Grass land maintenance other treatments
GOTHER(Y,PS,NC)	Grass land maintenance other
VETCOST(Y,PS,NC)	Veterinary costs and medicines (cost per animal)
ARTIFINSEM(Y,PS,NC)	Artificial insemination (cost per reprod female)
HERDER(Y,PS,NC)	Herder (months per year)
LABOUR(Y,PS,NC)	Salaried labour (days per year)
OTHERCONS(Y,PS,NC)	Other (maintenance transport) (cost per year)
GRAZING(Y,PS,NC)	Cost of access to grazing (ha)
LIVETAX(Y,PS,NC)	Livestock taxes (per animal)
AGTAX(Y,PS,NC)	Agricultural taxes (ha)
WATER(Y,PS,NC)	Cost of access to water (month)
FAMLAB(Y,PS,NC)	Family labour (people per year)
LIVECAPINT(Y,PS,NC)	Live capital (animals) (interest rate)

File and parameter names	Descriptions
LANDCAP(Y,PS,NC)	Land capital (cost per year)
PASTWAT(Y,PS,NC)	Cost of transhumance (pasture + water) (cost per year)
OTHERDOM(Y,PS,NC)	Other (cost per year)
LOANSHARE(Y,PS,NC)	% of production costs and general expenses financed by a loan
ANNUALINT(Y,PS,NC)	Annual interest rate on loan
LOANDUR(Y,PS,NC)	Duration of loan (month)
IMEAT1(Y,PS,NC)	Meat (unit price per kg)
IMILK1(Y,PS,NC)	Milk (unit price per litre)
ISKINS1(Y,PS,NC)	Hides and skins (unit price per kg)
IWOOL1(Y,PS,NC)	Wool (unit price per kg)
IORGM1(Y,PS,NC)	Organic matter (unit price per kg)
IDRAUGHT1(Y,PS,NC)	Animal draught (unit price per pair-day per year)
NDRAUGHT1(Y,PS,NC)	Number of draught animals in the herd
NTRACTION1(Y,PS,NC)	Number of days of animal traction per year
IMEAT2(PS,EXCH)	Meat (%)
IMILK2(PS,EXCH)	Milk (%)
ISKINS2(PS,EXCH)	Hides and skins (%)
IWOOL2(PS,EXCH)	Wool (%)
IORGM2(PS,EXCH)	Organic matter (%)
IDRAUGHT2(PS,EXCH)	Animal draught pair-day per year (%)

Parameters for calculations
Feed cost

FORAGE(Y,PS,ANAL)	Forage (dry matter) feed cost
CONCFEED(Y,PS,ANAL)	Concentrated feed cost
ADDITIVESTOT(Y,PS,ANAL)	Additives feed cost
SALTSTOT(Y,PS,ANAL)	Salts and minerals feed cost
FEEDTOT(Y,PS,ANAL)	Feed cost total

Costs of forage crops and grass land maintenance

LABOURPERSYSTEM(Y,PS,ANAL)	Salaried labour per forage system
OPERATIONALCOST(Y,PS,ANAL)	Operational cost seed fertiliser etc.
FORAGEGRASSTOT(Y,PS,ANAL)	Total costs of forage crops and grass land maintenance

Consumables and small equipment

VETCOSTY(Y,PS,ANAL)	Veterinary costs and medicines (cost per animal)
ARTIFINSEMY(Y,PS,ANAL)	Artificial insemination (cost per reprod female)
HERDERY(Y,PS,ANAL)	Herder (months per year)
LABOURY(Y,PS,ANAL)	Salaried labour (days per year)
OTHERCONSY(Y,PS,ANAL)	Other (maintenance transport) (cost per year)
CONSUMABLETOT(Y,PS,ANAL)	Consumables total cost per year

Taxes and contributions

File and parameter names	Descriptions
GRAZINGY(Y,PS,ANAL)	Cost of access to grazing (ha)
LIVETAXY(Y,PS,ANAL)	Livestock taxes (per animal)
AGTAXY(Y,PS,ANAL)	Agricultural taxes (ha)
WATERY(Y,PS,ANAL)	Cost of access to water (month)
TAXTOT(Y,PS,ANAL)	Tax total

Domestic costs for economic analysis

FAMLABY(Y,PS,ANAL)	Family labour (people per year)
LIVECAPINTY(Y,PS,ANAL)	Live capital (animals) (interest rate)
LANDCAPY(Y,PS,ANAL)	Land capital (cost per year)
PASTWATY(Y,PS,ANAL)	Cost of transhumance (pasture + water) (cost per year)
OTHERDOMY(Y,PS,ANAL)	Other (cost per year)
DOMCOSTTOT(Y,PS,ANAL)	Domestic cost total

PRODEXPCOSTTOT(Y,PS,ANAL)	Total production costs and general expenses

Valuation of animal products

IMEATINV(Y,PS,ANAL)	Income from meat + inventory change per year
IMEAT(Y,PS,ANAL)	Income from meat per year
IMILK(Y,PS,ANAL)	Income from milk per year
ISKINS(Y,PS,ANAL)	Income from hides and skins per year
IWOOL(Y,PS,ANAL)	Income from wool per year
IORGM(Y,PS,ANAL)	Income from organic matter per year
IDRAUGHT(Y,PS,ANAL)	Income from draught animals per year
LIVEPRODTOT(Y,PS,ANAL)	Total livestock produce per year
LIVEPRODINVTOT(Y,PS,ANAL)	Total livestock produce + inventory change per year

6DynModIndOption2.inc

Financial and economic indicators for animal activity

NETINCANIM(Y,PS,ANAL)	Net income from animal production (gross margin)
PROFITMARGIN(Y,PS,ANAL)	Profit margin (net income per product)
NETINCFAM(Y,PS,ANAL)	Net income per active family member
NETINCFEM(Y,PS,ANAL)	Net income per reproductive female
NETINCPERANIM(Y,PS,ANAL)	Net income per animal
PRODCOSTFEM(Y,PS,ANAL)	Production costs and gen expenses per repr female
FEEDCOSTFEM(Y,PS,ANAL)	Feed cost per reproductive female
OTHERINCAGRIC(Y,PS,ANAL)	Other agric income (other livestock production + crops)
OHTERINCNONAG(Y,PS,ANAL)	Other non-agricultural income
NETINCBEFORELOAN(Y,PS,ANAL)	Total net income before financing the loan for working capital
INTERESTLOAN(Y,PS,ANAL)	Interest on loans for working capital
NETINCAFTFINANCE(Y,PS,ANAL)	Net income from animal prod after financing loan for working capital
NETINC(Y,PS,ANAL)	Total net income after financing the loan for working capital

Other indicators

Structure of production costs and general expenses (%)

CSTRUCLAB(Y,PS,ANAL)	Cost share of salaried labour

File and parameter names	Descriptions
CSTRUCFEED(Y,PS,ANAL)	Cost share of feeds
CSTRUCVET(Y,PS,ANAL)	Cost share of veterinary costs and artificial insemination
CSTRUCOTH(Y,PS,ANAL)	Cost share of other costs (water and taxes)
CSTRUCDOM(Y,PS,ANAL)	Cost share of domestic costs

Product structure

PSTRUCMEAT(Y,PS,ANAL)	Production share of meat
PSTRUCMILK(Y,PS,ANAL)	Production share of milk
PSTRUCSKIN(Y,PS,ANAL)	Production share of hides and skins
PSTRUCWOOL(Y,PS,ANAL)	Production share of wool
PSTRUCORGMAT(Y,PS,ANAL)	Production share of organic matter
PSTRUCDRAUGHT(Y,PS,ANAL)	Production share of animal draught

Unit margin for meat

MEATPRODCOST(Y,PS,ANAL)	Production cost of meat
MEATSALEPRICE(Y,PS,ANAL)	Sale price of meat
MEATGROSSBEN(Y,PS,ANAL)	Gross unitary benefit of meat
MEATPROFRATE(Y,PS,ANAL)	Profit rate (gross benefit div by prod cost) of meat

Unit margin for milk

MILKPRODCOST(Y,PS,ANAL)	Production cost of milk
MILKSALEPRICE(Y,PS,ANAL)	Sale price of milk
MILKGROSSBEN(Y,PS,ANAL)	Gross unitary benefit of milk
MILKPROFRATE(Y,PS,ANAL)	Profit rate (gross benefit div by prod cost) of milk

Calculations of parameters for modules 4, 5 and 6

TAXCONS(Y,PS,ANAL)	Tax receipts generated from concentrates
ECOSTTRADCONS(Y,PS,ANAL)	Economic cost of tradeable concentrates
ECOSTNTRADCONS(Y,PS,ANAL)	Economic cost of non-tradeable concentrates
TAXGOODS(Y,PS,ANAL)	Tax receipts generated from all goods (incl concentrates)
ECOSTTRADGOODS(Y,PS,ANAL)	Economic cost of all tradeable goods (incl concentrates)
ECOSTNTRADGOODS(Y,PS,ANAL)	Economic cost of all non-tradeable goods (incl concentrates)
DOMCOSTRESOURCE(Y,PS,ANAL)	Domestic resource costs
INTCOST(Y,PS,ANAL)	Intermediate cost
INTCOSTPERANIM(Y,PS,ANAL)	Intermediate cost per animal used
INTCOSTSTRUCANIM(Y,PS,ANAL)	% intermediate cost per animal
INTCOSTSTRUCMILK(Y,PS,ANAL)	% intermediate cost per litre of milk
INTCOSTSTRUCTRAC(Y,PS,ANAL)	% intermediate cost energy per hour of traction

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Income indicators - part of diagnostic sheet section III

Declared in previous include file for option 2 (with survey data),

but calculated here because it uses data for option 1 (without survey data)

Selected descriptions repeated here for clarity

NETINCANIM(Y,PS,ANAL)	Net income from animal production (gross margin)
OTHERINCAGRIC(Y,PS,ANAL)	Other agric income (other livestock production + crops)

File and parameter names	Descriptions
OHTERINCNONAG(Y,PS,ANAL)	Other non-agricultural income
NETINCBEFORELOAN(Y,PS,ANAL)	Total net income before financing the loan for working capital
INTERESTLOAN(Y,PS,ANAL)	Interest on loans for working capital
NETINCAFTFINANCE(Y,PS,ANAL)	Net income from animal prod after financing loan for working capital
NETINC(Y,PS,ANAL)	Total net income after financing the loan for working capital

Indicators of vulnerability

In relation to the livestock farming system considered

(F in front of parameter name indicates farming system)

Monetary vulnerability

FSINC(Y,PS,ANAL)	Net income from livestock prod per hhold poverty line
FSTOTINC(Y,PS,ANAL)	Total net income per household poverty line
FSINCTOTINC(Y,PS,ANAL)	Net income from livestock prod per total net income
FSNOANIMREQ(Y,PS,ANAL)	Number of animals needed to reach poverty threshold (per person)
FSNOFEMERQ(Y,PS,ANAL)	Number of reprod females needed to reach poverty threshold (per person)
FSCAPREQ(Y,PS,ANAL)	Live capital needed to reach the poverty threshold (per person)
FSNOPEOPLE(Y,PS,ANAL)	Number of people covered by the single farming system

Values used in food security calculations

These parameters are not displayed in the diagnostic sheet but are used as intermediate step to facilitate the nutritional contributions in the food security section

NUTREQCAL(PS)	Nutritional calorie requirement per family
NUTREQPROT(PS)	Nutritional protein requirement per family
NUTREQLIP(PS)	Nutritional lipid requirement per family
MEATCAL(PS)	Meat calories consumed on farm
MEATPROT(PS)	Meat calories consumed on farm
MEATLIP(PS)	Meat calories consumed on farm
MILKCAL(PS)	Milk or egg calories consumed on farm
MILKPROT(PS)	Milk or egg calories consumed on farm
MILKLIP(PS)	Milk or egg calories consumed on farm

Food security for single livestock farming system (part of diagnostic sheet section IV)

Nutritional contributions (%)

Household nutritional requirements (HREQ) covered by animal production

HREQCALORIES(Y,PS,ANAL)	Household calorie requirements covered by animal production
HREQPROTEINS(Y,PS,ANAL)	Household protein requirements covered by animal production
HREQLIPIDS(Y,PS,ANAL)	Household lipid requirements covered by animal production

Cereal requirements (CREQ) covered by income from animal production

CREQCASH(Y,PS,ANAL)	Cash flow from animal production
CREQANIMSH(Y,PS,ANAL)	Household cereal requirements covered by animal production (%)
CREQANIMMNTH(Y,PS,ANAL)	Household cereal requirements covered by animal production (in months)
CREQNOANIM(Y,PS,ANAL)	Number of animals needed to cover household cereal requirements
CDEFANIMSH(Y,PS,ANAL)	Household cereal deficit covered by animal production (%)

File and parameter names   **Descriptions**

For the whole livestock farming system (including the other species) (part of diagnostic sheet section IV)

(W in front of parameter name indicates whole system)

Monetary vulnerability for whole livestock farming system

WINC(Y,PS,ANAL)	Net income from whole system livestock prod per hhold poverty line
WINCTOTINC(Y,PS,ANAL)	Net income from whole system livestock prod per total net income
WNOPEOPLE(Y,PS,ANAL)	Number of people covered by the whole system

Food security for whole livestock farming system (nutritional contributions)

WREQCALORIES(Y,PS,ANAL)	Household calorie requirements covered by whole system animal production
WREQPROTEINS(Y,PS,ANAL)	Household protein requirements covered by whole system animal production
WREQLIPIDS(Y,PS,ANAL)	Household lipid requirements covered by whole system animal production

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RES1	Result set 1 for synthesis 1 for selected year

OfftakeRate	Offtake rate (by zootechnical unit)
ProductyRate	Rate of productivity in numbers
MeatAveWght	Average weight of animals used
Dressing	Dressing percentage
MeatProd	Total meat production (kg)
ReprFem	Proportion of reproductive females in the herd
MilkProdty	Milk productivity (litre per repr fem per year)
MilkProd	Total herd milk production (litre per year)
SkinProd	Hides and skins production (kg)
WoolProd	Wool production (kg)
Draughts	% draught animals in the herd
EnerProd	Energy production (number of days of draughts)
OrgMatProd	Organic matter production (kg per year)
MeatAveP	Average price of meat (per kg)
MilkAveP	Average price of milk (per litre)
SkinsAveP	Average price of hides and skins (per kg)
WoolAveP	Average price of wool (per kg)
OrgMatAveP	Average price of organic matter (per kg)
MeatHome	Meat share home consumed
MilkHome	Milk share home consumed
SkinsHome	Hides and skins share home consumed
WoolHome	Wool share home consumed
OrgMatHome	Organic matter share home consumed
DraughtHome	Draught share home consumed
MeatCons	Meat share direct sales to consumer

File and parameter names	Descriptions
MilkCons	Milk share direct sales to consumer
OrgMatCons	Organic matter share direct sales to consumer
DraughtCons	Draught share direct sales to consumer
MeatValCh	Meat share traded in value chain
MilkValCh	Milk share traded in value chain
SkinsValCh	Hides and skins share traded in value chain
WoolValCh	Wool share traded in value chain
OrgMatValCh	Organic matter share traded in value chain

RES2   Result set 2 for synthesis 2 for financial and economic analysis for selected year

NetIncAnim	Net income from livestock production
NetIncFam	Net income from livestock production per active family member
NetIncPerAnim	Net income from livestock production per animal
NetIincFem	Net income from livestock production per reproductive female
ProfitMargin	Profit margin (net income per product)
CReqCash	Cash flow per animal
TaxGoods	Tax receipts per animal
IntCostStrucAnim	% intermediate costs per animal (%)
IntCostStrucMilk	% intermediate costs per litre of milk (%)
IntCostStrucTrac	% intermediate costs of energy (per hour of traction) (%)
MeatProdCost	Meat production cost (kg)
MilkProdCost	Milk production cost (litre)
ProdCostFem	Production costs and general expenses per reproductive female
FeedCostFem	Feed cost per reproductive female
DomCostResource	% Domestic resource cost (DRC) (%)

RES3   Result set 3 for synthesis 1 for average over period

OfftakeRateAVE	Offtake rate (by zootechnical unit) (average)
ProductyRateAVE	Rate of productivity in numbers (average)
MeatAveWghtAVE	Average weight of animals used (average)
DressingAVE	Dressing percentage (average)
MeatProdAVE	Total meat production (kg) (average)
ReprFemAVE	Proportion of reproductive females in the herd (average)
MilkProdtyAVE	Milk productivity (litre per repr fem per year) (average)
MilkProdAVE	Total herd milk production (litre per year) (average)
SkinProdAVE	Hides and skins production (kg) (average)
WoolProdAVE	Wool production (kg) (average)
DraughtsAVE	% draught animals in the herd (average)
EnerProdAVE	Energy production (number of days of draughts) (average)
OrgMatProdAVE	Organic matter production (kg per year) (average)

File and parameter names	Descriptions
RES4　　Result set 4 for synthesis 2 for financial and economic analysis for average over period	
NetIncAnimAVE	Net income from livestock production (average)
NetIncFamAVE	Net income from livestock production per active family member (average)
NetIncPerAnimAVE	Net income from livestock production per animal (average)
NetIincFemAVE	Net income from livestock production per reproductive female (average)
ProfitMarginAVE	Profit margin (net income per product) (average)
CReqCashAVE	Cash flow per animal (average)
TaxGoodsAVE	Tax receipts per animal (average)
IntCostStrucAnimAVE	% intermediate costs per animal (%) (average)
IntCostStrucMilkAVE	% intermediate costs per litre of milk (%) (average)
IntCostStrucTracAVE	% intermediate costs of energy (per hour of traction) (%) (average)
MeatProdCostAVE	Meat production cost (kg) (average)
MilkProdCostAVE	Milk production cost (litre) (average)
ProdCostFemAVE	Production costs and general expenses per reproductive female (average)
FeedCostFemAVE	Feed cost per reproductive female (average)
DomCostResourceAVE	% Domestic resource cost (DRC) (%) (average)