Animal Production and Health Division

LDPS² User's Guide

by Louis-Gilles Lalonde
and Takuo Sukigara

Food and Agriculture Organization of the United Nations
November, 1997

TABLE OF CONTENTS

Work in progress
For proposals and comments, please contact:

Henning Steinfeld
Animal Production and Health Division (AGA), FAO
Viale delle Terme di Caracalla, 00100 Rome, ITALY
FAX: +39 6 5705 5749
E-mail: henning.steinfeld@fao.org

LIST OF FIGURES

LIST OF TABLES

Abbreviations

AGA	Animal Production and Health Division, Agriculture Department of FAO
CF	Crude Fibre
CME	metabolisable energy required for maintaining the breeding female for one year
CP	Crude Protein
DCP	Digestible Crude Protein
DLP	Dermal Loss requirements of Protein
DM	Dry matter
EUP	Endogenous Urinary Requirements of protein
FAO	Food and Agriculture Organization, Rome
FAOSTAT	on-line/multilingual database of the Food and Agriculture Organization
FUM	Feed Utilization Matrix
GDP	Gross Domestic Product
gr	gram
ha	hectare
IFPRI	International Food Policy Research Institute
kg	kilogram
LDPS	Livestock Development Planning System
LSU, LSUs	Livestock Standard Unit(s)
LW	average liveweight
Mcal	Mega Calorie (energy)
ME	Metabolisable Energy
MEP	Metabolisable Energy for milk Production
mill	millions
MJ	Mega Joule (energy)
OECF	Overseas Economic Cooperation Fund
PFP	additional protein requirement for pregnant female breeder
RAM	Random Access Memory
RDP	Rumen Degradable Protein
rLSU	Reference Livestock Standard Unit
sLSU	System Specific Livestock Standard Unit
TP	Tissue Protein retention
UDP	rumen undegradable protein
USDA	United States Department of Agriculture
WAICENT	World Agricultural Information Centre of the Food and Agriculture Organization

Introduction

How this guide is organized

Chapter 1 takes you on a tour of $LDPS^2$. It is an introduction to livestock planning and a quick overview of the spreadsheet's functions. It is suited for first-time users and introduces the more detailed presentation of chapter 2.

Chapter 2 explores $LDPS^2$ in details. Every sheet and module is explained quoting examples and tips to use the guide more efficiently.

Chapter 3 discusses some of the most common problems you are likely to encounter using $LDPS^2$ and Excel. Possible causes and solutions are given for each type of problem. A few warnings are issued concerning the uses and misuses of $LDPS^2$ as a planning tool.

A complete case study of China using $LDPS^2$ is given in chapter 4. This case is based on actual data, so tips to use $LDPS^2$ are explained thoroughly.

Conventions

The following conventions are used throughout the guide:

- Menu commands appear in **CAPITAL BOLD** (ex: choose **FILE_QUIT** to exit Excel);
- Excel keywords appear in *CAPITAL ITALIC* (ex: cell contain the formula *SUM*);
- user input appears in `lowercase monospace font` (ex: enter `Cattle` in the cell)
- Cell or range address are in **bold Arial font** (ex: cell **D25**)
- Range of cells is given in matrix notation, like this: **[N30 : X54]**. This refers to a range of cells beginning in row 30, column N and ending in row 54, column X.

CAUTION
The Caution box contains critical information about the operations described. Failure to comply with these instructions may result in a malfunction of $LDPS^2$.

TIP
The Tip box tells you about methods that are easier, faster and more efficient.

Within the spreadsheet, the following conventions are used:

- the **blue color** indicates the only cells that can be edited: parameters, some labels, etc.
- text in **black** cannot be edited: equations, variable names, macros, etc.;
- text in **green** indicates final results, as shown in sheets "Results" ;
- text in **red** indicates negative results which cannot be edited. If you find numbers in red, it may mean that calculations are incorrect. You should check your parameters value.
- Notes and comments are indicated in **purple**.

What is LDPS²?

LDPS² stands for "Livestock Development Planning System, version 2". It is the second version of a software originally written in Basic. The new version is an Excel 5 workbook containing six visible and two hidden sheets as described in Table 1.

Table 1: LDPS² sheets

Sheet name	**Status**	**Content**
Welcome	Visible	Logo, starting tips and usage instructions.
Labels	Visible	LDPS² user-defined labels.
Parameters	Visible	Sheet containing most of LDPS² parameter sets
Resources	Visible	Sheet containing equations sets for determining available resources, assigning available resources to the various animal systems and calculating the manure output.
Results	Visible	Screen for selecting and displaying the results of Demand-driven routine, the Resource-driven routine and Herd Growth Routine.
Sensitivity	Visible	Sheet for performing sensitivity analysis
Calculations	Hidden	Basic equation sets of LDPS². **To be edited only by advanced users only.**
Macros	Hidden	Macro commands of LDPS². **To be edited only by advanced users only.**

Some sheets have been hidden to protect the spreadsheet. However, altering any of the sheets may cause LDPS² not to work correctly. It is strongly recommended that you make a backup copy of the original version of LDPS² and that you keep it unmodified in a safe place.

Installation

LDPS² has been tested using Excel versions 5 and 7. If you are using the English Excel, we recommend that you use the English version of LDPS², since some keywords are not automatically translated. LDPS² is currently available in English, French and Spanish. Please contact FAO to obtain the appropriate version (see the following "Finding help" for the address).

Minimum requirements for using LDPS² are:

- IBM-PC or compatible, 486 processor;
- 4 megabytes RAM, 5 megabytes of free disk space;
- Excel 5.0 (or Excel 7.0) and Windows 3.1 (or Windows 95)
- color monitor with a VGA card.

LDPS² is distributed as a self-decompressing archive named ldps2.exe. This archive contains only one file named "ldps2.xls". To decompress the archive, copy it into a folder of its own anywhere on your hard disk (for example, folder C:\LDPS2) and double-click on it from the

File manager. The archive then decompresses itself and automatically creates the file "ldps2.xls". You are now ready to start using LDPS^2 by double-clicking on the file "ldps2.xls". If Excel doesn't start automatically, you will have to first start Excel, and then open ldps2.xls from the "**FILE_OPEN**" menu.

For a list of possible problems and solutions, see Chapter 3: "Problem solving".

Finding help

There are three sources of help for LDPS^2 users:

- the user's guide contains detailed information on how LDPS^2 works and how to use it;
- Excel help files, from the HELP item in the menubar;
- FAO staff and the authors of the spreadsheet can be reached at the following addresses:

FAO/AGA	**Authors**	
Henning Steinfeld	Louis-Gilles Lalonde	Takuo Sukigara
FAO/AGA, Rome, Italy	Quebec, Canada	FAO/AGA, Rome, Italy
FAX: 396.5705.5749		
E-mail: henning.steinfeld@fao.org	E-mail: baobab@iname.com	E-mail : takuo.sukigara@fao.org

1. First time through

This chapter is designed to give you a quick overview of the way LDPS^2 works and how the spreadsheet is structured. A more advanced discussion on LDPS^2 can be found in Chapter 2.

LDPS^2 is a spreadsheet-based tool designed to help planners around the world simulate animal herd growth and structure. These simulations are based on a number of parameters, variables and equation sets. Parameters can be changed, while variables and equation sets cannot.

LDPS^2 is an Excel spreadsheet, so it will not work with Lotus or Quattro Pro. You also need Windows (3.1, 3.11 or 95) to run it. You can start LDPS^2 by double-clicking on the file "ldps2.xls" from the File Manager (Windows 3.1) or from the Explorer (Windows 95).

(1) SHEET "WELCOME"

The first sheet displayed when starting LDPS^2 is the Welcome Sheet. This sheet is a condensed version of the introduction chapter and is aimed at providing on-screen information to help you navigate within the file. You can jump from one screen to another by clicking the "Next" and "Previous" buttons. The fifth screen contains a Tour Map of LDPS² (see Figure 1). The Map contains buttons to jump directly to the specified section of the spreadsheet. Use this Map to move around and to get familiar with LDPS². You can also use the sheet tabs located at the bottom of the every sheet, as shown in Figure 2. These tabs show the name of each sheet. For example, clicking on the tab named "Labels" brings that sheet on top so you can see the content. You can display whatever sheet you like, whenever you wish. Switching from one sheet to the other has no impact on the way LDPS² works.

The best way to get familiar with the spreadsheet is to start working with it. Since LDPS² is shipped with a complete default data set, you can switch to the "Results" sheet and experiment with the different animal systems straight away.

Figure 1: Tour Map of LDPS² in the "Welcome" sheet

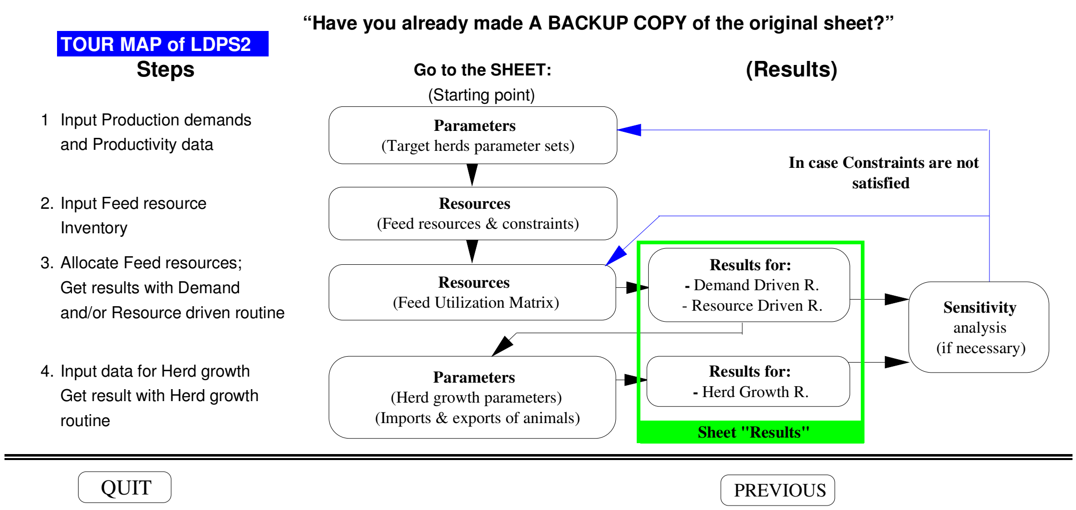


Figure 2: Sheet tabs of LDPS²

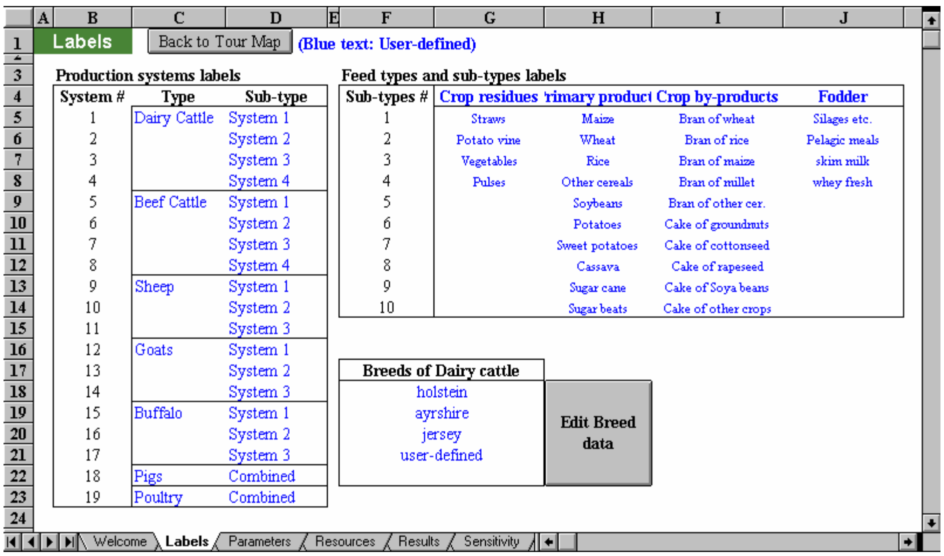
<u>(2) SHEET "LABELS"</u>

Jump to sheet "Labels" by clicking on the tab named "Labels". Figure 3 shows the upper-left part of the screen. This sheet is used to change the default names used by LDPS² throughout the spreadsheet. For example, you can model up to four animal sub-systems for

Dairy Cattle. By default, these sub-systems are named "System 1", "System 2" and so on. To change these defaults, simply type in a new name. For example, in the Dairy Cattle animal system, change "System 1" to "`Nomadic`" or “`Farm A`”. This change is instantly updated throughout the spreadsheet, so every cell using "System 1" before will now show "Nomadic" instead.

Names of feedstuff and of dairy breeds can also be changed. Basic parameters defining each breed can be edited by clicking on the "Edit Breed data" button.

Figure 3: Sheet "Labels"



In Figure 3 above, system sub-types are named “system 1”, “system 2”, and so on. These names may actually differ from the ones displayed within your own version of LDPS^2. These labels can be changed to whatever suits you. Changes made to labels do not affect the way LDPS^2 works.

(3) Sheet "Parameters"

Sheet "Parameters" contains five sections, each containing a specific set of parameters. These sections are:

- Target herds parameter sets (range A1:AA61)
- System LSUs (range A69:L78)
- Constants (range A81:O93)
- Herd growth parameters (range A96:W127)
- Imports and Exports of live animals (range A139: J174)

Figure 4 shows the upper left corner of sheet “Parameters”. Columns A to F refer to the four animal systems of Dairy cattle : Column A shows the number assigned to each Parameter ; Column B contains the name of each parameter ; Columns C to F contain the parameters’ actual values.

Figure 4: Sheet "Parameters"

	A	B	C	D	E	F
1	Target herds parameter sets			Back to Tour Map		
2						
3		Parameter	Dairy Cattle			
4	No	name	System 1	System 2	System 3	System 4
5	1	Milk production demand	1,515,000	3,224,000	1,025,000	0
6	2	Distribution losses	0.000	0.000	0.000	0.000
7	3	Fertility rate	0.750	0.900	0.900	0.000
8	4	Prolificacy rate	1.000	1.000	1.000	0.000
9	5	Breeder males per breeder female	0.001	0.001	0.001	0.000
10	6	Milk yield per lactation	2.000	4.500	4.500	0.000
11	7	Fraction of females milked	0.900	0.900	0.900	0.000
12	8	Cow mortality rate	0.030	0.040	0.040	0.000
13	9	Bull mortality rate	0.030	0.040	0.040	0.000
14	10	Female replacement mortality rate	0.030	0.040	0.040	0.000
15	11	Male replacement mortality rate	0.030	0.040	0.040	0.000
16	12	Female young mortality rate	0.070	0.060	0.060	0.000
17	13	Male young mortality rate	0.070	0.060	0.060	0.000
18	14	Other stock mortality rate	0.030	0.040	0.040	0.000
19	15	Draught animals mortality rate	0.030	0.040	0.040	0.000
20	16	Years in breeding herd, cows	5.000	4.500	4.500	0.000
21	17	Years in breeding herd, bulls	5.000	5.000	5.000	0.000
22	18	Years in replacement herd, females	1.000	1.000	1.000	0.000
23	19	Years in replacement herd, males	1.000	1.000	1.000	0.000
24	20	Years from young to slaughter, other stock	1.000	1.000	1.000	0.000

Welcome / Labels / Parameters / Resources / Results

(4) SHEET "RESOURCES"

Sheet “Resources” contains all the data, equations and parameters needed to set the quantity of feedstuff available for every animal system.

a) Quantities are entered in 100 hectares (Grazing land) or tons of dry matter, and LDPS[2] converts it into total energy in LSUs[1] and tons of digestible protein. Figure 5 shows the upper-left part of the sheet “Resources” where total available feedstuff is set for each feed type (range **[B1 : J78]**).

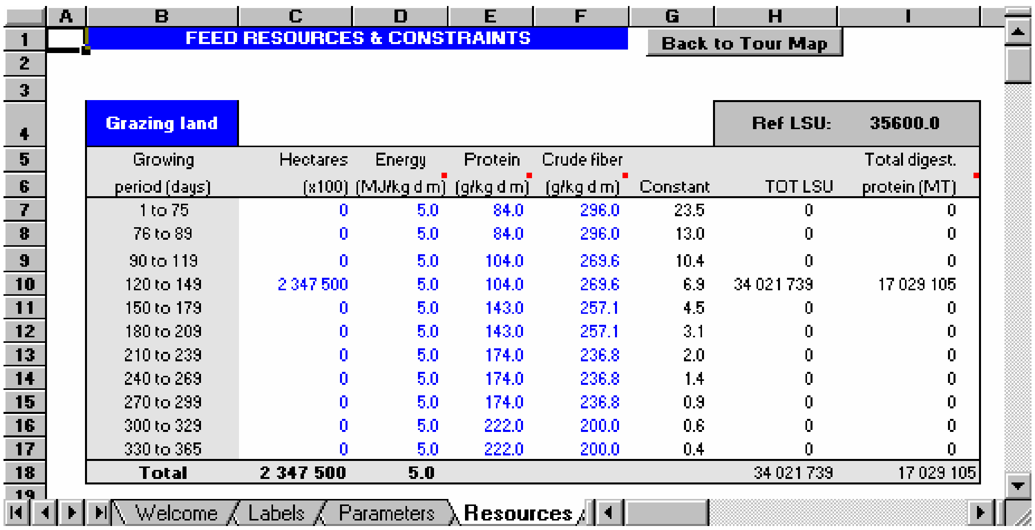
b) Allocation of available feedstuff is performed using the Feed Utilization Matrix (FUM, Figure 6) that can be found in range **[N1 : X27]**. Available feed can be allocated in two ways:

1) Manually: allocated LSUs are entered directly by the user in the central part of the FUM;

[1] Livestock Standard Units; see chapter 2.3.1.2

2) Automatically: Allocation of feedstuff to the various animal systems can be performed using a built-in optimization routine. To run the optimization routine, simply click on the «Optimize» button in range **[N2]**.

Figure 5: Sheet "Resources"



Growing period (days)	Hectares (x100)	Energy (MJ/kg d m)	Protein (g/kg d m)	Crude fiber (g/kg d m)	Constant	TOT LSU	Total digest. protein (MT)
1 to 75	0	5.0	84.0	296.0	23.5	0	0
76 to 89	0	5.0	84.0	296.0	13.0	0	0
90 to 119	0	5.0	104.0	269.6	10.4	0	0
120 to 149	2 347 500	5.0	104.0	269.6	6.9	34 021 739	17 029 105
150 to 179	0	5.0	143.0	257.1	4.5	0	0
180 to 209	0	5.0	143.0	257.1	3.1	0	0
210 to 239	0	5.0	174.0	236.8	2.0	0	0
240 to 269	0	5.0	174.0	236.8	1.4	0	0
270 to 299	0	5.0	174.0	236.8	0.9	0	0
300 to 329	0	5.0	222.0	200.0	0.6	0	0
330 to 365	0	5.0	222.0	200.0	0.4	0	0
Total	**2 347 500**	**5.0**				34 021 739	17 029 105

Allocated LSUs are then automatically converted by LDPS² into tons of digestible protein (range **[N30 : X54]**. Protein allocation can not be set directly.

You can set minimum LSU allocation per animal system and per feed type in range **[N57 : U80]**. These minimum values are used by the optimization routine to ensure more realistic results. If you allocate manually the available resources, the minimum values are not used by LDPS².

Sheet “Resources” also contains equations and parameters used for the calculation of manure output by the various animal systems. These calculations are performed in range **[AH1 : AT231]**. Manure output is also shown in the “Results” sheet.

Figure 6: The Feed Utilization Matrix section of Sheet "Resources"

FEED UTILIZATION MATRIX (LSUs)

Optimize allocation

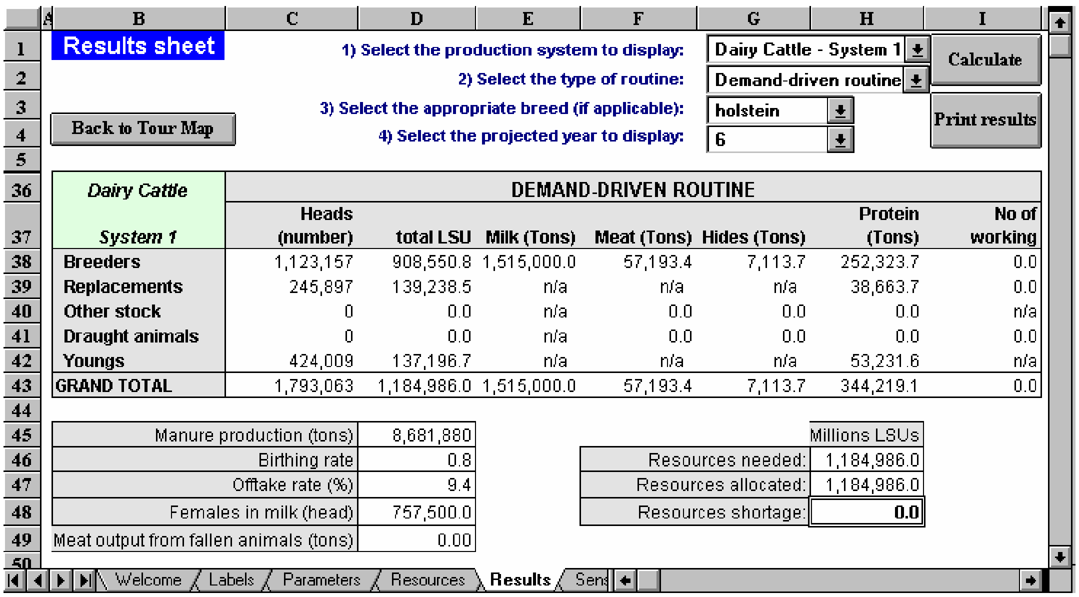
			Grazing land		Crop residues	Primary products	Crop by-products	Fodder	ME (Million Mcal)			
			< 90 days	> 90 days					1,256,324	1,266,133	-9,809	
		Relative prices	1	1.1	1.5	2	1.4	1.3	Total LSU needed	Total LSU allocated	Total LSU missing	Total needed M Mcal
Total available:		148,940,390	0	34,021,739	29,779,942	55,558,013	27,887,961	1,692,735				
Total allocated:		148,806,246	0	34,021,739	29,661,094	55,558,013	27,887,961	1,677,439				
Total remaining:		134,144	0	0	118,848	0	(0)	15,296	147,653,369	148,806,246	(1,152,877)	1,256,324
Dairy Cattle	System 1		0	1,000,000	34,986	0	100,000	50,000	1,184,986	1,184,986	(0)	10,083
	System 2		0	1,000,000	11,068	200,000	100,000	100,000	1,411,068	1,411,068	(0)	12,006
	System 3		0	200,000	28,618	150,000	50,000	20,000	448,618	448,618	(0)	3,817
	System 4		0	0	0	0	0	0	0	0	0	0
Beef Cattle	System 1		0	4,000,000	300,000	0	200,000	100,000	5,101,369	4,600,000	501,369	43,406
	System 2		0	5,000,000	11,400,000	300,000	900,000	300,000	19,821,717	17,900,000	1,921,717	168,655
	System 3		0	3,900,000	6,950,000	750,000	1,000,000	400,000	14,489,130	13,000,000	1,489,130	123,282
	System 4		0	0	0	0	0	0	0	0	0	0
Sheep	System 1		0	4,308,865	0	0	0	0	4,951,184	4,308,865	642,319	42,128
	System 2		0	586,308	0	0	0	0	690,579	586,308	104,271	5,876
	System 3		0	2,500,000	0	50,000	135,258	100,000	3,448,860	2,785,258	663,602	29,345
Goats	System 1		0	1,231,713	0	0	0	0	1,377,292	1,231,713	145,579	11,719
	System 2		0	378,428	0	0	0	0	427,735	378,428	49,307	3,639
	System 3		0	6,000,000	450,000	98,661	700,000	200,000	9,037,939	7,448,661	1,589,278	76,900
Buffalo	System 1		0	3,916,425	5,870,000	750,000	1,426,000	0	13,298,773	11,962,425	1,336,348	113,154
	System 2		0	0	0	0	0	0	0	0	0	0
	System 3		0	0	0	0	0	0	0	0	0	0
Pigs	Combined		0	0	0	37,259,352	21,776,703	0	47,040,240	59,036,055	(11,995,815)	400,247
Poultry	Combined		0	0	4,616,422	16,000,000	1,500,000	407,439	24,923,881	22,523,861	2,400,020	212,067

Welcome | Labels | Parameters | Resources | Results | Sensitivity

(5) SHEET "RESULTS"

Sheet “Results” shows results for all animal systems and products calculated by the Demand-driven routine, the Resource-driven routine and the Herd Growth routine. The sheet contains two sections: the upper-left section (range **[B1 : J49]**, see Figure 7) shows selectable results in a concise way. Only one system is shown at a time. The displayed system is selected using the appropriate buttons (range **[G1 : G4]**). The second section (range **[B60 : I163]** and **[R36 : Y321]**) contains all the results for all systems. This section of the sheet shows results in a less aggregate fashion.

Figure 7: Sheet "Results"



Dairy Cattle System 1	Heads (number)	total LSU	Milk (Tons)	Meat (Tons)	Hides (Tons)	Protein (Tons)	No of working
	DEMAND-DRIVEN ROUTINE						
Breeders	1,123,157	908,550.8	1,515,000.0	57,193.4	7,113.7	252,323.7	0.0
Replacements	245,897	139,238.5	n/a	n/a	n/a	38,663.7	0.0
Other stock	0	0.0	n/a	0.0	0.0	0.0	n/a
Draught animals	0	0.0	n/a	0.0	0.0	0.0	0.0
Youngs	424,009	137,196.7	n/a	n/a	n/a	53,231.6	n/a
GRAND TOTAL	1,793,063	1,184,986.0	1,515,000.0	57,193.4	7,113.7	344,219.1	0.0

Manure production (tons)	8,681,880
Birthing rate	0.8
Offtake rate (%)	9.4
Females in milk (head)	757,500.0
Meat output from fallen animals (tons)	0.00

	Millions LSUs
Resources needed:	1,184,986.0
Resources allocated:	1,184,986.0
Resources shortage:	0.0

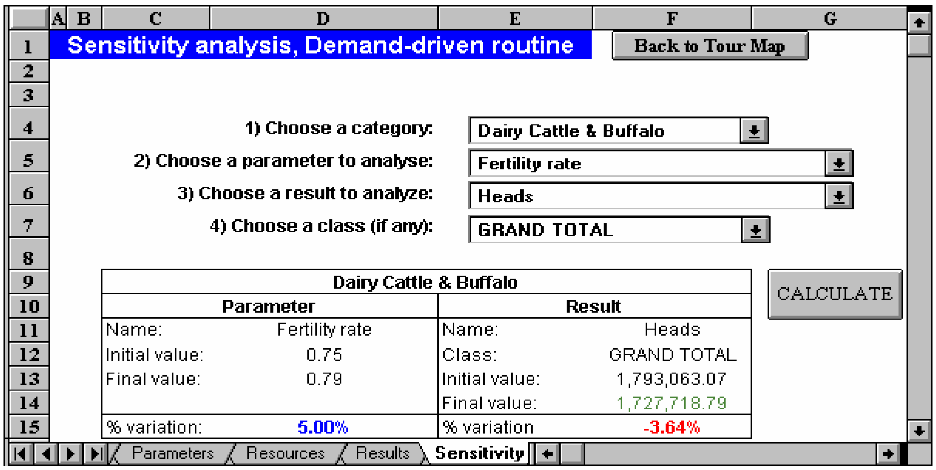
When choosing to display the Herd Growth results, LDPS[2] unhides rows 6 through 35 (inclusive). These rows are normally hidden when showing Demand-driven results.

(6) SHEET "SENSITIVITY"

Once results have been calculated, you can perform sensitivity on selected parameters and results. Sensitivity analysis answers the following question: “How does a small variation in a parameter’s value affect a given result’s value?”. A 5% variation in a given parameter may induce a 10% variation in a given result. That specific result would therefore be considered highly sensitive to that specific parameter’s value. On the contrary, a 5% variation in a parameter’s value may induce only a 0.5% variation in a given result. Such a result would then show a low sensitivity to that parameter.

Figure 8 shows sheet “Sensitivity”. Sensitivity analysis is a four step process: first, you must select an animal category. Second, you select a parameter to analyze. Third, you select a result, and fourth, you select a class (this fourth step is applicable only for a certain number of results). You can change the level of sensitivity used by LDPS². By default, this level is set to 5%. You can change this percentage to whatever you like, but in order for the sensitivity calculations to perform in a meaningful way, this percentage value should be kept small (not over 10%). Negative values can also be used for the percentage.

Figure 8: Sheet "Sensitivity"



<u>(7) Quitting LDPS²</u>

Once you have finished working with LDPS² and want to quit the spreadsheet, you may do so by choosing one of the following methods:

1) Go back to the "Welcome" sheet and click on the "Quit" button. This will close LDPS² ;
2) In the "**File**" menu of Excel (the first menu in the upper menubar), select "**Quit**". This closes LDPS² and Excel altogether;
3) Press the "Alt" key on your keyboard and while holding it, press the "F4" key. The combination of "Alt" and "F4" closes Excel.

In any case, Excel will ask you if you want to save the changes made to the worksheet. If you want to keep the changes, you should select "Yes". If you do not want to keep these changes or do not recall having made any significant changes, select "No" (see 2.6 Saving your work).

The best way to learn how LDPS² works and how to use it, is to actually use it. Try different things, change values, consult the "Results" sheet to see the impact of your changes and understand how the spreadsheet reacts. This is the fastest method for learning LDPS².

<u>Don't forget to make a copy of the spreadsheet first!</u>

2. Working with $LDPS^2$

2.1 Introduction

The livestock development planner is commonly faced with a series of demands for meat and milk and must answer the following questions:

- What are the alternative ways of meeting the product demand?
- How might production be best divided between the various livestock systems?
- What are the implications of the production for resource use?
- Are the production demands achievable with current resources? If not, what is the extent of various resource constraints?

$LDPS^2$ is designed to help the livestock planner to:

1) identify and quantify the herd/flock composition and size required to provide the specified production demand of meat and milk;
2) identify and quantify the feed and livestock constraints to reaching specified demand levels;
3) provide a means to analyze the effects of various development programmes, such as veterinary or range improvement programmes.

$LDPS^2$ consists of eight interrelated sheets (including two hidden sheets), each one assuming a particular function. There are 19 animal systems modeled in $LDPS^2$, as shown in Table 2 below. The seven broad animal categories (dairy cattle, beef cattle, sheep, goats, buffalo, pigs and poultry) are subdivided into animal systems. These subsystems may reflect geographic differences (i.e. savanna vs. forest), social and economic differences (i.e. nomadic vs. sedentary), etc.

When using $LDPS^2$, there is no compulsory sequence of action. Since $LDPS^2$ is a spreadsheet, all calculations are simultaneous. Furthermore, $LDPS^2$ comes with a complete set of default data included, so you can start working with it right out of the box.

However, the preloaded data sets may not fit. Furthermore, you may have your own data sets at hand. It is therefore recommended that you edit the default parameters to ensure that they are error free and consistent with your own data.

Table 2: Animal systems of LDPS[2]

Index	Name	Inputs	Outputs
1 2 3 4	Dairy cattle, system 1 Dairy cattle, system 2 Dairy cattle, system 3 Dairy cattle, system 4	Productivity values and Milk production	Milk, meat, hides and manure; Herd structure Energy needs Protein requirements
5 6 7 8	Beef cattle, system 1 Beef cattle, system 2 Beef cattle, system 3 Beef cattle, system 4	Productivity values and Meat production	Milk, meat, hides and manure Herd structure Energy needs Protein requirements
9 10 11	Sheep, system 1 Sheep, system 2 Sheep, system 3	Productivity values and Meat production	Milk, meat, wool and manure Herd structure Energy needs Protein requirements
12 13 14	Goats, system 1 Goats, system 2 Goats, system 3	Productivity values and Meat production	Milk, meat, wool and manure Herd structure Energy needs Protein requirements
15 16 17	Buffalo, system 1 Buffalo, system 2 Buffalo, system 3	Productivity values and Milk production	Milk, meat, hides and manure Herd structure Energy needs Protein requirements
18	Pigs, combined	Productivity values and Meat production	Meat Herd structure Energy needs Protein requirements
19	Poultry, combined	Productivity values, eggs and meat production	Eggs and meat Herd structure Energy needs Protein requirements

MODELS USED BY LDPS[2]

Three models are used within LDPS[2]:

1) The ***Demand-driven routine*** allows the calculation of a herd's size and composition, given a specified demand for domestic meat or milk. After you set the production target and the productivity parameters (fertility rate, mortality rates, etc.), LDPS[2] calculates the required herd size and composition based on a demographic model contained in sheet "Calculations". Some animal systems share the same demographic model (and thus the same equation set):

   - All Dairy cattle and buffalo systems share a common equation set, which is driven by milk production;

- All Beef cattle, sheep and goat systems share a common demographic model. These systems are meat-driven, meaning that meat production is their main purpose, even though there are other products;

- Pig system has a model of its own. It models two distinct sub-models: traditional (village pig production and commercial pig production. The results are combined at the end of the calculation process;

- Poultry also has its own equation set. This combined (village and commercial poultry) system is driven by demand for domestic egg and meat.

Results are shown in sheet "Results". These animal systems are explained in more detail in the next section.

2) The ***Resource-driven routine*** is like using the Demand-driven routine backwards: instead of asking the question "What herd size and composition is needed, given my production target?", you would rather ask yourself "What production is attainable, given total resources available and within the limits of resources allocated to the various systems?". Because demand-driven routine doesn't take resource availability into account, the resource-driven routine is a way of checking back on the targets to ensure that the calculated herds are sustainable. Resource-driven works for all 19 animal systems. Results are shown in sheet "Results".

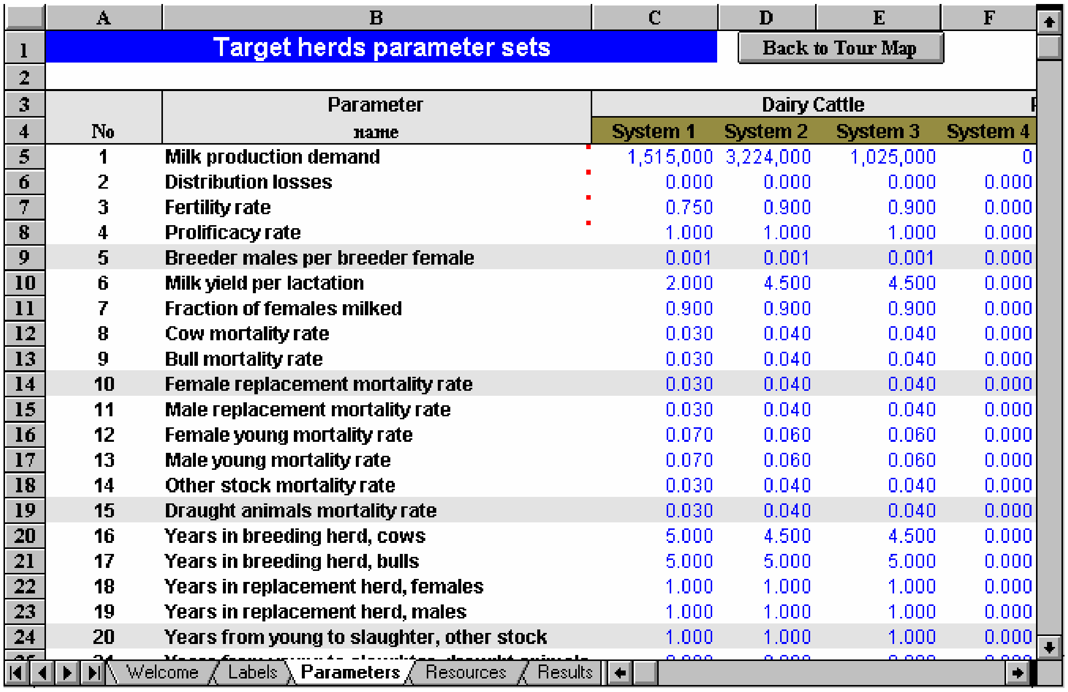
3) The ***Herd growth routine*** calculates, on a yearly basis, the size and composition of the specified system, given a base year structure of the herd. After the user has edited the base year figures and set the number of years, LDPS^2 calculates, for every year, the herd size and composition, the quantity of every product generated and the energy needs and balance, given the allocated resources. You can select a projection period ranging from 2 to 20 years. The base year is Year 0. Results are shown in sheet "Results".

TIP
Recalculation of LDPS^2 is set to "Manual" by default. This is to prevent LDPS^2 from constantly recalculating the whole 8 sheets, which can be quite annoying on a slow computer. Since calculations are manually performed, changes made to the sheets (new parameters or new labels) may not be taken into account immediately by LDPS^2. To update all calculations at once, simply press the **F9** key on your keyboard (You can also set recalculation to "Automatic" from the menu "**TOOLS_OPTIONS_CALCULATION**").

2.2 Setting Parameters and Labels

The first step in using LDPS^2 is to edit the default parameter sets included in the spreadsheet. These parameters can be found in sheet "Parameters". The upper-left part of the sheet contains the parameters for Demand-driven routine, as shown in figure 9.

Figure 9: Parameters sheet



	A	B	C	D	E	F
1	Target herds parameter sets			Back to Tour Map		
2						
3		Parameter	Dairy Cattle			
4	No	name	System 1	System 2	System 3	System 4
5	1	Milk production demand	1,515,000	3,224,000	1,025,000	0
6	2	Distribution losses	0.000	0.000	0.000	0.000
7	3	Fertility rate	0.750	0.900	0.900	0.000
8	4	Prolificacy rate	1.000	1.000	1.000	0.000
9	5	Breeder males per breeder female	0.001	0.001	0.001	0.000
10	6	Milk yield per lactation	2.000	4.500	4.500	0.000
11	7	Fraction of females milked	0.900	0.900	0.900	0.000
12	8	Cow mortality rate	0.030	0.040	0.040	0.000
13	9	Bull mortality rate	0.030	0.040	0.040	0.000
14	10	Female replacement mortality rate	0.030	0.040	0.040	0.000
15	11	Male replacement mortality rate	0.030	0.040	0.040	0.000
16	12	Female young mortality rate	0.070	0.060	0.060	0.000
17	13	Male young mortality rate	0.070	0.060	0.060	0.000
18	14	Other stock mortality rate	0.030	0.040	0.040	0.000
19	15	Draught animals mortality rate	0.030	0.040	0.040	0.000
20	16	Years in breeding herd, cows	5.000	4.500	4.500	0.000
21	17	Years in breeding herd, bulls	5.000	5.000	5.000	0.000
22	18	Years in replacement herd, females	1.000	1.000	1.000	0.000
23	19	Years in replacement herd, males	1.000	1.000	1.000	0.000
24	20	Years from young to slaughter, other stock	1.000	1.000	1.000	0.000

Parameter names are shown in columns **B** for Dairy Cattle, **G** for Beef Cattle, and so on. To see the full name of a parameter, you can change the column's width. This operation has no effect on the calculations.

The columns refer to specific animal systems while the lines refer to individual parameters. For example, cell **C7** in sheet "Parameters" refers to the parameter "Fertility rate" of the animal system called "Dairy Cattle, System 1".

To edit values, simply select the desired cell using the mouse (or the arrows on your keyboard) and type in the new value. Remember that **ONLY BLUE CELLS CAN BE EDITED**. Other cells contain equations and are normally protected. If you try to change the content of a protected cell, LDPS[2] will display message telling you that protected cells cannot be edited. In order to change the content of these cells, you have to first remove the protection from the current sheet.

CAUTION
Removing protection from a sheet enables you to change whatsoever is contained in that sheet. Before removing the protection, make sure you have an unmodified copy of LDPS[2] somewhere.

CAUTION
When editing parameters, typing characters instead of numbers will cause calculation errors. Be very careful when typing new values in sheet "Parameters" since these values are used throughout the application. Labels can be made of characters and numbers, or they can be left blank. They have no effect on calculations.

Sheet “Labels” is used to change the default names used by $LDPS^2$ throughout the spreadsheet. For example, you can model up to four animal sub-systems for Dairy Cattle. By default, these sub-systems are named "System 1", "System 2" and so on. To change these defaults, simply type in a new name. For example, in the Dairy Cattle animal system, change "System 1" to "Nomadic". This change is instantly updated throughout the spreadsheet, so every cell using "System 1" before will now show "Nomadic" instead. If not, press the **F9** key on your keyboard to update all labels.

2.3 Demand-driven routine

The Demand-driven section of $LDPS^2$ calculates the composition, size and feed requirements of the livestock systems needed to meet specific production targets. "Demand-driven" means that it is the user-defined demand target for domestic livestock products (in terms of tons of meat, eggs or milk) that drives all the calculations. $LDPS^2$ answers this simple question: "What herd size and composition do I need to product X tons of meat (milk) per year?".

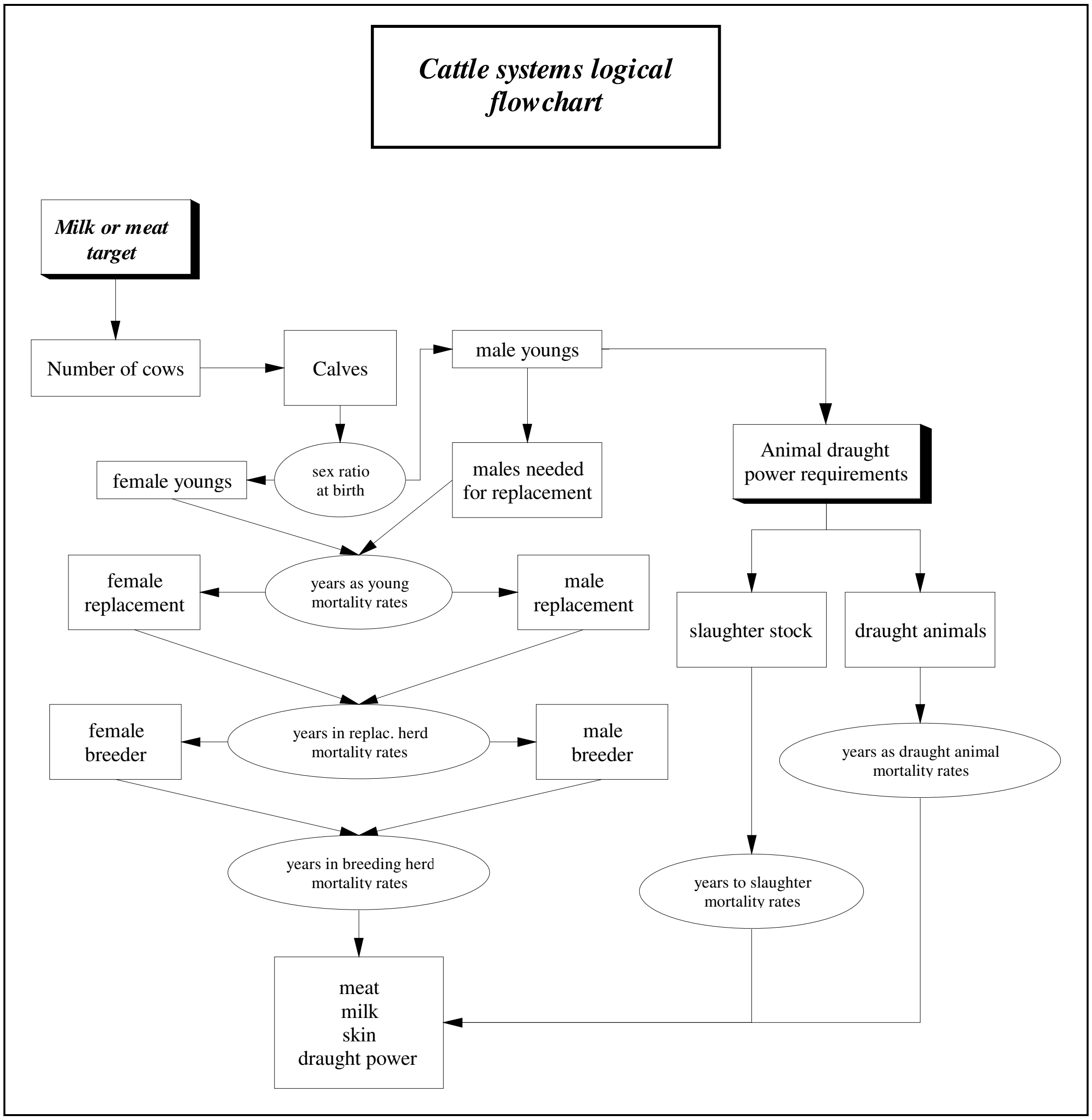
The following pages explain how Demand-driven routine works, and how to use it. Section 2.4 explores the Herd Growth routine in full detail. Figure 10 shows a graphical representation of the way $LDPS^2$ works for all Dairy Cattle systems.

2.3.1 Setting demands

The demands are set within the "Parameters" sheet, line 5. This is either a milk, meat or eggs target, expressed in metric tons per year. The way these demands are used within the system's equation set is explained 2.3.1.1 below. Section 2.3.1.2 explains how the energy requirements are calculated after herd size and composition has been determined by $LDPS^2$.

TIP FOR EXCEL 7 USERS
Some cells contain a small red square in the upper right corner. This mark indicates that a label is attached to the cell. To see the label, select "**INSERT_NOTE**" from the main Excel menubar. With Excel 7, just leave the cursor over the cell for 1 second. The label is then displayed. A label gives information on the units used for that particular cell.

Figure 10: Cattle systems logical flowchart



2.3.1.1 Calculating herd size and composition

<u>DAIRY CATTLE AND BUFFALO (SYSTEMS 1 TO 4 AND 15 TO 17)</u>

For dairy cattle and buffalo systems, the milk target drives all the calculations. The system calculates the number of cows required to produce the desired amount of milk and then builds the total herd that results from the computed number of lactating cows. While milk is the actual production target[2], all dairy and buffalo herds produce meat, hides and manure as by-products from culls and slaughter stock.

Heads and energy requirements for draught animals are also computed. Draught power is considered an output of adult dairy cattle, beef cattle and buffaloes only. Draught animals are regarded as a "by-product" of dairy and buffalo production systems, where surplus calves (i.e. those calves not kept for herd growth) are partly diverted into draught use, and partly diverted into slaughter stock. The number of surplus calves diverted into draught use depends on the power output expected from draught animals. These power requirements are specified by the user. LDPS^2 then allocates surplus calves to draught use until needs are met, the extra calves (if any) being diverted into slaughter stock. The flow chart on the previous page illustrates this method for dairy cattle.

Draught animals are not put to work all year. During the days where they are idle, they assume the same productivity and needs as the males from their group of origin (dairy cattle or buffalo). During the days where they are put to work, they need more energy. The set of parameters applied to these animals is adjusted accordingly. Draught animals typically have two system LSUs applied to them: one for idle days (same as male replacement), and one for working days.

Draught animals have their own parameter set. These parameters can be edited in the "Parameters" sheet.

The same model is used for all dairy and buffalo systems. The differences in the various types are accounted for by different values in the productivity data used for the calculations.

<u>BEEF CATTLE, SHEEP AND GOATS (SYSTEMS 5 TO 14)</u>

For beef cattle, sheep and goats, the meat target drives the calculations, all other products being calculated as residual values. The user sets the desired amount of beef as a production target, and sets the level of each parameter. The spreadsheet then calculates the herd size and composition required to meet that demand value. The results can be seen in the "Results" sheet.

---

2 The target can be seen either as a demand or a production target, since within LDPS^2, production is assumed to meet demand, without any economic modeling of demand and production.

All those meat-oriented systems also produce milk as a by-product (in the same manner that meat is viewed as a by-product by milk-oriented systems, i.e. Dairy cattle and Buffalo). Table 3 shows products computed by $LDPS^2$ for each animal type.

As for Dairy Cattle and Buffalo, number and energy requirements for draught animals are also computed.

PIGS (SYSTEM 18)

As for beef cattle, sheep and goats, the pig system is also meat-driven. Meat is the only product calculated for this system. There are two sub-systems modeled: intensive (modern) production and traditional production. Unlike the previous livestock systems, these two sub-systems are analyzed and computed together. Total production demand is split between the two sub-systems by the user who must supply, as one of the parameter values (see sheet «Parameters», cell Y6), the fraction of production to be met by the intensive system. A zero value means that the traditional sub-system supplies 100 percent of the required meat, while a value of 1 means that all of the production demand will be met by the intensive sub-system. Therefore, the value provided should be somewhere between zero and 1.

Table 3: Products per animal type

Type	Products
Dairy cattle	Milk, meat, hides, manure
Beef cattle	Meat, milk, hides, manure
Sheep	Meat, milk, wool, manure
Goats	Meat, milk, fleece, manure
Buffalo	Milk, meat, hides, manure
Pigs	Meat
Poultry	Meat, eggs

CAUTION
Some parameters are expressed as percentage values. Typing "2" therefore means 200%, not 2%. If you mean 2%, you should type ".02" and let $LDPS^2$ convert the displayed value into "2%". Check all the percentage values you changed before consulting the results.

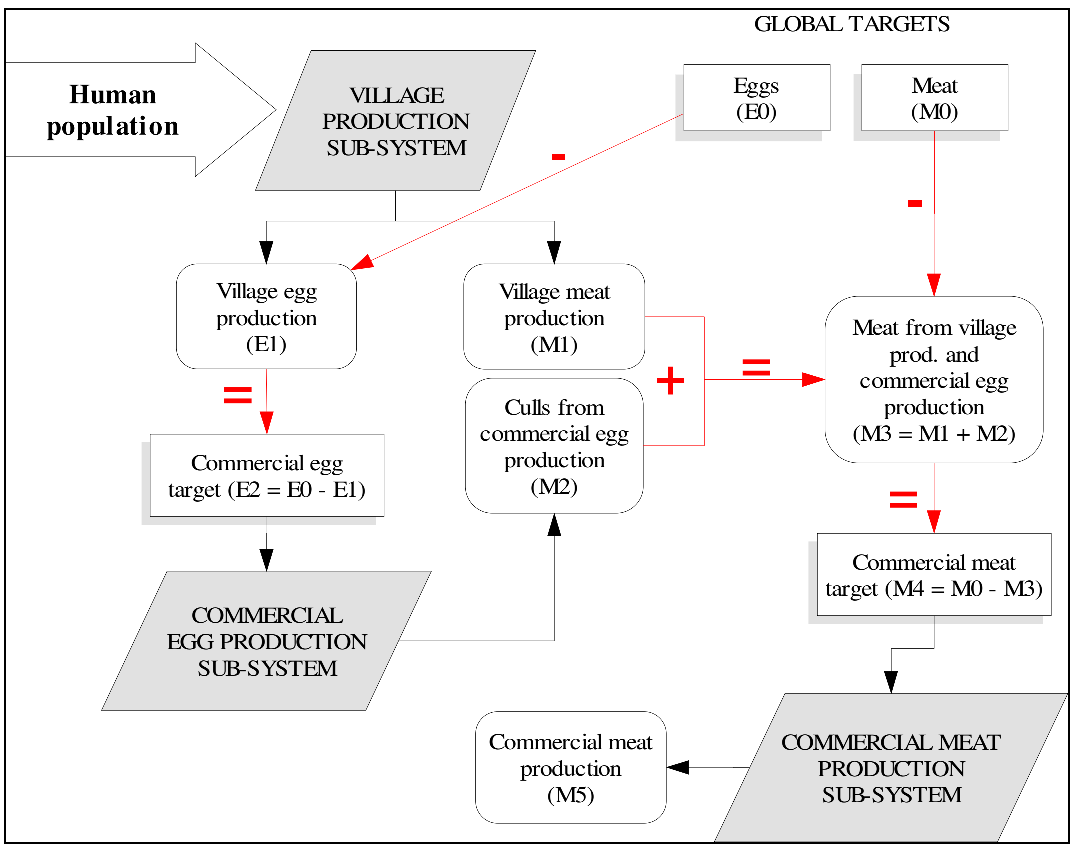
POULTRY (SYSTEM 19)

The poultry system is in fact composed of three sub-systems: village production of meat and eggs , commercial egg production and commercial meat production. These three sub-systems are combined by $LDPS^2$ to meet the global production targets for meat and eggs.

For the poultry system, two targets are set: meat and eggs (See Sheet “Parameters”, cells **AA5** and **AA6**). But unlike other systems, the main drive comes from human population (see sheet “Parameters”, cells **AA7** and **AA8**). The village poultry population being set as a proportion of the human population, the village poultry produce eggs and meat not in response to the production targets, but rather as a function of human population and the productivity values of the flock.

After calculation, the village eggs production is subtracted from total egg target. The remaining egg target becomes the production target for the commercial egg production sub-system. Village meat production and meat from culls from the commercial egg sub-system are subtracted from global meat production target. The remaining meat becomes the meat production target for the commercial meat production sub-system. Figure 11 shows how the poultry system works.

Figure 11 : Poultry system logical flowchart



Commercial egg production is driven by the unsatisfied egg target after the village egg production has been subtracted out. LDPS[2] calculates the size and composition of the laying flock required to meet the remaining egg production target. This laying flock also produces meat through the normal culling of the laying flock. That meat is subtracted from the unsatisfied meat production target.

Commercial meat production is driven by the unsatisfied meat target after both the village meat production and the commercial egg system's meat from culling have been subtracted out. $LDPS^2$ calculates the size and composition of the poultry meat flock required to satisfy the remaining meat production target.

In some cases, this approach will lead to overproduction. In the case of village production, the production targets may be smaller than the production of meat and eggs resulting from the projected increase in village poultry population. When the egg and meat production targets are out of balance there can be over production of meat resulting from the incidental culls of the commercial egg laying flock. The user is encouraged to use several iterations of the programme to ensure that the production targets are consistent.

The easiest way to set the rural population figures is first use 1 as both the current and future population for the base year LDPS session. Then, the future population can be increased by the expected percentage. For example, if the population is expected to increase by 20% by the horizon year, set the base year to 1 and the horizon year population to 1.2.

DRAUGHT POWER CALCULATION

Parameters No. 47-57 are used for draught calculation (Parameters sheet, rows 51-61). As mentioned above, number and energy requirements for draught animals are computed for cattle and buffaloes. They are calculated as a by-product in order to avoid over-estimation of the herd size.

Table 4. Parameters for draught calculation

47	Peek animal draught power demand / month	6000000
48	Are there Draught specific oxen?(Y=1 / N=0)	1
49	Are Male Breeders used for draught?(Y=1 / N=0)	1
50	Are Female Breeders used for draught?(Y=1 / N=0)	0
51	Are Male replacements used for draught?(Y=1 / N=0)	1
52	Number of days worked, Draught specific animals	100
53	Number of days worked, Breeders	100
54	Number of days worked, Replacements	100
55	Average productivity /animal /day, draught specific oxen	1
56	Average productivity /animal /day, Breeders	1
57	Average productivity /animal /day, Replacements	1

In $LDPS^2$, four kinds of animals are available for draught use, breeders (males and females), male replacements and draught specific oxen. The user can select animals used for draught with parameters No. 48-51. $LDPS^2$ distributes total power demand to draught specific oxen, which come from other (slaughter) stock, at first. When the demand is not satisfied by the stock, the remaining demand is distributed to male breeders, male replacements and female breeders, in turn.

It is difficult to estimate total requirements for draught (or animal) power with a set of generalized coefficients because different types of work, techniques and other factors affect the requirements. Then, $LDPS^2$ does not estimate the requirements, but the user determines it empirically. $LDPS^2$ calculates number of draught animals with the following formula:

No. of draught animals
= (Peek power requirement per month) / 30 days / (Average productivity per animal per day)

A unit for the requirement and productivity is also defined by the user. Hectares/day, Man-day or Animal-day, for example, will be available. The following is an example in Nepal.

Cultivation with hill Zebu and swamp buffalo in Nepal (Oli, 1985)
(1) hill Zebu
- Working days 62 days/annum
- Average time taken by a pair of hill Zebu to accomplish work (days/ha)

Nature of work	Maize	Wheat	Rice
First ploughing	8	10	11
Second ploughing	7	7	10
Seeding	7	6	6.6

(2) swamp buffalo
- Working days 130 days/annum
- Average productivity 0.37 ha/day/head

2.3.1.2 Calculating energy requirements

Once the size and composition is calculated, the feed requirements are determined. The feed requirements are calculated first as SYSTEM SPECIFIC LSUs and then converted into REFERENCE LSUs.

LSU stands for ***Livestock Standard Unit***. It is a standard measure of the energy needs of livestock systems. In LDPS[2], ***System Specific LSUs*** are measures of the annual energy needs of each member of the herd relative to the needs of the breeder female, which are assumed to be the greatest. The breeder female in all livestock systems (except Poultry) is assigned a ***System Specific LSU*** of 1. The other members of the herd are assigned LSU ratings that are proportional to the breeder female LSU of 1. The default ***System Specific LSUs*** of the various members of the livestock systems are listed in table 5 below.

Table 5: System Specific LSUs

System	System LSU
Dairy Cattle	
Female breeder	1.0
Male breeder	1.0
Female replacement	0.7
Male replacement	0.7
Other Males	0.7
Draught animals	1.2
Female young	0.4
Male Young	0.4

Beef Cattle	
Female breeder	1.0
Male breeder	1.0
Female replacement	0.7
Male replacement	0.7
Slaughter stock	0.7
Draught animals	1.2
Female young	0.4
Male Young	0.4
Sheep	
Female breeder	1.0
Male breeder	1.0
Female replacement	0.8
Male replacement	0.8
Other Males	0.8
Female young	0.6
Male Young	0.6
Goats	
Female breeder	1.0
Male breeder	1.0
Female replacement	0.7
Male replacement	0.7
Other Males	0.8
Female young	0.5
Male Young	0.5
Buffalo	
Female breeder	1.0
Male breeder	1.0
Female replacement	0.7
Male replacement	0.7
Other Males	0.7
Draught animals	1.2
Female young	0.4
Male Young	0.4
Pigs	
Female breeder	1.0
Male breeder	1.0
Female replacement	0.4
Male replacement	0.4
Slaughter stock	0.4
Female young	0.3
Male Young	0.3

This means that, for example, the annual energy needs of the pig male replacement is 40% that of the female breeder.

The SYSTEM SPECIFIC LSUs can be found in range **[A59 : K68]** of sheet "Parameters". Figure 12 below shows that portion of the sheet. The user can change the values manually.

Figure 12: Systems specific LSUs of the various animal systems and classes

	A B	C	D	E	F	G	H	I	J	K	L
69	System LSUs										
70		breeder		replacement		other	draught A	draught A	young		MEPs
71		fem	male	fem	male	stock	resting	working	fem	male	
72	(1) Cattle - Milk	1.000	1.000	0.700	0.700	0.700	0.700	1.200	0.400	0.400	5.000
73	(1) Cattle - Meat	1.000	1.000	0.700	0.700	0.700	0.700	1.200	0.400		5.000
74	(1) Buffalo	1.000	1.000	0.700	0.700	0.700	0.700	1.200	0.400	0.400	8.300
75	(1) Sheep	1.000	1.000	0.800	0.800	0.800			0.600		4.600
76	(1) Goats	1.000	1.000	0.700	0.700	0.800			0.500		4.600
77	(1) Pigs - int.	1.000	1.000	0.400	0.400	0.400			0.300		
78	Pigs - trad.	1.000	1.000	0.400	0.400	0.400			0.300		

Welcome / Labels / Parameters / Resources / Results / Sensitivity

The REFERENCE LSU is a measure used to arrive at a consistent value of the energy required by animals. The REFERENCE LSU is defined as:

> "a 500 kg mature cow, with a calving interval of 13 months, producing 3,500 kg of milk per lactation (butterfat 40 gr/kg, non-fat solids 80 gr/kg). It is also equivalent to the annual metabolisable energy (ME) requirement of the LSU for maintenance, growth, pregnancy, lactation and activity. This is defined as 35,600 MJ" [3].

The SYSTEM SPECIFIC LSUs are converted into REFERENCE LSUs using the following formulas:

DAIRY CATTLE, BEEF CATTLE AND BUFFALO

REFERENCE LSU = (CME/35600) * SYSTEM SPECIFIC LSU

Where:

→ CME is the Metabolic Energy required for maintaining the breeding female of the livestock system for one year.

CME is calculated as:

CME = (365*(8.3 + (0.091 * (Female breeder Carcass Weight in kg * 2)))) + (MEP * Milk Yield per Lactation in kg * Fertility Rate)

where MEP is defined as the metabolisable energy required for milk production.

[3] LDPS Technical Reference, 1987, page 51

By default, MEP is set to:	5.0	for Dairy Cattle
	5.0	for Beef Cattle
	8.3	for Buffalo

These MEP values can be edited in range **[L72 : L76]** of sheet "Parameters".

SHEEP AND GOATS

REFERENCE LSU = (CME/35600) * SYSTEM SPECIFIC LSU

where CME is the Metabolic Energy required for maintaining the breeding female of the livestock system for one year. CME is calculated as:

CME = (365 * (1.8 + (0.1 * (Female breeder Carcass Weight in kg * 2)))) + (MEP * Milk Yield per Lactation in kg * Fertility Rate)

where MEP is defined as the metabolisable energy required for milk production.

By default, MEP is set to:	4.6	for Sheep
	4.6	for Goats

PIGS

REFERENCE LSU = 0.3 * SYSTEM SPECIFIC LSU

POULTRY

REFERENCE LSUs for Poultry are calculated by multiplying the number of birds by specific factors, one for each type of bird:

Village flock:	.007
Commercial egg culls:	.007
Commercial layers:	.014
Commercial egg breeders:	.014
Commercial meat breeders:	.014
Commercial broilers:	.001 * Carcass weight in kg

Calculated LSUs are aggregated to a total herd SYSTEM SPECIFIC LSU. The total is then converted into REFERENCE LSUs using the formulas above. The resulting aggregated value is shown in the Demand-driven results as "Total LSU" in sheet "Results" of LDPS[2]. Poultry system is calculated directly in REFERENCE LSUs so no conversion is needed.

Conversion of REFERENCE LSUs into MJ or Mcal can be made using the following equations:

MJ = REFERENCE LSUs × 35,600
Mcal = REFERENCE LSUs × 35,600 / 4.184

Range **[B82 : O87]** of sheet “Parameters” contains constants used by LDPS[2] . These constants cannot be changed. They represent standard conversion coefficients needed in the equations.

2.3.2 Feed resource inventory

Inventory of feed resources is performed using the "Resources" sheet. Figure 13 shows a screenshot of the upper left corner of the "Resources" sheet. In figure 13, the visible part of the sheet allows the user to manually set the amount of grazing land available to the different animal systems. Grazing land is subdivided into 11 land classes, based on the length of the growing season. All these classes need not be completed. Just fill in the classes you need. All quantities (except hectares) are in tons of dry matter.

Figure 13: Sheet "Resources" of LDPS[2]

FEED RESOURCES & CONSTRAINTS — Back to Tour Map

Grazing land — Ref LSU: 35600.0

Growing period (days)	Hectares (x100)	Energy (MJ/kg d m)	Protein (g/kg d m)	Crude fiber (g/kg d m)	Constant	TOT LSU	Total digest. protein (MT)
1 to 75	0	5.0	84.0	296.0	23.5	0	0
76 to 89	0	5.0	84.0	296.0	13.0	0	0
90 to 119	0	5.0	104.0	269.6	10.4	0	0
120 to 149	2 347 500	5.0	104.0	269.6	6.9	34 021 739	17 029 105
150 to 179	0	5.0	143.0	257.1	4.5	0	0
180 to 209	0	5.0	143.0	257.1	3.1	0	0
210 to 239	0	5.0	174.0	236.8	2.0	0	0
240 to 269	0	5.0	174.0	236.8	1.4	0	0
270 to 299	0	5.0	174.0	236.8	0.9	0	0
300 to 329	0	5.0	222.0	200.0	0.6	0	0
330 to 365	0	5.0	222.0	200.0	0.4	0	0
Total	**2 347 500**	**5.0**				34 021 739	17 029 105

Welcome / Labels / Parameters / **Resources** / Results / Ser

The sheet "Resources" contains input screens for 5 types of feed resources:

NOTE
As for animal systems, the names of the feed resources are provided for information only since they can be modified, with the exception of grazing land. You can change the names of the feed types within the sheet “Labels”.

1) **Grazing land:** The grazing land resources are classified according to the duration of the growing season, defined as those days when the environmental conditions (moisture and temperature) are suitable for the growth of grass land vegetation.

   The amount of land in each class (in hundreds of hectares) is multiplied by a specific factor to reflect the higher carrying capacity of land with longer growing seasons. These factors are:

From	**To**	**Factor**

0 days	75 days	23.5
76 days	89 days	13.0
90 days	119 days	10.4
120 days	149 days	6.9
150 days	179 days	4.5
180 days	209 days	3.1
210 days	239 days	2.0
240 days	269 days	1.4
270 days	299 days	0.9
300 days	329 days	0.6
330 days	365 days	0.4

The carrying capacity of the grazing land is assumed to depend upon the length of the growing period. The best pastures, with a growing period of 365 days, are assumed to be able to support (1÷0.4 =) 2.5 REFERENCE LSUs per hectare (i.e. 2.5 * 35,600 MJ). Multiplying this reference carrying capacity by the corresponding factor listed in the table gives the energy equivalent of that specific class of pasture in terms of REFERENCE LSUs. The user may modify the carrying capacity by changing the factors in the sheet "Resources", range **[G7:G17]**.

To calculate the available grazing land in terms of REFERENCE LSUs, LDPS[2] divides the number of 100 hectares entered in sheet "Resources", range **[C7 : C17]** by the corresponding factor. Resulting values are shown in range **[H7 : H17]**. Grazing land classes are then grouped into two broad classes for further calculations:

1) 0 to 89 days
2) 90 to 365 days

Other user-defined parameters are:
1) Energy content of grazing land, in millions of Joules per kilogram of dry matter;
2) Protein content, in grams per kilogram of dry matter;
3) Crude fiber content, in grams per kilogram of dry matter.

2) Crop residues: Crop residues are organic matter left behind after harvest. Typically, these consist mainly of straws and stubble from crop production. You can define up to 10 different types of crop residues. Only crop residues actually available for animal consumption should be considered. Amounts are in tons of dry matter.

Other user-defined parameters are:
1) imports, in tons of dry matter per year;
2) Exports, in tons of dry matter per year;
3) Energy content of crop residues, in millions of Joules per kilogram of dry matter;
4) Protein content, in grams per kilogram of dry matter;
5) Crude fiber content, in grams per kilogram of dry matter.

Calculation for crop residues is performed as follows:

$$\text{Total LSUs} = \frac{[\text{Feed Energy Content (MJ / kg)}] \; * \; \text{Amount Available (Tons)} \; * \; 1000 \text{ kg / ton}}{35600 \text{ MJ / LSU}}$$

NOTE	Calculations are the same for all feed types except grazing land.

Table 6 shows some representative energy content for common crop residues.

Table 6: Representative values of metabolic energy content

Crop residues	Energy content (in MJ/kg DM)
Wheat straw	5.6
Rice straw	5.6
Maize stover	7.3
Sorghum stover	8.4
Sugar cane tops	9.0

Source: Tropical feeds

TIP	You may find information on feed values in ***"Tropical feeds"*** published by FAO .

3) Primary products

Primary products are chiefly cereals that are intended for use as animal feed. Commercial poultry operations, for instance, almost always use primary products as feed (cracked corn, laying mash, etc.). Ten types can be defined in LDPS[2].

Table 7 shows some representative energy content for common primary products.

Table 7: Representative values of metabolic energy content

Primary products	Energy content (in MJ/kg DM)
Maize	14.2
Wheat	14.0
Sorghum	13.4
Millet	11.3
Cassava	12.2
Soybean	14.9

Source: Tropical feeds

4) Crop by-products

The most important crop by-products are cereal brans and oilcakes. These are the by-products of milling and crushing cereals and oil seeds. Table 8 shows some representative energy content for common crop by-products.

Table 8: Representative values of metabolic energy content

Crop by-products	Energy content (in MJ/kg DM)
Cereal brans	
Wheat	10.1
Rice	12.5
Maize	12.5
Oil cakes	
Shelled groundnuts	11.4
Sunflower	9.5
Cottonseed	8.7
Soybean	13.3
Sesame	11.0

Source: Tropical feeds

5) Fodder

The last type of feed resources considered by LDPS[2] is fodders. Ten types can be defined. As with the other feed resources, it is extremely important to include only those fodders that will actually be available to the livestock.

For every individual feed resource, there are 6 different values that you can set:

1) total available quantity of dry matter each feed sub-type (see range **[C23 : C32]** for example);
2) the energy content of each individual feed resource, in millions of Joules per kilogram of dry matter (see range **[F23 : F32]** for example);
3) the protein content of each feed resource, in grams per kilogram of dry matter (see range **[G23 : G32]** for example);
4) the crude fiber content of feed, given in grams per kilogram of dry matter (see range **[H23 : H32]** for example).

For all feed resources except grazing land, two more variables can be set:

5) Imports, in tons of dry matter per year;
6) exports, in tons of dry matter per year.

You can also set the relative prices of each one of the 6 feed types. These prices need not be actual real prices. The only important aspect is their importance relative to that of others. For example, if crop residues are twice as expensive as fodder, you could simply set the price of crop residues to 2 and that of fodder to 1. Keeping these relative values small (between 0 and 10) will assure a faster performance of the optimization routine.

Using the reference LSU (35600 MJ), these values are converted into total Livestock Standard Units, or LSU (column **H** or **I**) and into total digestible protein content (column **I** or **J**) given in millions of tons per year. For grazing land, conversion of hectares into total LSU is performed using a standard conversion factor (column **G**).

After you have set the amount of feed resources available and their associated technical parameters (energy and protein content), you are ready to allocate these resources to the various animal systems.

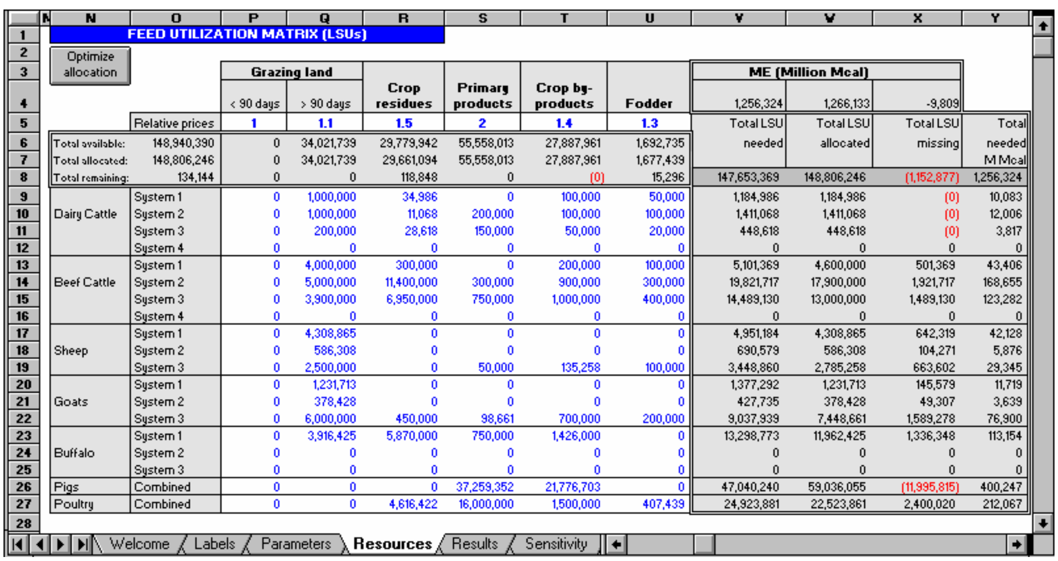
The feed utilization matrix (FUM) can be found in sheet "Resources", column **N**. Figure 14 shows the FUM of LDPS^2, as found in sheet "Resources". There are two ways to do so: 1) manually allocate feed resources, or 2) optimize allocation between systems using linear programming. These two methods are explained below.

For the animal systems you do not want to analyze, enter zero values in the cells of the corresponding line.

2.3.2.1 Manual allocation of feed resources

Manual allocation is a quite straightforward method: Go to column **N** of sheet "Resources" and manually allocate available feed resources to the systems of your choice. Available feed resources per type of feed is shown in row 6. The more feed you allocate, the more values in row 7 and column **W** ("Total allocated") increase, and the more values in row 8 ("Total remaining") and column **X** ("Total missing") decrease.

Figure 14: Feed Utilization Matrix (FUM) of LDPS^2



	N	O	P	Q	R	S	T	U	V	W	X	Y
1	FEED UTILIZATION MATRIX (LSUs)											
2	Optimize allocation											
3			Grazing land						ME (Million Mcal)			
4			< 90 days	> 90 days	Crop residues	Primary products	Crop by-products	Fodder	1,256,324	1,266,133	-9,809	
5		Relative prices	1	1.1	1.5	2	1.4	1.3	Total LSU needed	Total LSU allocated	Total LSU missing	Total needed M Mcal
6	Total available:	148,940,390	0	34,021,739	29,779,942	55,558,013	27,887,961	1,692,735				
7	Total allocated:	148,806,246	0	34,021,739	29,661,094	55,558,013	27,887,961	1,677,439				
8	Total remaining:	134,144	0	0	118,848	0	(0)	15,296	147,653,369	148,806,246	(1,152,877)	1,256,324
9	Dairy Cattle	System 1	0	1,000,000	34,986	0	100,000	50,000	1,184,986	1,184,986	(0)	10,083
10		System 2	0	1,000,000	11,068	200,000	100,000	100,000	1,411,068	1,411,068	(0)	12,006
11		System 3	0	200,000	28,618	150,000	50,000	20,000	448,618	448,618	(0)	3,817
12		System 4	0	0	0	0	0	0	0	0	0	0
13	Beef Cattle	System 1	0	4,000,000	300,000	0	200,000	100,000	5,101,369	4,600,000	501,369	43,406
14		System 2	0	5,000,000	11,400,000	300,000	900,000	300,000	19,821,717	17,900,000	1,921,717	168,655
15		System 3	0	3,900,000	6,950,000	750,000	1,000,000	400,000	14,489,130	13,000,000	1,489,130	123,282
16		System 4	0	0	0	0	0	0	0	0	0	0
17	Sheep	System 1	0	4,308,865	0	0	0	0	4,951,184	4,308,865	642,319	42,128
18		System 2	0	586,308	0	0	0	0	690,579	586,308	104,271	5,876
19		System 3	0	2,500,000	0	50,000	135,258	100,000	3,448,860	2,785,258	663,602	29,345
20	Goats	System 1	0	1,231,713	0	0	0	0	1,377,292	1,231,713	145,579	11,719
21		System 2	0	378,428	0	0	0	0	427,735	378,428	49,307	3,639
22		System 3	0	6,000,000	450,000	98,661	700,000	200,000	9,037,939	7,448,661	1,589,278	76,900
23	Buffalo	System 1	0	3,916,425	5,870,000	750,000	1,426,000	0	13,298,773	11,962,425	1,336,348	113,154
24		System 2	0	0	0	0	0	0	0	0	0	0
25		System 3	0	0	0	0	0	0	0	0	0	0
26	Pigs	Combined	0	0	0	37,259,352	21,776,703	0	47,040,240	59,036,055	(11,995,815)	400,247
27	Poultry	Combined	0	0	4,616,422	16,000,000	1,500,000	407,439	24,923,881	22,523,861	2,400,020	212,067
28												

Allocation of feed resources in LSU is automatically converted in tons of digestible proteins in range **[N30 : X54]** of sheet "Resources" (just below the FUM). The values contained in this range cannot be edited.

CAUTION

Since LDPS² does not provide any mechanism to prevent allocation of more feed then there actually is, you should constantly check row 8 (« Total remaining ») and column X (« Total missing »). Be Also careful not to enter negative values; even if negative allocation does not make any sense, LDPS² won't reject these values.

2.3.2.2 Optimizing feed allocation

Automatically optimized feed allocation is one of the new features added to LDPS². It calculates optimal feed quantities based on feed requirements and relative prices (or values)[4]. Optimization of feed allocation is performed using the integrated linear programming capabilities of Excel 5 and 7. There are 139 preset constraints on the systems:

1) Constraints forcing the remaining energy per feed type (line **8** of the FUM) to be greater than or equal to zero (6 constraints);
2) Constraints forcing the total missing energy per animal system (column **X** of the FUM) to be equal to or smaller than zero (19 constraints);
3) Constraints forcing every allocated amount of LSU (blue cells of the FUM) to be greater than or equal to a minimal energy allocation. These minimum values are user-defined. The matrix used to enter the minima is located in sheet "Resources", range **[N57 : U80]**.

Once you have edited the minimum values in range **[N57 : U80**], you are ready to start the optimization procedure. This is done by clicking on the "Optimize allocation" button over cell **N3**. Once pressed, you have two choices: you can run the allocation procedure with or without taking ***relative prices*** into account. A wait screen then informs you that LDPS² is calculating. The optimization routine can take up to 30 minutes to find a solution. **You can stop the procedure any time by pressing the CONTROL and BREAK keys simultaneously.**

Solution may be impossible for a particular set of values: LDPS² will then stop the procedure and inform you that no feasible solution could be found.

CAUTION
Optimization is a resource intensive process within Excel. It is recommended to use this procedure only if you have a Pentium 90 MHz (or better) with at least 16 megabytes of memory.

2.3.3 Calculating Target Herd size and composition

Once you have set the production demand targets and the productivity parameters, you can display results for the system of your choice using the "Results" sheet. Once you select the desired settings and press the «CALCULATE» button, calculations are performed for all systems at once but only the selected one is displayed. The sheet "Results" is simply a more convenient way of showing some of the results. The detailed set of results, along with all the calculations, can be found in the hidden sheet "Calculations".

---

[4] Relative prices (values) are defined by the user on the basis of farm prices or protein contents, for example. The most economic (low valued) feed is allocated first in the automaticcally optimized allocation.

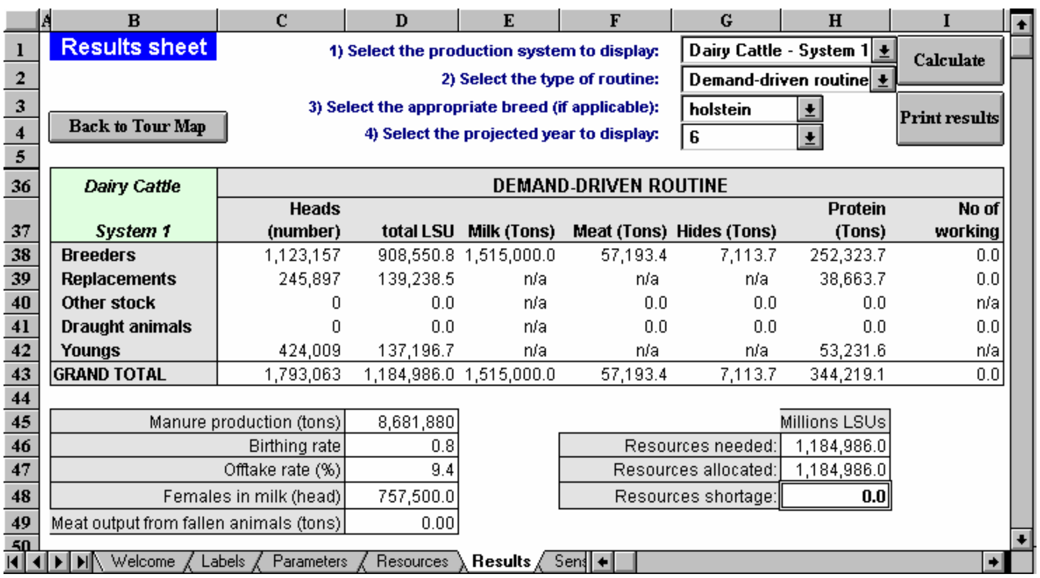
CAUTION

You may display the sheet “Calculations”. This sheet is hidden by default to prevent any accidental changes to it. Beware not to change any equation contained in this sheet, since it will change the way $LDPS^2$ behaves and may impede completely the calculations.

Animal systems are selected using the top pull-down list near cell **G1**. Make sure that demand-driven is selected in the second pull-down list (cell **G2**). The third pull-down list is used to set the number of years in the herd growth routine. It is not used within the demand-driven routine.

The following figure shows the results screen using the default data set for "Dairy cattle, System 1" system.

Figure 15: Results for "Dairy cattle, System 1"



Dairy Cattle System 1	Heads (number)	total LSU	Milk (Tons)	Meat (Tons)	Hides (Tons)	Protein (Tons)	No of working
	DEMAND-DRIVEN ROUTINE						
Breeders	1,123,157	908,550.8	1,515,000.0	57,193.4	7,113.7	252,323.7	0.0
Replacements	245,897	139,238.5	n/a	n/a	n/a	38,663.7	0.0
Other stock	0	0.0	n/a	0.0	0.0	0.0	n/a
Draught animals	0	0.0	n/a	0.0	0.0	0.0	0.0
Youngs	424,009	137,196.7	n/a	n/a	n/a	53,231.6	n/a
GRAND TOTAL	1,793,063	1,184,986.0	1,515,000.0	57,193.4	7,113.7	344,219.1	0.0

Manure production (tons)	8,681,880
Birthing rate	0.8
Offtake rate (%)	9.4
Females in milk (head)	757,500.0
Meat output from fallen animals (tons)	0.00

	Millions LSUs
Resources needed:	1,184,986.0
Resources allocated:	1,184,986.0
Resources shortage:	0.0

The upper range of values shows detailed results for every class of animal within the selected system. Note that classes (and products) may be changing from one system to the other (try selecting Poultry instead of Cattle).

Row 45 to 49 shows some calculated ratios and variables for the selected system. Table 9 shows the results associated with the different animal systems.

Table 9: Results per animal systems

	Dairy and Buffalo	Beef, Sheep and Goats	Pigs	Poultry
Number of breeders	X	X	X	
Number of producers			X	
Number of replacements	X	X	X	
Number of other stock	X	X		
Number of draught animals	X			
Number of youngs	X	X		
Village animals				X
Commercial animals				X
Total heads	X	X	X	X
Birthing rate	X	X		
Offtake rate	X	X		
Females in milk	X			
Average milk yield	X	X		
Meat from fallen animals	X	X		
Manure production	X	X		
Resources needed	X	X	X	X
Resources allocated	X	X	X	X
Resources shortage	X	X	X	X

2.3.4 Calculating products and protein needs

In the Demand-driven routine, LDPS[2] performs six more types of calculations. Each one is explained below.

1) Meat production, in tons per year:

Meat production is calculated by multiplying the number of culls per class by the average carcass weight of the corresponding class:

$$Meat_i = Culls_i * CW_i$$
$$TotalMeat_n = \sum_i MEat_i$$

where:
- $Meat_i$ = Meat production for class i, in tons
- $Culls_i$ = Number of culls from class i
- CW_i = Average carcass weight for class in tons
- $TotalMeat_i$ = Total meat production for system n

2) Milk production, in tons per year:

Milk production only concerns the breeder females of Dairy Cattle, Beef Cattle and Buffalo systems. Milk production is calculated as follows:

$$\text{Milk prod}_n = \text{Breeders}_n * Fert_n * MYIELD_n * MILKED_n$$

where:
- Milk prod_n = Milk production for system n in tons
- Breeders_n = Number of female breeders in system n
- Fert_n = Fertility rate
- MYIELD_n = Milk yield per lactation, in tons

$MILKED_n$ = Fraction of female breeders that are milked

3) Hides production, in tons per year:

LDPS[2] also calculates usable hides and skins produced by dairy and beef cattle, sheep, goats and buffalo systems. Six parameters are needed:

1° proportion of female breeders producing usable hide ;
2° " " male " " " " " ;
3° " other males " " " ;
4° kg per hide (green weight) for male breeders ;
5° " " for female breeders ;
6° " " for other stock .

Total yield per class of animal and per system is then calculated as follows:

$$Hides_i = Culls_i * WEIGHT_i * USABLE_i$$

$$Hides_n = \sum_i Hides_i$$

where:

$Hides_i$ = Hides production from class i, in tons per year
$Culls_i$ = Number of culls from class i
$WEIGHT_i$ = Average weight of skin (green weight), in tons
$USABLE_i$ = Proportion of usable skins from culls
$Hides_n$ = Total hides production for system n

Total production is calculated as the sum of all yields per class. The same procedure is employed for sheep and goats systems ,using an average weight per head per class.

4) Wool production, in tons per year:

Three specific parameters are used to calculate wool production:

1° Number of shearings per year per class ;
2° Standard fleece weight (SFW);
3° percentage of yield that is sold or used, for all classes (default value: 0).

Classes being: 1° Breeding females
2° Breeding males
3° Replacement females
4° Replacement males

Parameters necessary for wool/hair calculations are:

Standard fleece weight (kg)
Shearings per year, breeder female
Shearings per year, breeder male
Shearings per year, replacement female
Shearings per year, replacement male
Wool used or sold, breeder female

Wool used or sold, breeder male
Wool used or sold, replacement female
Wool used or sold, replacement male

Total yield in tons/year is then calculated in the following way:

$$YIELD_i = HEADS_i * SHEARINGS_i * USED_i * SFW_n$$

$$totYIELD = \sum_i (YIELD_i)$$

where	$YIELD_i$	=	Yield of wool/hair for class i
	$HEADS_i$	=	Number of heads in class i
	$SHEARINGS_i$	=	Number of shearings per year for class i
	$USED_i$	=	Percentage of product that is used or sold in class i
	SFW_n	=	Standard fleece weight of shearings for production system n
and :			
	$totYIELD_n$	=	Total production of wool/hair for production system n

This product is then presented onscreen along with meat, milk and hides. These calculations are meant for sheep and goats systems only. It is also assumed that only adult animals are shorn.

5) Manure output

Calculations needed to estimate manure output are complex. Data needed to perform these calculations will rarely be available, especially for countries with little data on the livestock sector. Therefore, only gross estimates can be produced.

One of the major problems arising when one tries to estimate manure output is the fact that only metabolisable energy is taken into account throughout LDPS[2]. Non-digestible fibers constitute an important part of the dry matter content of manure. Estimating production (in tons per year) of manure without taking into account the non-metabolisable part of ingested feed can only lead to systematic under-estimation of dry matter production.

Keeping these observations in mind, there is a simple way of approximating the maximum theoretical manure output for a given class of land or feed resource. Maximum manure output (MMO) from a given feed resource can be calculated as follows:

$$MMO_i = \frac{totLSU_i * rLSU}{ME_i * cFAC}$$

where:	MMOi	= Tons of manure from feed resource i (maximum value)
	totLSUi	= Total LSUs available from feed resource i
	rLSU	= Reference LSU (35600 MJ/kg d.m.)
	MEi	= Metabolisable energy per kilo of feed resource i
	cFAC	= Conversion factor (kilos into tons). This is a constant equal to .001

The previous equation can be applied to every single feed resource and every class of grazing land. In the latter case, MMO_i cannot be calculated directly since ME_i is not available (in the actual version of LDPS[2]). The user will be requested to input the energy content per kilo for each class of grazing land. Breaking down of the conversion factor used in LDPS[2] yields two unknown parameters that are used to calculate manure output from grazing land. The user could then choose the one parameter he finds more reliable and/or available, the other one being calculated automatically by LDPS[2]. Calculations are explained below.

LDPS[2] converts hectares of grazing land into total LSUs by means of a simple conversion factor, which can be written as follows:

$$CONV\,(LSUs\,/\,year) = \frac{\frac{Tons\ d.m.}{ha\,/\,year} * \frac{Energy}{Ton\ d.m.}}{rLSU}$$

Comment:

CONV multiplied by the number of hectares gives the number of LSUs per year for that particular class of grazing land. Since CONV can be broken down into two unknown parts:

$$\frac{Tons\ d.m.}{ha\,/\,year} \quad \text{and} \quad \frac{Energy}{Ton\ d.m.}$$

the user could be asked to input either one or the other part, depending on which one is available. If "Tons/ha/year" is supplied, "Energy/ton" can be calculated automatically, using the actual conversion factor CONV.

The previous equation holds for all feed resources since "Energy/ton" is already available for "Crop residues", "Primary products", "Crop by-products" and "Fodders".

Converting the maximum manure output from individual feed resources into manure production by class of animal is more complex and requires information on animal diets. The breakdown of the various feeds consumed by a particular class of animal is not known. On the other side, the amount of each individual feed resource entering a particular system is known, along with the global amount of energy consumed by each class of animal inside a particular system. Unfortunately, there is no way of connecting these two sets of data directly.

One possible solution is to calculate feed resource proportions used by each production system. First, the total energy consumed by class of animal needs to be computed. The following table shows these calculations for an imaginary dairy cattle herd .

	Energy consumption per class, dairy cattle			
	sLSUs	Energy consumed (MJ/head)	Total heads /class	Total energy (MJ/class)
breeding females	1	30401.5	104166.7	3166823.3
breeding males	1	30401.5	104166.7	3166823.3
Replac females	0.7	21281.1	52873.8	1125210.0

Replac males	0.7	21281.1	52873.8	1125210.0
Other stock	0.7	21281.1	0.0	0.0
Young females	0.4	12160.6	10416.7	126672.9
Young males	0.4	12160.6	10416.7	126672.9
Total			**334914.3**	**8837412.4**

Where: Total energy/class = Energy/head * total heads/class

Feed resource energy availability is then computed for every production system. A percentage is also calculated reflecting the weight (in terms of LSUs) of every single feed in the total available for that system, as shown below:

Feed resources available for dairy cattle			
	(1000 LSUs)	%	MJ / kg
Grazing land <90	10000	16.95	4.16
Grazing land >90	20000	33.90	5.96
Crop residues	6000	10.17	15.4
Primary products	15000	25.42	10.00
By-products	5000	8.47	10.00
Fodders	3000	5.08	10.00
Total	**59000**	**100.00**	

Ex: 16.95% = 10000 * 100 / 59000

Feed energy availability per type of feed is actually a weighted average of every single feed resource specified by the user. In the case of grazing land, it is a weighted average of the different land types in each of the two groups ("under 90 days" and "over 90 days"). Feed resources consumed by type of feed and by class of animal is then computed using total energy consumed per class (first table) and feed proportions (second table), along with the energy content per feed type, producing the following figure:

Figure 16 : Manure production per class, dairy cattle, in tons per year

MANURE OUTPUT CALCULATIONS

Dairy Cattle, System 1			Breed females	Breed males	Replac females	Replac males	Other stock	Draught animals	Young females	Young males	Total
CME=	28797.75		1122222.2	935.2	245631.9	204.7	0.0	0.0	420833.3	3175.7	--> heads
	LSUs	**MJ/kg**	1.0	1.0	0.7	0.7	0.7	1.2	0.4	0.4	--> sLSUs
Grazing land <90	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grazing land >90	1000000.0	5.00	5454431.0	4545.4	835919.0	696.6	0.0	0.0	818173.6	6174.1	7119939.8
Crop residues	34986.0	2.33	410114.5	341.8	62851.4	52.4	0.0	0.0	61517.2	464.2	535341.4
Primary products	0.0	13.58	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crop by-products	100000.0	11.41	239101.2	199.3	36643.1	30.5	0.0	0.0	35865.2	270.6	312109.8
Fodders	50000.0	2.49	547310.0	456.1	83877.1	69.9	0.0	0.0	82096.5	619.5	714429.1
Total	1184986.0		6651016.6	5542.5	1019290.6	849.4	0.0	0.0	997652.5	7528.5	8681880.1

Welcome / Labels / Parameters / **Resources** / Results / Sensitivity

Column totals represent total manure production per class of animal, while line totals represent total manure production by feed type for a given production system (in the previous example, dairy cattle).

Manure production per type of animal and per feed resource is thus calculated as:

$$\text{manure prod}_{i,j} = \frac{CME * sLSU_j * Heads_j * {LSU_i}/{(\text{tot LSUs from feeds})}}{(\text{Energy content})_i * 1000\ {kg}/{ton}}$$

where i = feed resources
j = type of animal

Feed consumed may differ from feed available, since availability may be higher then needs. In the case where availability is lower than needs, the number of heads in each class is adjusted accordingly by LDPS^2, thus lowering the "Total heads" column in the first table.

The main postulate underlying these calculations is that all types of animal in a given system consume feed resources in the same proportions. The release of this postulate requires a detailed diet scheme for every type of animal. Such a procedure has not been implemented yet.

6) Protein needs

Along with energy content, feed requirements and availability can be expressed in terms of Digestible Protein content. If the user wants to take into account protein content, he needs to input all the necessary data, i.e. protein content (grams per kilogram of dry matter) of every feed resource and protein requirements (in kilograms per year) for every class of animal.

The Feed Utilization Matrix then displays both energy content and protein content. Allocating feeds in one of these two forms implies automatic calculation of the other one, for consistency. Protein content is calculated as a residual.

In LDPS^2, protein requirement and supply are calculated only for ruminants. When amino acids are provided as intact proteins there is never an overall deficiency of nitrogen in poultry diets (Farrell 1987) and it is recommended to provide 18 grams/day CP for poultry laying 50 grams eggs mass/day. However, the user should take care to specify those feeds for use by poultry which have an analysis adequate for use by them. Because of the same reason, protein use by pig is not modeled in LDPS^2 at this stage (Anderson, 1993).

6.1) Protein availability

Calculation of total protein content of feeds is performed as follows:

For grazing land:

$$\text{Protein}_i = \frac{totLSU_i * 35{,}600 * PROT_i}{ENERGY_i * 10^6}$$

where
$Protein_i$ = Total protein content of feed i
$totLSU_i$ = Total LSUs available from feed i
$PROT_i$ = Protein content of feed i in grams per kilogram of dry matter
$ENERGY_i$ = Energy content of feed i in MJ per kilograms of dry matter

For other feed resources: $$\text{Protein}_i = \frac{\text{TONS}_i * \text{PROT}_i}{1000}$$

where TONSi = Tons of feed i available
PROTi = Protein content of feed i in grams per kilogram of dry matter

The user should be aware that the available amount of protein is a somewhat crude estimate based on aggregation of individual protein content. Whenever possible, calculations made by LDPS[2] regarding protein availability should be cross-checked with field data in order to validate and/or adjust the parameters used.

6.2) Fiber content

For ruminants, protein content (as calculated above) is adjusted to account for fiber content of feedstuff. Since the value of a feedstuff to ruminants is a function of crude fiber content (among other factors), crude protein content is converted into degradable protein by use of a conversion factor. Following Anderson[5], degradable protein is computed as follows:

$$\text{D factor} = \frac{\left(\text{CP} - \text{CF}/8\right)}{\text{CP}} \quad \text{and} \quad \text{Degrad. protein} = \text{CP} * \text{D factor}$$

where: D factor = Degradability factor (fraction)
CP = Crude protein content, in grams per kg of dry matter
CF = Crude fiber content, in grams per kg of dry matter

Crude protein is calculated by LDPS[2], based on feed availability, whereas Crude fiber are user-specified parameters. With fiber-rich feedstuff, D factor can be negative. Negative values are thus set to zero by LDPS[2].

6.3) Protein requirements

Feed requirements can also be expressed in terms of tons of digestible protein per year and per class. The equations needed to calculate protein requirements are presented in the following pages. Classes and systems of interest are cattle and sheep. Buffalo calculations would be the same as cattle, and goats calculations would be the same as sheep.

6.3.1) Cattle

According to ***"The Nutrient Requirements of Ruminant Livestock** (Agricultural Research Council Working Party, 1980, CAB)",* the protein requirements (gr/head/day) can be calculated with following formula :

DCP = Rumen Degradable Protein (RDP) + Undegradable Protein (UDP)

[5] See Anderson (1993) in the reference section.

where $RDP = 7.8 \times ME$

$UDP = if\ (1.91 \times TP - 6.25 \times ME <0, 0, 1.91 \times TP - 6.25 \times ME)$

ME (Metabolisable Energy in MJ/head/day)

TP (Tissue Protein Retention)

TP = EUP + DLP + PIG (for young, replacement and other stocks)

= EUP + DLP + MP (for breeders, MP for male = 0)

EUP (Endogenous urinary requirements) $= 37 \times \log_{10}LW - 42.2$

DLP (Dermal loss requirements)$= 0.11 \times LW^{0.75}$

PIG (Protein in gain) $= DG \times (168.07-0.16869 \times LW+0.0001633 \times LW^2) \times (1.12-0.1223 \times DG)$

MP (Milk protein) $= C \times 6.25 \times totLact/365$

C = constant (Friesian = 4.8, Ayrshire = 5, Jersey = 5.7)

totLact = milk yields per head per year

LW = average liveweight in kilogram

DG = daily gain calculated with LW and years in each class

And protein requirement for pregnancy has to be added to CP for female breeders. Additional protein requirement for pregnancy (during last two months of pregnant period) is 270 grams per day (***Animal nutrition,*** *McDonald et al., 1973, p447).*

Then, additional protein requirement for pregnant female cattle breeder (PFP) is;

$$PFP = 270 \times \text{Fertility rate} \times 60 / 365 \ \ (g/day)$$

6.3.2) Sheep:

The protein requirements (gr/head/day) for sheep is also calculated with following formula :

DCP = Rumen Degradable Protein (RDP) + Non-degradable Protein (UDP)

where : $RDP = 7.8 \times ME$

$UDP = if\ (1.91 \times TP - 6.25 \times ME <0, 0, 1.91 \times TP - 6.25 \times ME)$

ME (Metabolisable Energy in MJ/head/day)

TP (Tissue Protein Retention) = EUP + WP + PIG (for young, replacement and other stocks)

= EUP + WP + MP (for breeders, MP for male = 0)

EUP (Endogenous urinary requirements) $= 0.147 \times LW + 3.375$

WP (Wool protein) $= 6.25 \times 0.85$

PIG (Protein in gain) $= DG \times (160.4-1.22 \times LW+0.0105 \times LW^2$ (for male)

$= DG \times (156.1-1.94 \times LW+0.0173 \times LW^2$ (for female)

MP (Milk protein) $= 6.25 \times 7.66 \times totLact/365$

totLact = milk yields per head per year

LW = average liveweight

DG = daily gain calculated with LW and years in each class

And protein requirement for pregnancy has to be added to CP for female breeders. Additional protein requirement for pregnancy (during last six weeks of pregnant period) is :

$-0.5 \times LW + 50$ grams per day (***Animal nutrition,*** *McDonald et al., 1973, p449).*

Then, additional protein requirement for pregnant female sheep breeder (PFP) is;

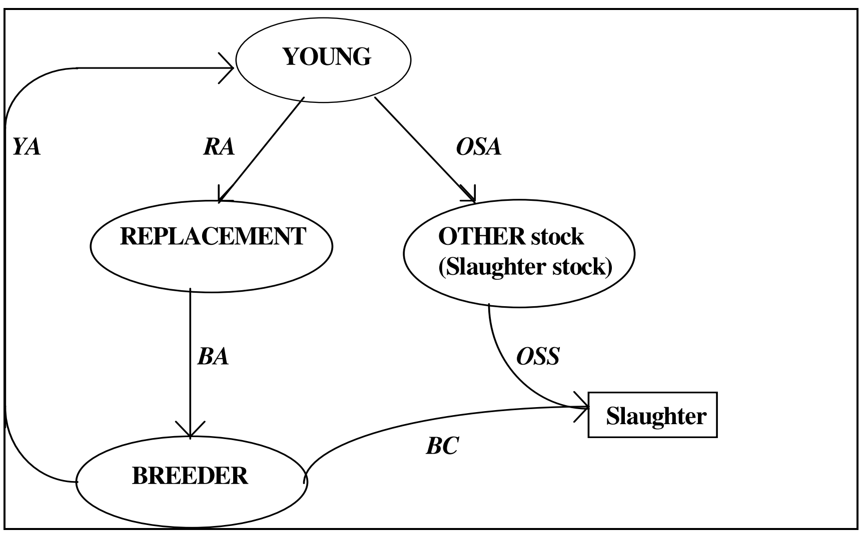
$$PFP = (-0.5 \times LW + 50) \times \text{Fertility rate} \times 42 / 365 \ \ (g/day)$$

2.4 Herd Growth routine

The herd growth routine is used to calculate the yearly expansion of the herds given a specified herd size and composition in the base year. The base year data is input by the user. All other parameters are transferred from Demand-driven routine (to ensure consistency).

The Herd growth routine is designed to model any of the five major livestock systems considered by LDPS[2]: Dairy cattle, Beef cattle, Sheep, Goats and Buffalo. The systems are, however, analyzed using exactly the same model. The differences in results only pertain to differing productivity parameters as specified by the user. Pigs and Poultry herd/flock are not modeled. The high growth rates and ease of import of these livestock usually allow these systems to expand very quickly. Constraints to their expansion are not biological growth constraints, but rather they are such things as available feed or capital.

Figure 17 : Flows of animals in the Herd Growth Routine



YA **= femaleBREEDER × Fertility rate × Prolification rate**
RA **= femaleYOUNG × Fraction of fertile / Years in young**
(*RA of male = RA* × Bulls/Cows)
BA **= REPLACEMENT / Years in replacement**
BC **= Breeder / Years in breeder**
OSA **= femaleYOUNG × (1 - Frac. of fertile × Frac. of retention) / Years in young**
(*OSA of male = OSA* × Bulls/Cows)
OSS **= OTHER / Years in Other stock**
Death = Number of the class in former year × Mortality rate

flow \ class	YOUNG	REPLACEMENT	BREEDER	OTHER
Increase flow	+*YA*	+*RA*	+*BA*	+*OSA*
Decrease flow	-*RA*-*OSA*	-*BA*	-*BC*	-*OSS*

Death	**- Death**	**- Death**	**- Death**	**- Death**
Trade	**+Imp.-Exp.**	**+Imp.-Exp.**	**+Imp.-Exp.**	**+Imp.-Exp.**

2.4.1 Setting up Base year data

Parameters are passed from Demand-driven to herd growth, except the base year data, which specifies the herd size and composition for $LDPS^2$ to start with. In some of the systems with long gestation periods and single offspring, the size of the breeding herd is one of the major constraint to increasing herd size. Occasionally, when such constraints are important, importing of livestock has been used to speed up herd growth.

Base year data can be edited within the "Parameters" sheet, starting at cell **A96**. The first 7 parameters (blue cells in rows 100 to 106) refer to the base year herd structure. The remaining parameters (8 through 26, rows 107 to 125) are copied from Demand-driven parameters. To change these values, go back to the Demand-driven parameters (sheet "Parameters", starting at cell **A1**).

The user needs to edit parameter No. 27 and 28 (rows 126 and 127). All parameters in the Herd Growth routine are equivalent to those in the Demand Driven routine with the exception of the Fraction of female young retained (No.28). The Herd Growth routine, unlike the Demand Driven routine, does not assume a stable herd. The number of young retained for use as future replacements and growth of the breeding herd is a policy variable that the user sets. The number of female young retained for herd maintenance and augmentation in the Herd Growth routine is: The total number of female young minus the fraction of young that are sterile times the fraction of female young retained. The reminder of young are placed in the Other stock class for eventual slaughter. Thus, the parameter 'Fraction of female young retained' operates on a much larger number in the Herd Growth routine than in the Demand Driven routine.

If the Herd growth models are to have any value then the base year data should be as accurate as possible. This is particularly true for the female classes of animals (female breeders, female young and female replacements) since they are the prime constraint to herd growth.

TIP
The best way to test and adjust the productivity parameters is to run $LDPS^2$ using real historical data series, when available. By comparing the results with the actual herd size and composition, you will be able to fine tune your parameter set to reflect more closely the observed evolution of the herds.

2.4.2 Setting up yearly imports and exports

Herd Growth routine lets you specify yearly imports and exports of live animals. The yearly values are supposed constant throughout the projection period. Figure 18 shows the upper left corner of the input table for imports and exports of live animals. This input table can be found in sheet "Parameters", range **[A139 : J174]**.

Figure 18: Input table for imports and exports of live animals

	A	B	C	D	E	F	G	H	I	J
139	Imports and Exports of live animals				(Number of heads per year)					
140				Breeder Females	Breeder Males	Replacement Females	Replacement Males	Young Females	Young Males	Other Stock
141	Dairy Cattle	System 1	Imports							
142			Exports							
143		System 2	Imports							
144			Exports							
145		System 3	Imports							
146			Exports							
147		System 4	Imports							
148			Exports							
149	Beef Cattle	System 1	Imports							
150			Exports							
151		System 2	Imports							
152			Exports							
153		System 3	Imports							
154			Exports							
155		System 4	Imports							
156			Exports							

Welcome / Labels / Parameters / Resources / Results / Sensitivity

Within the Herd Growth routine, net imports (imports minus exports) are added to the herd's classes at the end of each projection year. The resulting figures are then used base herd size and composition at the beginning of the next year.

2.4.3 Calculating results

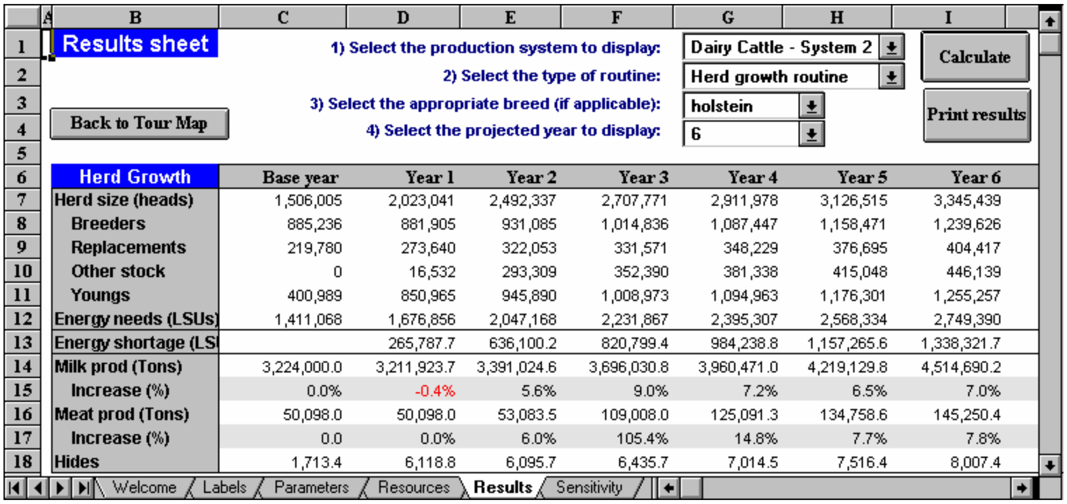
Within the Herd Growth routine, calculations are not simultaneous (as is the case with Demand-driven routine). Herd Growth routine is started when "Herd growth routine" is selected from the pull-down menu at the top of sheet "Results" (on top of cell **G2**).

Figure 19 shows a 6-year period results for Dairy cattle, System 2. Note that figure 19 shows only the upper left part of the results sheet (first 6 years). LDPS^2 allows a total projection period of 20 years.

The same results are shown for all growth systems. Pigs herds and poultry flocks are not projected with the Herd Growth routine.

If you change the selected animal system or the number of years, LDPS^2 recalculates all the results. While recalculating, LDPS^2 halts all screen activity, so you won't be able to move around or do some other tasks.

Figure 19: Herd Growth results sheet



	Results sheet							
	1) Select the production system to display:	Dairy Cattle - System 2						
	2) Select the type of routine:	Herd growth routine						
	3) Select the appropriate breed (if applicable):	holstein						
	4) Select the projected year to display:	6						
6	Herd Growth	Base year	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
7	Herd size (heads)	1,506,005	2,023,041	2,492,337	2,707,771	2,911,978	3,126,515	3,345,439
8	Breeders	885,236	881,905	931,085	1,014,836	1,087,447	1,158,471	1,239,626
9	Replacements	219,780	273,640	322,053	331,571	348,229	376,695	404,417
10	Other stock	0	16,532	293,309	352,390	381,338	415,048	446,139
11	Youngs	400,989	850,965	945,890	1,008,973	1,094,963	1,176,301	1,255,257
12	Energy needs (LSUs)	1,411,068	1,676,856	2,047,168	2,231,867	2,395,307	2,568,334	2,749,390
13	Energy shortage (LS		265,787.7	636,100.2	820,799.4	984,238.8	1,157,265.6	1,338,321.7
14	Milk prod (Tons)	3,224,000.0	3,211,923.7	3,391,024.6	3,696,030.8	3,960,471.0	4,219,129.8	4,514,690.2
15	Increase (%)	0.0%	-0.4%	5.6%	9.0%	7.2%	6.5%	7.0%
16	Meat prod (Tons)	50,098.0	50,098.0	53,083.5	109,008.0	125,091.3	134,758.6	145,250.4
17	Increase (%)	0.0	0.0%	6.0%	105.4%	14.8%	7.7%	7.8%
18	Hides	1,713.4	6,118.8	6,095.7	6,435.7	7,014.5	7,516.4	8,007.4

2.5 Sensitivity analysis

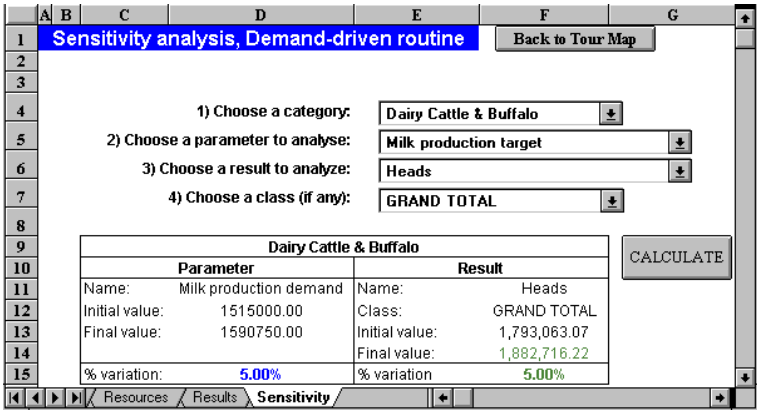
The sensitivity analysis is a feature of LDPS[2] that allows you to test how results are affected by changes in the parameter values. Some parameters affect greatly the results, while others have almost no effect. Sensitivity analysis allows you to test which parameters have the most influence on the resulting values.

Sensitivity analysis is performed using the sheet "Sensitivity". Figure 20 shows the content sheet "Sensitivity" where a sensitivity analysis is performed using the milk production target of Dairy cattle and Buffalo systems as the varying parameter. Results show a 5% increase in total milk production (target result to analyze) from a 5% increase in the parameter value, which suggests a linear relationship between the parameter and the result.

To perform a sensitivity analysis, just select the desired animal system, parameter, result and percentage increase or decrease), and press "CALCULATE". Result is shown in cell **F15**.

You can change the percentage increase in the parameter used by LDPS[2]. Just type a new value in cell **D15**.

Figure 20 : Sensitivity analysis



2.6 Saving your work

Since LDPS[2] is an Excel workbook, saving the file saves the results altogether. If you want to save multiple result sets, you may use any of the following methods:

1) save the ldps2.xls workbook under a different name (for example, ldps2a.xls or result1.xls) with the "**File_Save As**" menu ;
2) copy the results and paste the values in a different workbook;
3) copy the calculations sheet and paste the values in a different workbook. This method saves all results from Demand-driven AND Herd Growth, but in a much less orderly fashion than in sheets "Results" and "Growth".

2.7 Printing results

The simplest way to print results is by pressing the "Print results" button in sheet "Results". This prints the visible results in range **[B1 : J19]**. To print other results, first select the appropriate ones using the pull-down menus, press "Calculate" and then press "Print results".

If you want to print another part of the sheet, or any range in another sheet, first select a range of cells in the sheet of your choice. For example, select range **[A1 : J18]** in sheet "Results" to print results from Demand-driven routine. Then, using the standard Excel "Print" command (**FILE_PRINT**), select your printer, turn it on, et voilà!.

You can print whatever part of LDPS[2] you want: Results, parameters, equations, labels, etc. Choose "**File_Print preview**" from the main Excel menubar to make sure the selected area fits in one page.

NOTE
You can print whatever part of LDPS[2] you want: Results, parameters, equations, labels, etc. Choose "**File_Print preview**" from the main Excel menubar to make sure the selected area fits in one page.

3. Problem solving

3.1 Cautions when using LDPS[2] in a planning environment

A. Restrictions on the Herd Growth routine

As you can see, the routine figures flows of animals in each class on yearly basis. Then the user needs to remember that this sometimes causes unexpected decrease in animal numbers, especially in animals with short production cycles such as sheep and goats. For example, if you set 0.5 for years in replacement stock, it means the number of replacements which become to be breeders in one year is nearly two times as much as the number of replacement stocks at any point in time. However, in the Herd Growth routine, a flow to the next class is always smaller than the size of the stock.

The user also needs to pay attention to the difference between results of the Herd Growth routine and that of the Demand Driven routine. When you use the size and composition of the herd shown in results of the Demand Driven routine for base year structure in the Herd Growth routine, production amount of meat in the Herd Growth routine is not same as that in the Demand Driven routine. There are some reasons; a) a part of replacement stock produces meat in the Demand Driven routine, however, does not in the Herd Growth routine, b) as mentioned above, animals are slaughtered once a year in the Herd Growth routine.

B. Do not use LDPS[2] to make projections aimed at forecasting exact herd size and production values.

Animal production systems are complex and subject to a wide range of factors, most of which the planner have no control, and often no data describing their behavior.

C. LDPS has great value in pointing out inconsistencies in existing data, but is limited in identifying which data are incorrect.

While using LDPS[2], you may notice some strange behavior or awkward results. This may be caused by inconsistent data sets. This happens when incompatible or contradictory data are used in a same set. LDPS2 may show you these inconsistencies, but pinpointing the wrong data is another cup of tea.

If you are faced with such a problem, go through you data sets and try to find suspicious data values or parameter levels. This is the only way out of there.

D. LDPS never gives the ‘right’ answer.

LDPS[2] has a mathematical behavior. The number of factors taken into account is limited, and the equation sets are a simplified image of reality. Always keep these facts in mind when using the spreadsheet and when interpreting the results. These results should not be used directly to implement or influence real policy. They should be put to the test by experienced officers in the field of animal production.

3.2 Common problems

Here is a list of the problems you are most likely to encounter when using LDPS^2. The left column of the following table spells the problem, and the right column shows a possible cause and solutions.

Table 10: Solution to common problems

Problem	Cause and solution
1) Installing LDPS^2	
LDPS^2 will not install on your hard disk.	You may need more free space (at least 5 meg)
Message "No program is associated with this file".	Either you don't have Excel installed, or the file extension ".XLS" is not associated with Excel. Find Excel, open it and open the file with the "**FILE_OPEN**" menu.
Message "This program requires Microsoft Windows"	You are trying to run Excel from the DOS prompt. Start Windows first, then run Excel.
Message “File ldps2.xls already exists. Overwrite file?”	You have already installed LDPS^2 are attempting to install it over again. Check the version already installed. If you do want to re-install it, just answer « YES » when the message shown at left is displayed.

2) Using LDPS^2	
Message "Object does not support property".	You may be using an old version of Excel. Try at least version 5
Macro error at run time.	Macros have been modified. Try using an unmodified version of LDPS^2
LDPS^2 shows wrong values.	Calculation updating has been set to manual. Try pressing the F9 key (Recalculate) on your keyboard. If LDPS^2 still shows wrong results, check your parameter values.
Message "Out of memory".	You need more real memory (RAM) or a larger virtual memory block. See the Windows and Windows 95 manuals.
Message “Not enough system resources to display completely”	You need more system resources (memory). See the Windows manuals, or terminate other software running behind LDPS^2. When you set zoom control to 100%, sometimes you can avoid the message.
Cells show “####” instead of numbers ,or only a part of the text.	Cell content cannot be displayed because the column is too narrow. This is not an error. You just have to change the column’s width with the “**Format_Column_Width**” menu.

4. Case study: China

This chapter gives an example of using $LDPS^2$, applying it to the case of China with real data.

China is one of the major livestock producers in the world. According to WAICENT it keeps nearly 50 percent of pigs, 20 percent of goats and chickens and 15 percent of buffaloes of the world inventory. The number of livestock in China has grown considerably since economic reform began in the late 1970s. Meat production has grown even more dramatically. Annual growth rates of meat production from different species were more than 10 percent, except for pork (8.2 percent), over the last decade. Current production of beef and chicken meat has reportedly multiplied by 10.7 and 4.8, respectively, over the last 10 years. In the same period, cattle numbers have grown by 4.8 percent annually. As shown by $LDPS^2$, this is technically impossible and suggests over-reporting in statistics.

4.1 Current situation of livestock production in China

4.1.1 Production systems in China

China has extremely diverse production environments, ranging from tropical in the south to sub-arctic in the north. It contains mountains, high plateau and deserts in the west and plains, deltas and hills in the east. Taking this diversity into account, livestock production in China can be conveniently divided into 18 different production systems, on the basis of agro-ecological zones and type of animal (Table 11 and Figure 21).

Table 11 : Livestock production systems in China

Dairy cattle	(1) pastoral area, (2) warm and cold area, (3) tropic and subtropical area
Beef cattle	(4) pastoral area, (5) warm and cold area, (6) tropic and subtropic area
Sheep	(7) pastoral area, (8) semi-pastoral area, (9) crop area
Goats	(10) pastoral area, (11) semi-pastoral area, (12) crop area
Buffaloes	(13) tropic and subtropic area
Pigs	(14) traditional production, (15) intensive production
Chicken	(16) traditional production, (17) commercial egg production, (18) commercial meat production

Figure 21 : Agro-ecological zones in China

4.1.2 Input demands and data

As mentioned before, livestock statistics in China seem to be inconsistent, as reported production, livestock numbers and expected and reported productivity do not match. They narrowed the range of possible data sets. The reported output of livestock products in 1995 was used as for a demand target in LDPS[2], and these were tentatively adjusted through calculation with data on productivity of each production system. Table 12 shows the production levels for livestock products. Parameters used are shown in Appendix B.

Table 12 : Demand for livestock products in 1995

Production systems	Production in 1995
1. Dairy cattle production (1)Pastoral area (2)Warm and Cold areas (3)Tropic and sub tropic areas	Milk 5,764,000 tons 1,515,000 3,224,000 1,025,000
2. Beef cattle production (1)Pastoral area (2)Warm and Cold areas (3)Tropic and sub tropic areas	Meat 3,200,000 tons 400,000 1,600,000 1,200,000
3. Buffaloes	Milk 2,200,000 tons
4. Sheep (1)Pastoral area (2)Sub-pastoral area (3)Crop area	Meat 1,030,000 tons 480,000 70,000 480,000
5. Goats (1)Pastoral area (2)Sub-pastoral area (3)Crop area	Meat 890,000 tons 130,000 40,000 720,000
6. Pigs	Meat 36,484,000 tons
7. Chicken	Meat 6,450,000 tons Egg 13,414,000 tons

4.1.3 Livestock production modelled by LDPS²

Beef production

Statistics in China, cattle comprises water buffaloes (*Bubalus*) and yaks (*Bos grunniens*) besides cattle in a narrower sense (*Bos taurus*). In this chapter, the word 'cattle' is used for *Bos taurus,* or for cattle called 'Yellow cattle' which are kept for both meat production and draught. The amount of beef produced in 1995 is reported in FAOSTAT to be 3.7 million tons (3 kg per capita). However, this is at variance with meat consumption reported in official statistics in China at 2.4 kg of beef and mutton per capita in urban households and 0.7 kg per capita in rural households. Meat production of yellow cattle was classified into three production systems, and total beef production (from yellow cattle) was estimated by LDPS² to be 3.2 million tons. According to China Agricultural Yearbook, more than 70 percent of beef is produced in warm and cold areas where only 50 percent of the total cattle is kept. LDPS² indicates that beef production in warm and cold areas is likely to be over-reported, whereas that in tropic and subtropic areas seems to be under-estimated in the statistics.

Beef production and the number of cattle are reported to have grown by 27.5 and 4.8 percent annually over the last five years, which is technically impossible. The statistics also showed that the offtake rate of all cattle, including buffaloes and yaks, was 23 percent in 1995. However, LDPS² showed that the cattle herd is growing by two to three percent annually, and the offtake rates are 15 percent for yellow cattle and 9 percent for buffaloes. This suggests that the amount of meat produced and its growth rate are also over-reported in the statistics.

Table 13 : Inventory of yellow cattle (1000 heads)

	LDPS²	China Agricultural Yearbook
1. Pastoral total	15,110	15,705
female breeders	5,327	6,409
calves under 1 yr.	3,196	3,307
2. Warm and cold total	57,826	45,538
female breeders	18,967	22,830
calves under 1 yr.	12,329	13,648
3. Tropic and subtropic total	39,040	38,062
female breeders	13,487	15,089
calves under 1 yr	8,092	6,962
4. Grand total	111,977	99,305
female breeders	37,781	44,326
calves under 1 yr	23,617	23,919

LDPS² indicates that the number of female breeders must be smaller than that reported and that the total number in warm and cold area shown by LDPS² was larger. Male yellow cattle are kept for draught for more than three years on average, and breeders are kept for six years. According to the statistics, the ratio of breeders to total inventory is about 50 percent in warm and cold area, while that in the other areas is 40 percent. This means that the ratio of draught cattle to total inventory and/or years in draught use in the warm and cold area are smaller than those in the other areas, and that production has shifted from draught to meat production faster than the LDPS² has estimated. However, this does not seem to be a realistic proposition, according to interviews to farmers and government officials.

Mutton production

In China sheep is kept for meat and wool production. Sheep production is classified into three sub-production systems, pastoral, semi-pastoral and crop areas. Productivity of mutton is generally low in pastoral area.

Table 14 : Inventory of sheep (1000 heads)

	$LDPS^2$	China Agricultural Yearbook
1. Pastoral total	93,537	78,334
female breeders	41,434	41,439
2. Semi-pastoral total	9,229	10,423
female breeders	4,185	5,734
3. Crop area total	48,082	38,507
female breeders	18,160	20,166
4. Grand total	150,847	127,263
female breeders	63,780	67,336
female replacements	19,473	21,201
under 1 yr.	60,886	43,100

In comparison with the herd size and composition stated in the statistics, $LDPS^2$ computes larger herd sizes to meet the production target. This occurs because $LDPS^2$ shows the number of all new-borns in one year as that of young stock and the statistics show only those retained for next year. The sheep inventory calculated by $LDPS^2$ is almost similar or a little bit smaller than that stated in the statistics. The user needs to remind the specification of $LDPS^2$.

Pork production

Pork is a very important livestock product in China. Pigs are kept all over the country. In rural areas, every farms is used to keeping a few pigs and slaughter them for the spring festival and other cerebrations. Pork production has intensified but traditional production is still the predominant form. It is said that today about 15 to 25 percent of total pork is produced using modern intensive systems. $LDPS^2$ can calculate two pig production systems at the same time and is able to change production ratio of those systems. $LDPS^2$ figured that, if the number of pigs and the amount of pork produces as stated in the statistics were correct, the traditional pork production sector would still be large in China.

Because per head energy requirements of the replacement and other stocks were thought to be almost equal to that of the breeder stock, 0.8 was used for system specific LSUs instead of the original value (0.4) in the study (see 2.3.1.2 and the parameters sheet [**E77:G78**]).

Table 15 : Pork production in China in 1995(1000 heads)

	$LDPS^2$ (Percentage of the modern sector)	China

	15%	20%	25%	Agricultural Yearbook
1. Number of total pigs	430,637	421,410	412,184	441,691
female breeders	32,447	31,873	31,300	34,302
2. Number of slaughtered pigs	498,256	498,155	498,054	480,510

Chicken meat and egg production

There are many backyard chickens in China. Their number is estimated to be about 1 billion (China Agriculture University). In addition, modern intensive chicken meat and egg production with improved breeds has grown rapidly. Recent fast growth of chicken meat and egg production has largely occurred in the intensive system. According to FAOSTAT, 6.45 million tons of chicken meat and 13.4 million tons of eggs were produced in 1995. $LDPS^2$ shows that nearly 30 percent of chicken meat and 40 percent of eggs were produced by the traditional sector.

Table 16 : Chicken meat and egg production figured by $LDPS^2$ in 1995 (million birds, 1000 tons)

	Total birds	Slaughtered birds	Meat	Egg
1. Traditional village production	1,000	800	1,760	5,000
2. Modern intensive egg production	1,645	622	752	8,414
3. Modern intensive meat production	934	2,550	3,938	
TOTAL	3,579	3,972	6,450	13,414

4.1.4 Feed supply and demand

Feed requirements of each production system are calculated with the demand driven routine of $LDPS^2$. The user can know surplus or deficit of feed resources by comparing the requirements and feed supply in the "Resources" sheet.

$LDPS^2$ is also able to calculate the size of target herd and possible production amounts with available feed resources using the resource driven routine.

4.1.4.1 Feed inventory

Grazing land

LDPS2 calculates feed supply from each grazing area with different growing period, however, there is no such information available in China.

According to China Agricultural University, grazing land in China (about 400 million ha in total) has a potential to produce about 1,256 million tons of fresh grass per year. It is roughly equivalent to 44 million LSUs (370 billion Mcal). According to the statistics, 313 million ha have actually been used as pasture in 1995. Energy supply from grazing land is 34 million LSUs for one year. (LDPS2 indicates that 235 million ha of grazing land with 120 to 149 growing days is needed to produce the amount of energy, but this does not make any sense.)

Other feed resources

Data concerning the other known feed resources were also calculated on the resource sheet of LDPS[2]. The known feed resources available were 116 million LSUs (990 billion Mcal, see Appendix B).

4.1.4.2 Feed Utilization Matrix

The feed resources were allocated to each production system, using a series of decision rules (Steinfeld and Becker, 1991).

i) Physiological criteria are straightforward in that they can be universally applied. Certain feed types are not suitable for certain animals (e.g. roughage for poultry) and so cannot be allocated to them, or only in small quantities.

ii) Geographical criteria relate to the locational coincidence of feed availability and livestock populations. For example, 30 percent of grazing land is in the pastoral area, of which 50 percent is in the tropic and subtropic areas. Crop residues and by-products are useful mainly in the crop areas. Indigenous maize, of which 90 percent is produced in the warm and cold areas, and hence would not be used much in other areas because of relatively high transport costs.

iii) Economic criteria relate to cost/price ratios of basic concentrates, or commercial feeds to the price of main livestock products. These ratios roughly indicate the profitability of feeding various feed types at given productivity levels.

Total feed requirements computed by LDPS[2] amounted to 181 million LSUs (1,541 billion Mcal) of feed energy, excluding half of sheep and young goat stocks which were shown too high in LDPS[2] (see section 4.1.3). According to the Feed Utilisation Matrix of LDPS[2], there was a gap of 31 million LSUs (262 million Mcal) between energy supply and demand. Even modelling yellow cattle and buffaloes on under-nutritional conditions, i.e. meeting only 90 percent of the requirements, it would still leave a gap of 26 million LSUs (218 billion Mcal) in pig and chicken production. Household wastes were estimates to account for 14 percent of the total feed resources allocated and 23 percent of the requirement for pigs and chicken.

Figure 22 : Feed utilization matrix

FEED UTILIZATION MATRIX (LSUs)

Optimize allocation		Grazing land		Crop residues	Primary products	Crop by-products	Fodder	ME (Million Mcal)			
		< 90 days	> 90 days					1,569,166	1,494,595	74,572	
	Relative prices	1	1.1	1.5	2	1.4	1.3	Total LSU needed	Total LSU allocated	Total LSU missing	Total needed M Mcal
Total available:	175,656,838	0	34,021,739	55,111,686	55,558,013	27,887,961	3,077,439				
Total allocated:	175,656,838	0	34,021,739	55,111,686	55,558,013	27,887,961	3,077,439				
Total remaining	(0)	0	0	(0)	0	(0)	(0)	184,421,119	175,656,838	8,764,281	1,569,166
Dairy Cattle	Pastoral	0	1,000,000	34,986	0	100,000	50,000	1,184,986	1,184,986	(0)	10,083
	Warm&Cold	0	1,000,000	11,068	200,000	100,000	100,000	1,411,068	1,411,068	(0)	12,006
	Tropical&ST	0	200,000	28,618	150,000	50,000	20,000	448,618	448,618	(0)	3,817
		0	0	0	0	0	0	0	0	0	0
Beef Cattle	Pastoral	0	4,000,000	300,000	0	200,000	100,000	5,101,369	4,600,000	501,369	43,406
	Warm&Cold	0	5,000,000	11,400,000	300,000	900,000	300,000	19,821,717	17,900,000	1,921,717	168,655
	Tropical&ST	0	3,900,000	6,950,000	750,000	1,000,000	400,000	14,489,130	13,000,000	1,489,130	123,282
		0	0	0	0	0	0	0	0	0	0
Sheep	Pastoral	0	4,308,865	0	0	0	0	4,951,184	4,308,865	642,319	42,128
	Semi-pastoral	0	586,308	0	0	0	0	690,579	586,308	104,271	5,876
	Crop area	0	2,500,000	0	50,000	135,258	100,000	3,448,860	2,785,258	663,602	29,345
Goats	Pastoral	0	1,231,713	0	0	0	0	1,377,292	1,231,713	145,579	11,719
	Semi-pastoral	0	378,428	0	0	0	0	427,735	378,428	49,307	3,639
	Crop area	0	6,000,000	450,000	98,661	700,000	200,000	9,037,939	7,448,661	1,589,278	76,900
Buffalo	Tropical&ST	0	3,916,425	5,870,000	750,000	1,426,000	0	13,298,773	11,962,425	1,336,348	113,154
		0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0
Pigs	Combined	0	0	23,050,572	37,259,352	21,776,703	1,400,000	83,807,991	83,486,627	321,364	713,089
Poultry	Combined	0	0	7,016,442	16,000,000	1,500,000	407,439	24,923,881	24,923,881	(0)	212,067

4.2 A scenario for growth of livestock production toward 2005

Many studies concerning China's food demand and supply toward the next century have been reported recently (Brown, IFPRI, USDA, World Bank, OECF). They pointed out that it is very important with regard to China's food security to consider the competition of grains between food and feed.

Though more detailed information and economic analysis are required, demands for livestock products in 2005 were roughly estimated and the potential of the livestock sector in China to meet the demands was technically assessed using LDPS[2].

4.2.1 Projected livestock production in 2005

Total demand in 2005 was estimated on the basis of population growth, income growth (GDP per capita) and income elasticity for each product. Demands for each sub-production system were estimated with total demand and growth rates of each sub-system calculated by the herd growth routine of LDPS[2] (Table 17). Effects of price changes and the role of trade were not considered in the estimation.

Table 17 : Livestock production in 2005 and 1995

Production systems	Demand in 2005 (*)	Production in 1995	Av. an. growth
1. Dairy cattle production	Milk 9.900,000 tons	Milk 5,764,000 tons	5.6 %
(1)Pastoral area	1,800,000	1,515,000	1.7
(2)Warm and Cold areas	6,800,000	3,224,000	7.8
(3)Tropic and sub tropic areas	1,300,000	1,025,000	2.4

2. Beef cattle production	Meat 4,900,000 tons	Meat 3,200,000 tons	4.4
(1)Pastoral area	520,000	400,000	2.7
(2)Warm and Cold areas	2,580,000	1,600,000	4.9
(3)Tropic and sub tropic areas	1,800,000	1,200,000	4.1
3. Buffaloes	Milk 2,400,000 tons	Milk 2,200,000 tons	0.9
4. Sheep	Meat 1,400,000 tons	Meat 1,030,000 tons	3.1
(1)Pastoral area	600,000	480,000	2.3
(2)Sub-pastoral area	90,000	70,000	2.5
(3)Crop area	710,000	480,000	4.0
5. Goats	Meat 1,100,000 tons	Meat 890,000 tons	2.1
(1)Pastoral area	130,000	130,000	0.0
(2)Sub-pastoral area	40,000	40,000	0.0
(3)Crop area	930,000	720,000	2.6
6. Pigs	Meat 46,500,000 tons	Meat 36,484,000 tons	2.5
7. Poultry (Chicken)	Meat 11,900,000 tons	Meat 6,450,000 tons	6.3
	Egg 17,000,000 tons	Egg 13,414,000 tons	2.4

(*) Estimated demand = population 2005 × production per capita 1995 × [1+ income elasticity × change in income]
source; Population; the UN
GDP; World Bank
Income elasticity; Meat and eggs: Simpson *et al.*, 1994
Milk: estimated with production in 1995 - 1990

4.2.2 Improvements in productivity

The following improvements in productivity and changes were assumed.

Table 18 : Assumed improvements in productivity (maximum and minimum)

Type of animal	Productivity parameter	1995	2005
Dairy cattle	Milk yield (tons)	2.0 4.5	2.4 5.4
	Young mortality rate	0.7 0.6	0.6 0.5
Beef cattle	Fertility rate	0.6 0.65	0.65 0.7
	Young mortality rate	0.11 0.08	0.10 0.07
	Carcass weight (tons)	0.18 0.25	0.198 0.275
	Demand for draught power (unit)	6 mill. 900 mill.	4.8 mill. 720 mill.
Sheep	Carcass weight (slaughter stock, tons)	.015 .017	.019 .015
	Young mortality rate	0.10 0.12	0.09 0.11
Goats	Carcass weight (slaughter stock, tons)	0.010 0.014	0.012 0.016
	Young mortality rate	0.10 0.12	0.09 0.11
Buffaloes	Fertility rate	0.55	0.60
	Demand for draught power (unit)	300 mill.	240 mill.

4.3 Livestock production in 2005

Demands for cow and buffalo milk in 2005 were estimated to be 9.9 and 2.4 million tons, respectively. This translates into annual growth rates of 5.6 and 0.9 percent, respectively. Estimates provided through the demand driven routine show that if average milk yield per cow was improved by 20 percent, only 3.0 million heads of cows (in total 4.9 million head of cattle) would be needed to achieve the demand.

Demand for beef in 2005 was estimated at 4.9 million tons (3.7 kg per capita), which is 1.5 times the present production. The demand driven routine showed that more than 190 million cattle would be required to meet this demand, if productivity does not improve. Results of sensitivity analysis showed that more than five percent of total stock could be decreased if carcass weight of slaughter stock increased by 10 percent. According to $LDPS^2$, growth rate of total cattle inventory was two to three percent annually and that of production in pastoral area was zero because of its low productivity. $LDPS^2$ figured that improvement of fertility rate from 60(65) percent to 65(70) percent and mortality rate of young stock from 11(8) percent to 10(7) percent would improve the growth rate of the herd to more than five percent. With these assumed improvements, the total cattle inventory and beef production in 2005 were estimated to be 155 million head and 4.9 million tons.

Demand for mutton and goat meat in 2005 was assessed at 1.4 and 1.1 million tons, respectively. The demand driven routine showed nearly 200 million sheep would be required to meet this demand if productivity is not improved, and the herd growth routine showed that it would be difficult to expand the herd to that level in ten years. The shortage of mutton to meet the demand in 2005 was estimated to be 0.1 to 0.2 million tons.

Demand for pork in 2005 was estimated at 46.5 million, 1.3 times the present production. About 80 percent of total pork is produced by the traditional backyard system. However, this would remain stable for the next ten years since the rural population has not grown significantly over the past five years. By 2005, its contribution to the total pork production would be decreased to 60 percent. $LDPS^2$ showed that the number of pigs in the intensive system would need to increase to 140 million, which was 2.5 times the present level, making the total number 490 million.

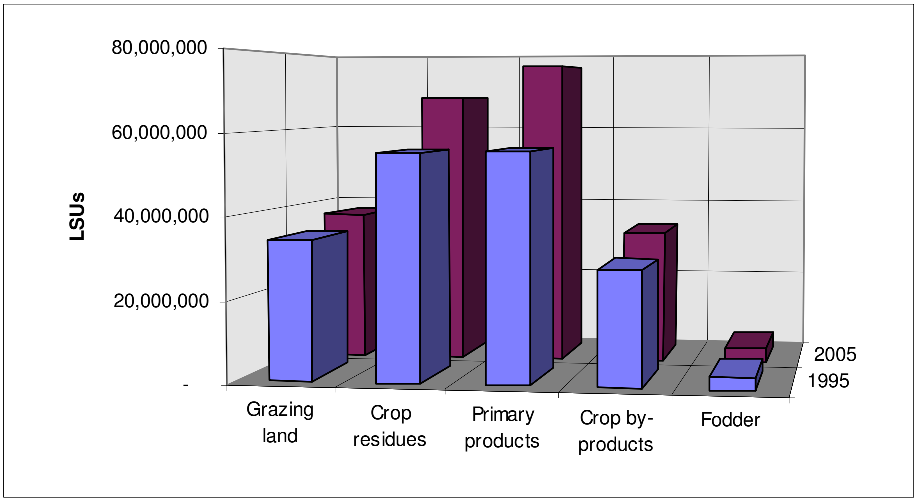
Demand for chicken meat and eggs in 2005 was estimated to be 11.9 and 17.0 million tons, 1.8 and 1.3 times the present production, respectively). The output of traditional backyard production, which produces 1.76 million tons of chicken meat and 5 million tons of eggs at present, would also remain stable. $LDPS^2$ showed that, 2.3 billion commercial layers (1.4 times the present number) and 2.2 billion commercial broilers (1.9 times the present number) would be required to meet the demands.

Demand for feed

$LDPS^2$ calculated that the energy requirement for livestock production in 2005 would reach 221 million LSUs (1,880 billion Mcal), which is 1.2 times the current requirement. This would require an increase of 19 million LSUs (163 billion Mcal) for beef, 8 million LSUs (71 billion Mcal) for pigs and 8 million LSUs (72 billion Mcal) for chickens.

To satisfy this demand for energy, supply should increase by twenty percent, excluding grazing land and house wastes (ten percent), straws (40 percent) and maize and soybeans (50 percent). The amount of cereal grains and its contribution to total energy supply would reach 168 million tons or nearly 30 percent in 2005 (Figure 23).

Figure 23 : Feed energy supply



4.4 Summary

Through the application, LDPS^2 can appraised various production systems of different outputs. One of the main purpose to use LDPS^2 is to correct technical inconsistencies in available information and to estimate values in lacking data. It is reported beef production in China has grown rapidly since the late 1970s, however, LDPS^2 successfully showed that the amount and the growth rate of beef production seems to be over-reported in recent years. There are also some discrepancies in the number and the composition of the cattle herd in each region. The sensitivity analysis of LDPS^2 was also useful for this purpose.

As mentioned in the part on sheep, LDPS^2 shows the number of all new-borns in one year for that of young stock, regardless of years in young, because the LDPS^2 model was designed to calculate on a yearly basis. It also causes other problems even in other calculation routines. The users are kindly requested to remind the specification of LDPS^2, especially in the case production cycle is shorter than a year.

About twenty percent of pork and two thirds of chicken meat and eggs are assumed to be produced by the modern intensive sector. The intensive production depends largely on purchased feeds (grains) and does not have enough land to recycle all manure produced. If the manure is not recycled appropriately, there would be a large threat for water pollution. LDPS^2 now shows maximum manure output in dry matter which is often larger than real amount (see 2.3.4-5). It can be used for rough estimation, but the users need to calculate with other method when they need more precise information such as application amount of manure to certain fields.

Strong demand for livestock products will continue for the next decades supported by income growth and urbanisation. The livestock sector in China has largely improved its productivity in order to meet the demand, and need to continue the effort. There seemed to be more room to improve the productivity.

The largest constraint for expanding livestock production in China is feed resources. LDPS[2] figured that available feed was definitely not enough to keep all livestock and large ruminants were in under nutritional condition in China. Now the government of China has started "the programme for grain saving livestock production" with efficient use of crop by-products and improvement of grazing land. I assumed increment of crop by-products and other resources for feed by ten to forty percent, and nearly 170 million tons of cereals was required to meet the demand for livestock products in 2005, besides them. A very rough estimation was used in this trial and more precise study was needed, however, efficient use of feed resources will also be indispensable for livestock production in the future. While the resource driven routine didn't play an active part in this chapter, the routine is useful to calculate the size of target herd and possible production amounts with available feed resources.

Appendix A: Parameters sets

A.1 Demand-driven routine, dairy cattle and buffalo

Index	Parameter name	Units
1	Milk production target	Tons of milk per year
2	Distribution losses	Fraction of losses from slaughter to final consumption
3	Fertility rate	Average number of parturitions per female per year (0.5 means one parturition per 2 years)
4	Prolificacy rate	Average number of live births per parturition (0.5 means that half of calves are dead at birth)
5	Breeder males per breeder female	Ratio of males on females
6	Milk yield per lactation	Tons of milk per cow per year
7	Fraction of females milked	Ratio between 0 and 1
8	Cow mortality rate	Ratio between 0 and 1
9	Bull mortality rate	Ratio between 0 and 1
10	Female replacement mortality rate	Ratio between 0 and 1
11	Male replacement mortality rate	Ratio between 0 and 1
12	Female young mortality rate	Ratio between 0 and 1
13	Male young mortality rate	Ratio between 0 and 1
14	Other stock mortality rate	Ratio between 0 and 1
15	Draught animals mortality rate	Ratio between 0 and 1
16	Years in breeding herd, cows	Average number of years elapsed between the time a replacement enters the breeding herd and the time that it is culled.
17	Years in breeding herd, bulls	Average number of years elapsed between the time a replacement enters the breeding herd and the time that it is culled.
18	Years in replacement herd, females	Average number of years elapsed between the time when an animal is no longer young and the time when it enters the breeding herd
19	Years in replacement herd, males	Average number of years elapsed between the time when an animal is no longer young and the time when it enters the breeding herd
20	Years from young to slaughter, other stock	Average number of years elapsed between the time when an animal is no longer young and when it is slaughtered
21	Years from young to slaughter, draught animals	Average number of years elapsed between the time when an animal is no longer young and when it is slaughtered
22	Years as young	Average number of years elapsed between birth and the time it enters the replacement herd
23	Carcass weight of female breeders	Tons per head (average)
24	Carcass weight of male breeders	Tons per head (average)
25	Carcass weight of other stock	Tons per head (average)
26	Carcass weight of draught animals	Tons per head (average)

27	Males in the system?	1= Yes 0=No
28	Fraction of fallen animal eaten	Fraction between 0 and 1
29	Proportion of female breeders with usable skin	Fraction between 0 and 1
30	Proportion of male breeders with usable skin	Fraction between 0 and 1
31	Proportion of other stock with usable skin	Fraction between 0 and 1
32	Proportion of draught animals with usable skin	Fraction between 0 and 1
33	Weight of skin for female breeders	Average weight in tons per head
34	Weight of skin for male breeders	Average weight in tons per head
35	Weight of skin for other stock	Average weight in tons per head
36	Weight of skin for draught animals	Average weight in tons per head
37	Average live weight, breeder female	Average weight in tons per head
38	Average live weight, breeder male	Average weight in tons per head
39	Average live weight, replacement female	Average weight in tons per head
40	Average live weight, replacement male	Average weight in tons per head
41	Average live weight, other stock	Average weight in tons per head
42	Average live weight, draught animals	Average weight in tons per head
43	Average live weight, young female	Average weight in tons per head
44	Average live weight, young male	Average weight in tons per head
45	Milk fat content	Grams per kilogram of milk produced
46	Peek animal draught power demand / month	User defined (ex : Man-days equivalent)
47	Are there Draught specific oxen?(Y=1 / N=0)	1= Yes 0=No
48	Are Male Breeders used for draught?(Y=1 / N=0)	1= Yes 0=No
49	Are Female Breeders used for draught?(Y=1 / N=0)	1= Yes 0=No
50	Are Male replacements used for draught?(Y=1 / N=0)	1= Yes 0=No
51	Number of days worked, draught specific animals	Number of days
52	Number of days worked, Breeders	Number of days
53	Number of days worked, Replacements	Number of days
54	Average productivity /animal /day, draught specific oxen	User defined (ex : Man-days equivalent)
55	Average productivity /animal /day, Breeders	User defined (ex : Man-days equivalent)
56	Average productivity /animal /day, Replacements	User defined (ex : Man-days equivalent)

A.2 Demand-driven routine, beef

Index	Parameter name	Units
1	Meat production target	Tons of meat per year
2	Distribution losses	Fraction of losses from slaughter to final consumption (between 0 and 1)
3	Fertility rate	Average number of parturitions per female per year (0.5 means one parturition per 2 years)
4	Prolificacy rate	Average number of live births per parturition (0.5 means that half of calves are dead at birth)
5	Breeder males per breeder female	Ratio of males on females
6	Female breeder mortality rate	Ratio between 0 and 1
7	Male breeder mortality rate	Ratio between 0 and 1
8	Female replacement mortality rate	Ratio between 0 and 1
9	Male replacement mortality rate	Ratio between 0 and 1
10	Young mortality rate	Ratio between 0 and 1
11	Other stock mortality rate	Ratio between 0 and 1
12	Draught animals mortality rate	Ratio between 0 and 1 (Not used)
13	Years in breeding herd	Average number of years elapsed between the time a replacement enters the breeding herd and the time that it is culled.
14	Years in replacement herd	Average number of years elapsed between the time when an animal is no longer young and the time when it enters the breeding herd
15	Years as young	Average number of years elapsed between birth and the time it enters the replacement herd
16	Years from young to slaughter, other stock	Average number of years elapsed between the time when an animal is no longer young and when it is slaughtered
17	Years from young to slaughter, draught animals	Average number of years elapsed between the time when an animal is no longer young and when it is slaughtered (Not used)
18	Carcass weight of female breeders	Tons per head (average)
19	Carcass weight of male breeders	Tons per head (average)
20	Carcass weight of other stock	Tons per head (average)
21	Carcass weight of draught animals	Tons per head (average) (Not used)
22	Fraction of females milked	Tons per head (average)
23	Milk yield per lactation	Tons of milk per cow per year
24	Fraction of calves that are fertile	Fraction between 0 and 1
25	Retention ratio for young females	Fraction of female calves retained for replacement of breeders that die or are culled.
26	Fraction of fallen animals eaten	Fraction between 0 and 1
28	Are young males slaughtered at birth ? (yes / no)	1= Yes 0=No
30	Proportion of female breeders with usable skin	Fraction between 0 and 1
31	Proportion of male breeders with usable skin	Fraction between 0 and 1
32	Proportion of other stock with usable skin	Fraction between 0 and 1
33	Proportion of draught animals with usable skin	Fraction between 0 and 1 (Not used)
34	Weight of skin for female breeders	Average weight in tons per head
35	Weight of skin for male breeders	Average weight in tons per head

36	Weight of skin for other stock	Average weight in tons per head
37	Weight of skin for draught animals	Average weight in tons per head (Not used)
38	Average live weight, breeder female	Average weight in tons per head
39	Average live weight, breeder male	Average weight in tons per head
40	Average live weight, replacement female	Average weight in tons per head
41	Average live weight, replacement male	Average weight in tons per head
42	Average live weight, other stock	Average weight in tons per head
43	Average live weight, draught animals	Average weight in tons per head (Not used)
44	Average live weight, young female	Average weight in tons per head
45	Average live weight, young male	Average weight in tons per head
46	Milk fat content	Grams per kilogram of milk produced
47	Peek animal draught power demand / month	User-defined (ex : Man-days equivalent)
48	Are there Draught specific oxen?(Y=1 / N=0)	1= Yes 0=No
49	Are Male Breeders used for draught?(Y=1 / N=0)	1= Yes 0=No
50	Are Female Breeders used for draught?(Y=1 / N=0)	1= Yes 0=No
51	Are Male replacements used for draught?(Y=1 / N=0)	1= Yes 0=No
52	Number of days worked, draught specific animals	Number of days
53	Number of days worked, Breeders	Number of days
54	Number of days worked, Replacements	Number of days
55	Average productivity /animal /day, draught specific oxen	User-defined (ex : Man-days equivalent)
56	Average productivity /animal /day, Breeders	User-defined (ex : Man-days equivalent)
57	Average productivity /animal /day, Replacements	User-defined (ex : Man-days equivalent)

A.3 Demand-driven routine, sheep and goats

Index	Parameter name	Units
1	Meat production demand	Tons of meat per year
2	Distribution losses	Fraction of losses from slaughter to final consumption (between 0 and 1)
3	Fertility rate	Average number of parturitions per female per year (0.5 means one parturition per 2 years)
4	Prolificacy rate	Average number of live births per parturition (0.5 means that half of calves are dead at birth)
5	Breeder males per breeder female	Ratio of males on females
6	Female breeder mortality rate	Ratio between 0 and 1
7	Male breeder mortality rate	Ratio between 0 and 1
8	Female replacement mortality rate	Ratio between 0 and 1
9	Male replacement mortality rate	Ratio between 0 and 1
10	Young mortality rate	Ratio between 0 and 1
11	Other stock mortality rate	Ratio between 0 and 1
12	Years in breeding herd	Average number of years elapsed between the time a replacement enters the breeding herd and the time that it is culled.
13	Years in replacement herd	Average number of years elapsed between the time when an animal is no longer young and the time when it enters the breeding herd
14	Years as young	Average number of years elapsed between birth and the time it enters the replacement herd
15	Years from young to slaughter, other stock	Average number of years elapsed between the time when an animal is no longer young and when it is slaughtered
16	Carcass weight of female breeders	Tons per head (average)
17	Carcass weight of male breeders	Tons per head (average)
18	Carcass weight of other stock	Tons per head (average)
19	Fraction of females milked	Tons per head (average)
20	Milk yield per lactation	Tons of milk per cow per year
21	Fraction of calves that are fertile	Fraction between 0 and 1
22	Retention ratio for young females	Fraction of female calves retained for replacement of breeders that die or are culled.
23	Fraction of fallen animals eaten	Fraction between 0 and 1
30	Proportion of female breeders with usable skin	Fraction between 0 and 1
31	Proportion of male breeders with usable skin	Fraction between 0 and 1
32	Proportion of other stock with usable skin	Fraction between 0 and 1
34	Weight of skin for female breeders	Average weight in tons per head
35	Weight of skin for male breeders	Average weight in tons per head
36	Weight of skin for other stock	Average weight in tons per head
38	Average live weight, breeder female	Average weight in tons per head
39	Average live weight, breeder male	Average weight in tons per head
40	Average live weight, replacement female	Average weight in tons per head
41	Average live weight, replacement male	Average weight in tons per head
42	Average live weight, other stock	Average weight in tons per head
43	Average live weight, young female	Average weight in tons per head

44	Average live weight, young male	Average weight in tons per head
45	Milk fat content	Grams per kilogram of milk produced
46	Standard fleece weight	Average weight of fleece, greasy
47	Shearings per year, breeder female	Number of shearings per year
48	Shearings per year, breeder male	Number of shearings per year
49	Shearings per year, replacement female	Number of shearings per year
50	Shearings per year, replacement male	Number of shearings per year
51	Wool used or sold, breeder female	Fraction between 0 and 1
52	Wool used or sold, breeder male	Fraction between 0 and 1
53	Wool used or sold, replacement female	Fraction between 0 and 1
54	Wool used or sold, replacement male	Fraction between 0 and 1

A.4 Demand-driven routine, pigs

Index	Parameter name	Units
1	Meat production demand	Tons of meat per year
2	Fraction of target to be met by intensive system	Fraction between 0 and 1
3	Distribution losses, intensive	Fraction of losses due to distribution (between 0 and 1)
4	Female breeder mortality rate, intensive	Ratio between 0 and 1
5	Male breeder mortality rate, intensive	Ratio between 0 and 1
6	Female replacement mortality rate, intensive	Ratio between 0 and 1
7	Male replacement mortality rate, intensive	Ratio between 0 and 1
8	Slaughter stock mortality rate, intensive	Ratio between 0 and 1
9	Years in breeding herd, intensive	Ratio between 0 and 1
10	Years in replacement herd, intensive	Ratio between 0 and 1
11	Years to slaughter for slaughter stock, intensive	Average number of years elapsed between the time when an animal is no longer young and when it is slaughtered
12	Average live weight, breeder female, intensive	Average weight in tons per head
13	Average live weight, breeder male, intensive	Average weight in tons per head
14	Average live weight, slaughter stock, intensive	Average weight in tons per head
15	Dressing percentage	Fraction between 0 and 1
16	Litters per sow per year, intensive	Number of litters per sow per year
17	Size of litter, intensive	Number of youngs per litter per sow
18	Females per male breeder, intensive	Number of female breeders divided by number of males breeders in the herd
19	Distribution losses, traditional	Percentage of losses from slaughter to final consumption
20	Female breeder mortality rate, traditional	Ratio between 0 and 1
21	Male breeder mortality rate, traditional	Ratio between 0 and 1
22	Female replacement mortality rate, traditional	Ratio between 0 and 1
23	Male replacement mortality rate, traditional	Ratio between 0 and 1
24	Slaughter stock mortality rate, traditional	Ratio between 0 and 1
25	Years in breeding herd, traditional	Average number of years elapsed between the time a replacement enters the breeding herd and the time that it is culled.
26	Years in replacement herd, traditional	Average number of years elapsed between the time when an animal is no longer young and the time when it enters the breeding herd
27	Years to slaughter for slaughter stock, traditional	Average number of years elapsed between the time when an animal is no longer young and when it is slaughtered
28	Average live weight, breeder female, traditional	Average weight in tons per head
29	Average live weight, breeder male, traditional	Average weight in tons per head
30	Average live weight, slaughter stock, traditional	Average weight in tons per head
31	Litters per sow per year, traditional	Number of litters per sow per year
32	Size of litter, traditional	Number of youngs per litter per sow
33	Females per male breeder, traditional	Number of female breeders divided by number of males breeders in the herd
34	Fraction of fallen animal eaten	Fraction between 0 and 1

A.5 Demand-driven routine, poultry

Index	Parameter name	Units
1	Meat production demand	Tons of meat per year
2	Egg production demand	Tons of meat per year
3	Rural human pop in target year	Relative number of people
4	Rural human pop in base year	Relative number of people
5	Village poultry numbers in base year	Absolute number of poultry
6	Annual egg yield of village poultry	Weight of eggs produced in kilograms per layer per year
7	Laying period of village poultry	Elapsed period in years between the time a bird enters the laying flock and the time it is culled
8	Village poultry mortality rate	Ratio between 0 and 1
9	Carcass weight, village poultry	Average weight in kilograms
10	Distributive loss rate for eggs	
11	Commercial egg layer mortality rate	Ratio between 0 and 1
12	Commercial chick mortality rate	Ratio between 0 and 1
13	Annual egg yield of commercial layers	Weight of eggs per layer per year
14	Laying period of commercial layers	Elapsed period in years between the time a bird enters the laying flock and the time it is culled
15	Commercial layer live weight	Average weight in kilograms
16	Hatching eggs per breeder	Number of eggs produced per breeder per year
17	Hatching rate for hatching eggs	Number of live chicks relative to the number of eggs set for hatching, expressed as a fraction between 0 and 1
18	Mortality rate for breeders	Ratio between 0 and 1
19	Breeder females per male	Ratio between 0 and 1
20	Laying period for breeders	Elapsed period in years between the time a bird enters the laying flock and the time it is culled
21	Breeder live weight	Average liveweight in kilograms
22	Poultry meat distribution loss rate	Percentage of losses due to distribution
23	Broiler mortality rate	Ratio between 0 and 1
24	Broiler live weight	Average liveweight in kilograms
25	Broiler fattening days	Number of days per year
26	Broiler fattening cycles per year	Number of cycles per year
27	Fraction of fallen animal eaten	Fraction between 0 and 1

A.6 Herd growth routine (all systems except pigs and poultry)

Index	Parameter name	Units
1	Number of female breeders in base year	Number
2	Number of male breeders in base year	Number
3	Number of female replacement in base year	Number
4	Number of male replacement in base year	Number
5	Number of other stock in base year	Number
6	Number of female young in base year	Number
7	Number of male young in base year	Number
8	Distribution loss rate	Fraction between 0 and 1
9	Fertility rate	Average number of parturitions per female per year (0.5 means one parturition per 2 years)
10	Prolificacy rate	Average number of live births per parturition (0.5 means that half of calves are dead at birth)
11	Number of breeder males per female	Ratio of males on females
12	Mortality rate, female breeder	Ratio between 0 and 1
13	Mortality rate, male breeder	Ratio between 0 and 1
14	Mortality rate, female replacement	Ratio between 0 and 1
15	Mortality rate, male replacement	Ratio between 0 and 1
16	Mortality rate, youngs	Ratio between 0 and 1
17	Mortality rate, other stock	Ratio between 0 and 1
18	Years in breeding herd	Average number of years elapsed between the time a replacement enters the breeding herd and the time that it is culled.
19	Years in replacement herd	Average number of years elapsed between the time when an animal is no longer young and the time when it enters the breeding herd
20	Years as young	Average number of years elapsed between birth and the time it enters the replacement herd
21	Years from young to slaughter, other stock	Average number of years elapsed between the time when an animal is no longer young and when it is slaughtered
22	Female breeder carcass weight	Tons per head (average)
23	Male breeder carcass weight	Tons per head (average)
24	Other stock carcass weight	Tons per head (average)
25	Fraction of females milked	Ratio between 0 and 1
26	Milk yield per lactation	Tons of milk per cow per year
27	Fraction of youngs that are fertile	Ratio between 0 and 1
28	Fraction of female youngs retained	Ratio between 0 and 1

Appendix B: Case study: China

B.1 Parameters used for Demand-driven routine

B.1 A) Dairy Cattle and Buffaloes

Parameter name	Dairy Cattle			Buffalo
	Pastoral	Warm&Cold	Tropic&ST	Tropic&ST
Milk production demand	1,515,000	3,224,000	1,025,000	2,200,000
Distribution losses	0.000	0.000	0.000	0.000
Fertility rate	0.750	0.900	0.900	0.550
Prolificacy rate	1.000	1.000	1.000	1.000
Breeder males per breeder female	0.001	0.001	0.001	0.001
Milk yield per lactation	2.000	4.500	4.500	0.550
Fraction of females milked	0.900	0.900	0.900	0.800
Cow mortality rate	0.030	0.040	0.040	0.050
Bull mortality rate	0.030	0.040	0.040	0.050
Female replacement mortality rate	0.030	0.040	0.040	0.080
Male replacement mortality rate	0.030	0.040	0.040	0.050
Female young mortality rate	0.070	0.060	0.060	0.100
Male young mortality rate	0.070	0.060	0.060	0.100
Other stock mortality rate	0.030	0.040	0.040	0.030
Draught animals mortality rate	0.030	0.040	0.040	0.030
Years in breeding herd, cows	5.000	4.500	4.500	7.000
Years in breeding herd, bulls	5.000	5.000	5.000	7.000
Years in replacement herd, females	1.000	1.000	1.000	1.000
Years in replacement herd, males	1.000	1.000	1.000	1.000
Years from young to slaughter, other stock	1.000	1.000	1.000	7.000
Years from young to slaughter, draught animals	0.000	0.000	0.000	7.000
Years as young	1.500	1.300	1.300	1.000
Carcass weight of female breeders	0.275	0.280	0.280	0.250
Carcass weight of male breeders	0.300	0.300	0.300	0.300
Carcass weight of other stock	0.200	0.200	0.200	0.250
Carcass weight of draught animals	0.300	0.300	0.300	0.250
Males in the system? (Y=1/N=0)	0.000	0.000	0.000	1.000
Are young males slaughtered at birth? (Y=1 / N=0)	1.000	1.000	1.000	0.000
Fraction of fallen animal eaten	0.000	0.000	0.000	0.000
Proportion of female breeders with usable skin	0.950	0.950	0.950	0.950
Proportion of male breeders with usable skin	0.950	0.950	0.950	0.950
Proportion of other stock with usable skin	0.950	0.950	0.950	0.950
Proportion of draught animals with usable skin	0.950	0.950	0.950	0.950
Weight of skin for female breeders	0.036	0.036	0.036	0.036
Weight of skin for male breeders	0.045	0.045	0.045	0.045
Weight of skin for other stock	0.023	0.023	0.023	0.027
Weight of skin for draught animals	0.030	0.030	0.030	0.030
Average live weight, breeder female	0.550	0.570	0.570	0.600
Average live weight, breeder male	0.600	0.620	0.620	0.700
Average live weight, replacement female	0.350	0.370	0.370	0.300
Average live weight, replacement male	0.400	0.420	0.420	0.350
Average live weight, other stock	0.350	0.370	0.370	0.600
Average live weight, draught animals	0.350	0.370	0.370	0.600
Average live weight, young female	0.200	0.200	0.200	0.100
Average live weight, young male	0.220	0.220	0.220	0.100
Milk fat content(g/kg)	45.000	34.000	34.000	126.000
Peek animal draught power demand / month	0	0	0	300000000

Are there Draught specific oxen?(Y=1 / N=0)	0	0	0	1
Are Male Breeders used for draught?(Y=1 / N=0)	0	0	0	1
Are Female Breeders used for draught?(Y=1 / N=0)	0	0	0	1
Are Male replacements used for draught?(Y=1 / N=0)	0	0	0	1
Number of days worked, draught specific animals	0	0	0	120
Number of days worked, Breeders	0	0	0	120
Number of days worked, Replacements	0	0	0	120
Average productivity /animal /day, draught specific oxen	0	0	0	1
Average productivity /animal /day, Breeders	0	0	0	1
Average productivity /animal /day, Replacements	0	0	0	1

B.1 B) Beef Cattle

Parameter name	Beef Cattle		
	Pastoral	Warm&Cold	Tropic&ST
Meat production demand	400,000	1,600,000	1,200,000
Distribution losses	0.000	0.000	0.000
Fertility rate	0.600	0.650	0.600
Prolificacy rate	1.000	1.000	1.000
Breeder males per breeder female	0.002	0.002	0.002
Female breeder mortality rate	0.050	0.030	0.030
Male breeder mortality rate	0.050	0.030	0.030
Female replacement mortality rate	0.030	0.020	0.020
Male replacement mortality rate	0.030	0.020	0.020
Young mortality rate	0.110	0.080	0.080
Other stock mortality rate	0.030	0.020	0.020
Years in breeding herd	6.000	6.000	6.000
Years in replacement herd	1.500	1.500	1.500
Years as young	1.000	1.000	1.000
Years from young to slaughter, other stock	3.000	3.000	3.000
Carcass weight of female breeders	0.180	0.180	0.200
Carcass weight of male breeders	0.230	0.230	0.250
Carcass weight of other stock	0.180	0.180	0.200
Fraction of females milked	0.000	0.000	0.000
Milk yield per lactation	0.400	0.500	0.500
Fraction of calves that are fertile	0.950	0.950	0.950
Retention ratio for young females	0.900	0.900	0.900
Emergency slaughter fraction	0.100	0.100	0.100
Are young males slaughtered at birth? (Y=1 / N=0)	0.000	0.000	0.000
Proportion of female breeders with usable skin	0.950	0.950	0.950
Proportion of male breeders with usable skin	0.950	0.950	0.950
Proportion of other stock with usable skin	0.950	0.950	0.950
Weight of skin for female breeders	0.036	0.036	0.036
Weight of skin for male breeders	0.045	0.045	0.045
Weight of skin for other stock	0.027	0.023	0.023
Average live weight, breeder female	0.400	0.400	0.500
Average live weight, breeder male	0.500	0.500	0.550
Average live weight, replacement female	0.320	0.320	0.400
Average live weight, replacement male	0.400	0.400	0.440
Average live weight, other stock	0.400	0.400	0.500
Average live weight, young female	0.150	0.150	0.170
Average live weight, young male	0.170	0.170	0.200
Milk fat content(g/kg)	34.000	34.000	34.000
Peek animal draught power demand / month	6000000	900000000	300000000

Are there Draught specific oxen?(Y=1 / N=0)	1	1	1
Are Male Breeders used for draught?(Y=1 / N=0)	1	1	1
Are Female Breeders used for draught?(Y=1 / N=0)	0	0	0
Are Male replacements used for draught?(Y=1 / N=0)	1	1	1
Number of days worked, draught specific animals	100	100	75
Number of days worked, Breeders	100	100	75
Number of days worked, Replacements	100	100	75
Average productivity /animal /day, draught specific oxen	1	1	1
Average productivity /animal /day, Breeders	1	1	1
Average productivity /animal /day, Replacements	1	1	1

B.1 C) Sheep

Parameter name	Sheep Pastoral	Semi-pastoral	Crop area
Meat production demand	480,000	70,000	480,000
Distribution losses	0.000	0.000	0.000
Fertility rate	0.800	0.900	1.100
Prolificacy rate	1.000	1.000	1.200
Breeder males per breeder female	0.020	0.020	0.020
Female breeder mortality rate	0.050	0.030	0.025
Male breeder mortality rate	0.050	0.030	0.025
Female replacement mortality rate	0.050	0.020	0.020
Male replacement mortality rate	0.050	0.020	0.020
Young mortality rate	0.120	0.100	0.100
Other stock mortality rate	0.050	0.020	0.020
Years in breeding herd	4.000	3.500	2.500
Years in replacement herd	1.000	0.500	0.300
Years as young	1.000	1.000	1.000
Years from young to slaughter, other stock	0.200	0.100	0.100
Carcass weight of female breeders	0.023	0.036	0.036
Carcass weight of male breeders	0.045	0.045	0.045
Carcass weight of other stock	0.017	0.013	0.013
Fraction of females milked	0.000	0.000	0.000
Milk yield per lactation	0.000	0.000	0.000
Fraction of calves that are fertile	1.000	1.000	1.000
Retention ratio for young females	0.950	0.900	0.800
Emergency slaughter fraction	0.000	0.000	0.000
Proportion of female breeders with usable skin	0.900	0.900	0.900
Proportion of male breeders with usable skin	0.900	0.900	0.900
Proportion of other stock with usable skin	0.900	0.900	0.900
Weight of skin for female breeders	0.003	0.003	0.003
Weight of skin for male breeders	0.004	0.004	0.004
Weight of skin for other stock	0.003	0.003	0.003
Average live weight, breeder female	0.050	0.080	0.080
Average live weight, breeder male	0.100	0.100	0.100
Average live weight, replacement female	0.040	0.060	0.060
Average live weight, replacement male	0.060	0.080	0.080
Average live weight, other stock	0.030	0.030	0.030
Average live weight, young female	0.020	0.020	0.020
Average live weight, young male	0.020	0.020	0.020
Milk fat content	100.000	100.000	100.000
Standard fleece weight (kg)	3.000	3.000	3.000
Shearings per year, breeder female	1.000	1.000	1.000
Shearings per year, breeder male	1.000	1.000	1.000

Shearings per year, replacement female	1.000	0.500	0.500
Shearings per year, replacement male	1.000	0.500	0.500
Wool used or sold, breeder female	0.950	0.950	0.800
Wool used or sold, breeder male	0.950	0.950	0.800
Wool used or sold, replacement female	0.950	0.950	0.800
Wool used or sold, replacement male	0.950	0.950	0.800

B.1 D) Goats

Parameter	Goats		
name	Pastoral	Semi-pastoral	Crop area
Meat production demand	130,000	40,000	720,000
Distribution losses	0.000	0.000	0.000
Fertility rate	0.750	0.900	1.200
Prolificacy rate	1.000	1.000	1.400
Breeder males per breeder female	0.020	0.020	0.020
Female breeder mortality rate	0.050	0.030	0.025
Male breeder mortality rate	0.050	0.030	0.025
Female replacement mortality rate	0.020	0.020	0.020
Male replacement mortality rate	0.020	0.020	0.020
Young mortality rate	0.120	0.100	0.100
Other stock mortality rate	0.050	0.020	0.020
Years in breeding herd	4.000	3.500	3.500
Years in replacement herd	1.000	1.000	0.500
Years as young	1.000	1.000	0.500
Years from young to slaughter, other stock	0.500	0.500	0.300
Carcass weight of female breeders	0.014	0.012	0.012
Carcass weight of male breeders	0.020	0.020	0.020
Carcass weight of other stock	0.014	0.012	0.010
Fraction of females milked	0.000	0.000	0.000
Milk yield per lactation	0.010	0.050	0.300
Fraction of calves that are fertile	1.000	1.000	1.000
Retention ratio for young females	0.950	0.900	0.500
Emergency slaughter fraction	0.000	0.000	0.000
Proportion of female breeders with usable skin	0.900	0.800	0.750
Proportion of male breeders with usable skin	0.900	0.800	0.750
Proportion of other stock with usable skin	0.900	0.800	0.750
Weight of skin for female breeders	0.003	0.003	0.003
Weight of skin for male breeders	0.003	0.003	0.003
Weight of skin for other stock	0.003	0.003	0.003
Average live weight, breeder female	0.030	0.025	0.025
Average live weight, breeder male	0.050	0.045	0.045
Average live weight, replacement female	0.028	0.020	0.020
Average live weight, replacement male	0.030	0.025	0.025
Average live weight, other stock	0.030	0.025	0.023
Average live weight, young female	0.020	0.015	0.015
Average live weight, young male	0.025	0.015	0.015
Milk fat content(g/kg)	35.000	35.000	35.000
Standard fleece weight(kg)	0.500	0.500	0.500
Shearings per year, breeder female	1.000	1.000	1.000
Shearings per year, breeder male	1.000	1.000	1.000
Shearings per year, replacement female	1.000	1.000	0.500
Shearings per year, replacement male	1.000	1.000	0.500
Hair used or sold, breeder female	1.000	0.070	0.600
Hair used or sold, breeder male	1.000	0.700	0.600

Hair used or sold, replacement female	1.000	0.700	0.600
Hair used or sold, replacement male	1.000	0.700	0.600

B.1 E) Pigs and Chickens

Parameter name	Pigs Combined	Parameter name	Poultry Combined
Meat production demand	36,484,000	Meat production demand	6,450,000
Fraction of target to be met by intensive system	0.200	Egg production demand	13414000
Distribution losses, int.	0.000	Rural human pop in target year	851970
Female breeder mortality rate, int.	0.010	Rural human pop in base year	851970
Male breeder mortality rate, int.	0.010	Village poultry numbers in base year	1000000000
Female replacement mortality rate, int.	0.010	Annual egg yield of village poultry(kg)	5.000
Male replacement mortality rate, int.	0.010	Laying period of village poultry(yr)	1.000
Slaughter stock mortality rate, int.	0.010	Village poultry mortality rate	0.200
Years in breeding herd, int.	3.500	Carcass weight, village poultry(kg)	2.200
Years in replacement herd, int.	0.670	Distributive loss rate for eggs	0.000
Years to slaughter for slaughter stock, int.	0.500	Commercial egg layer mortality rate	0.200
Average live weight, breeder female, int.	0.200	Commercial chick mortality rate	0.120
Average live weight, breeder male, int.	0.225	Annual egg yield of commercial layers	13.800
Average live weight, slaughter stock, int.	0.100	Laying period of commercial layers	1.000
Dressing percentage	0.725	Commercial layer live weight(kg)	1.700
Litters per sow per year, int.	2.000	Hatching eggs per breeder	130.000
Size of litter, int.	11.000	Hatching rate for hatching eggs	0.900
Females per male breeder, int.	25.000	Mortality rate for breeders	0.120
Distribution losses, trad.	0.000	Breeder females per male	50.000
Female breeder mortality rate, trad.	0.030	Laying period for breeders	1.200
Male breeder mortality rate, trad.	0.030	Breeder live weight(kg)	3.000
Female replacement mortality rate, trad.	0.030	Poultry meat distribution loss rate	0.000
Male replacement mortality rate, trad.	0.030	Broiler mortality rate	0.070
Slaughter stock mortality rate, trad.	0.030	Broiler live weight(kg)	2.200
Years in breeding herd, trad.	5.000	Broiler fattening days	50.000
Years in replacement herd, trad.	1.000	Broiler fattening cycle per year	3.000
Years to slaughter for slaughter stock, trad.	0.830	Fraction of fallen animal eaten	0.000
Average live weight, breeder female, trad.	0.175		
Average live weight, breeder male, trad.	0.085		
Average live weight, slaughter stock, trad.	0.100		
Litters per sow per year, trad.	1.500		
Size of litter, trad.	10.000		
Females per male breeder, trad.	12.500		
Fraction of fallen animal eaten	0.000		

B.2 Parameters used for Herd-growth routine

B.2 A) Dairy cattle and Buffaloes

System :	Dairy cattle			Buffaloes
Sub-system :	Pastoral	Warm&Cold	Tropic&ST	Tropic&ST
Number of female breeders in base year	1,122,222	884,499	281,207	9,090,909
Number of male breeders in base year	935	737	234	9,091
Number of female replacement in base year	245,692	219,613	69,821	1,612,049
Number of male replacement in base year	205	166	53	1,586
Number of other stock in base year	0	0	0	10,581,789
Number of female young in base year	420,833	398,025	126,543	2,500,000
Number of male young in base year	3,176	2,964	942	2,500,000
Fraction of youngs that are fertile	0.950	0.950	0.950	0.950
Fraction of other females retained	1.000	1.000	1.000	0.950

B.2 B) Beef cattle

Sub-system :	Pastoral	Warm&Cold	Tropic&ST
Number of female breeders in base year	5,327,088	18,966,977	13,487,306
Number of male breeders in base year	8,523	30,347	21,580
Number of female replacement in base year	1,996,882	7,958,677	5,246,864
Number of male replacement in base year	3,195	12,734	8,395
Number of other stock in base year	4,579,031	18,528,638	12,183,611
Number of female young in base year	1,598,126	6,164,267	4,046,192
Number of male young in base year	1,598,126	6,164,267	4,046,192
Fraction of youngs that are fertile	0.950	0.950	0.950
Fraction of other females retained	0.900	0.900	0.900

B.2 C) Sheep

Sub-system :	Pastoral	Semi-pastoral	Crop area
Number of female breeders in base year	41,433,940	4,185,188	18,160,468
Number of male breeders in base year	828,679	83,704	363,209
Number of female replacement in base year	14,702,151	957,564	3,813,313
Number of male replacement in base year	294,043	19,151	76,266
Number of other stock in base year	3,130,644	217,037	1,696,675
Number of female young in base year	16,573,576	1,883,335	11,985,909
Number of male young in base year	16,573,576	1,883,335	11,985,909
Fraction of youngs that are fertile	1.000	1.000	1.000
Fraction of other females retained	0.950	0.900	0.800

B.2 D) Goats

Sub-system :	Pastoral	Semi-pastoral	Crop area
Number of female breeders in base year	16,131,095	4,483,585	42,242,163
Number of male breeders in base year	322,622	89,672	844,843
Number of female replacement in base year	5,411,488	1,855,342	11,815,734
Number of male replacement in base year	108,230	37,107	236,315
Number of other stock in base year	2,810,236	1,044,725	17,358,798
Number of female young in base year	6,049,161	2,017,613	35,483,417
Number of male young in base year	6,049,161	2,017,613	35,483,417
Fraction of youngs that are fertile	1.000	1.000	1.000
Fraction of other females retained	0.950	0.900	0.500

B.3 Feed inventory

Grazing land						Ref LSU:	35600.0
Growing period (days)	Hectares (x100)	Energy (MJ/kg d m)	Protein (g/kg d m)	Crude fiber (g/kg d m)	Constant	TOT LSU	Total digest. protein (MT)
1 to 75	0	5.0	84.0	296.0	23.5	0	0
76 to 89	0	5.0	84.0	296.0	13.0	0	0
90 to 119	0	5.0	104.0	269.6	10.4	0	0
120 to 149	2,347,500	5.0	104.0	269.6	6.9	34,021,739	17,029,105
150 to 179	0	5.0	143.0	257.1	4.5	0	0
180 to 209	0	5.0	143.0	257.1	3.1	0	0
210 to 239	0	5.0	174.0	236.8	2.0	0	0
240 to 269	0	5.0	174.0	236.8	1.4	0	0
270 to 299	0	5.0	174.0	236.8	0.9	0	0
300 to 329	0	5.0	222.0	200.0	0.6	0	0
330 to 365	0	5.0	222.0	200.0	0.4	0	0
Total	**2,347,500**	**5.0**				34,021,739	17,029,105

Crop residues								
Name	Quantity (tons)	Imports (tons)	Exports (tons)	Energy (MJ/kg d m)	Protein (g/kg d m)	Crude fiber (g/kg d m)	Total LSUs	Total digest. protein (MT)
Straws	437,384,000	0.0	0.0	2.0	30.0	400.0	24,572,135	0
Potato vines	17,350,000	0.0	0.0	10.0	219.0	150.0	4,892,115	3,474,338
Vegetables	296,539	0.0	0.0	2.0	23.0	22.0	16,659	6,005
Pulses	649,911	0.0	0.0	16.4	264.0	75.0	299,032	165,484
Housewastes etc.	310,969,000	0.0	0.0	2.9	23.0	22.0	25,331,744	6,297,122
Total	**766,649,450**	**0.0**	**0.0**	**2.6**			**55,111,686**	**9,942,948**

Primary products								
Name	Quantity (tons)	Imports (tons)	Exports (tons)	Energy (MJ/kg d m)	Protein (g/kg d m)	Crude fiber (g/kg d m)	Total LSUs	Total protein (tons dm)
Maize	80,000,000	0.0	0.0	14.2	110.0	46.0	31,910,112	8,340,000
Wheat	12,000,000	0.0	0.0	14.0	135.0	33.0	4,719,101	1,570,500
Rice	18,000,000	0.0	0.0	12.4	70.0	119.0	6,269,663	992,250
Other cereals	10,000,000	0.0	0.0	12.0	100.0	30.0	3,370,787	962,500
Soybeans	4,000,000	0.0	0.0	14.9	429.0	49.0	1,674,157	1,691,500
Potatoes	3,200,000	0.0	0.0	12.4	103.0	20.0	1,114,607	321,600
Sweet potatoes	13,200,000	0.0	0.0	13.6	54.0	23.0	5,045,663	674,850
Cassava	746,611	0.0	0.0	12.2	39.0	49.0	255,861	24,545
Sugar cane	4,103,100	0.0	0.0	9.0	63.0	350.0	1,037,301	78,985
Sugar beats	424,500	0.0	0.0	13.5	74.0	62.0	160,761	28,123
Total	**145,674,211**	**0.0**	**0.0**	**13.6**			**55,558,013**	**14,684,853**

Crop by-products								
Name	Quantity (tons)	Imports (tons)	Exports (tons)	Energy (MJ/kg d m)	Protein (g/kg d m)	Crude fiber (g/kg d m)	Total LSUs	Total protein (tons dm)
Bran of wheat	26,410,000	0.0	0.0	10.1	169.0	113.0	7,492,725	4,090,249
Bran of rice	38,360,000	0.0	0.0	12.5	106.0	189.0	13,469,101	3,159,905
Bran of maize	2,453,267	0.0	0.0	12.5	120.0	30.0	861,400	285,192
Bran of millet	594,000	0.0	0.0	12.0	120.0	30.0	200,225	69,053
Bran of other cer.	1,582,781	0.0	0.0	10.0	100.0	100.0	444,601	138,493
Cake of groundnuts	2,010,000	0.0	0.0	11.4	335.0	255.0	643,652	609,281
Cake of cottonseed	6,010,000	0.0	0.0	8.7	269.0	240.0	1,468,736	1,436,390
Cake of rapeseed	4,720,000	0.0	0.0	11.7	360.0	104.0	1,551,236	1,637,840

Cake of Soya beans	3,201,473	0.0	0.0	13.3	475.0	51.0	1,196,056	1,500,290
Cake of other crops	1,699,546	0.0	0.0	11.7	300.0	300.0	560,230	446,131
Total	87,041,067	0.0	0.0	11.4			27,887,961	13,372,824

Fodder								
Name	Quantity (tons)	Imports (tons)	Exports (tons)	Energy (MJ/kg d m)	Protein (g/kg d m)	Crude fiber (g/kg d m)	Total LSUs	Total protein (tons dm)
Silages etc.	23,000,000	0.0	0.0	1.7	80.0	300.0	1,081,258	977,500
Pelagic meals	478,535	0.0	0.0	20.2	660.0	0.0	270,991	315,833
skim milk	646,760	0.0	0.0	17.3	370.0	0.0	314,369	239,301
whey fresh	61,493	0.0	0.0	15.1	108.0	0.0	26,117	6,641
animal by-products	1,941,325	0.0	0.0	16.8	600.0	49.0	916,131	1,152,904
dregs from brewing	1,498,759	0.0	0.0	11.1	278.0	126.0	468,573	393,050
Total	**27,626,872**	**0.0**	**0.0**	**4.0**			**3,077,439**	**3,085,229**

B.4 Result sheet

B.4.1 Demand-driven routine

Dairy Cattle system 1-4 (total)	**Results, Demand-driven routine**						
	Heads (number)	**total LSU**	**Milk (Tons)**	**Meat (Tons)**	**Hides (Tons)**	**Protein (Tons)**	**No of working**
Breeders	2,289,835	2,281,032.7	5,764,000.0	123,320.5	15,191.7	677,588.9	0.0
Replacements	535,550	377,763.0	n/a	n/a	n/a	104,897.2	0.0
Other stock	0	0.0	n/a	0.0	0.0	0.0	n/a
Draught animals	0	0.0	n/a	0.0	0.0	0.0	0.0
Youngs	952,483	385,876.0	n/a	n/a	n/a	129,364.9	n/a
GRAND TOTAL	3,777,869	3,044,671.6	5,764,000.0	123,320.5	15,191.7	911,851.0	0.0

Manure production	(tons)	17,112,939
Birthing rate	(/cow)	0.8
Offtake rate	(%)	9.4
Females in milk	(heads)	1,701,722.2
Average milk yield	(kg/cow)	3,387.2
Meat output from fallen animals	(tons)	0.00

Beef Cattle system 1-4 (total)	**Results, Demand-driven routine**						
	Heads (number)	**total LSU**	**Milk (Tons)**	**Meat (Tons)**	**Hides (Tons)**	**Protein (Tons)**	**No of working**
Breeders	37,841,821	18,051,016.9	0.0	1,066,982.5	194,920.4	5,013,454.6	0.0
Replacements	15,226,747	5,081,299.8	n/a	n/a	n/a	1,535,393.9	0.0
Slaughter stock	4,005,628	1,274,918.2	n/a	230,276.9	32,814.5	490,984.2	n/a
Draught animals	31,285,652	12,349,154.3	n/a	1,902,740.6	222,084.6	5,333,727.0	31,285,651.7
Youngs	23,617,171	4,502,333.4	n/a	n/a	n/a	2,196,984.4	n/a
GRAND TOTAL	111,977,018	41,258,722.5	0.0	3,200,000.0	449,819.5	14,570,544.0	31,285,651.7

Manure production	(tons)	358,972,893
Birthing rate	(/cow)	0.6
Offtake rate	(%)	15.3
Average milk yield	(kg/cow)	-
Meat output from fallen animals	(tons)	80,275.17

Sheep System 1-3 (total)	Results, Demand-driven routine						
	Heads (number)	total LSU	Milk (Tons)	Meat (Tons)	Wool (Tons)	Protein (Tons)	
Breeders	65,055,188	4,833,047.2	0.0	519,841.1	177,071.6	1,346,351.3	
Replacements	19,862,489	1,134,146.7	n/a	n/a	37,857.7	395,298.3	
Slaughter stock	5,044,357	303,044.1	n/a	510,158.9	n/a	87,423.9	
Youngs	60,885,639	2,820,384.4	n/a	n/a	n/a	1,352,442.1	
GRAND TOTAL	150,847,672	9,090,622.3	0.0	1,030,000.0	214,929.3	3,181,515.6	

Manure production	(tons)	63,494,523
Birthing rate	(/cow)	1.0
Offtake rate	(%)	34.8
Average milk yield	(kg/cow)	-
Meat output from fallen animals	(tons)	0.00

Goats System 1-3 (total)	Results, Demand-driven routine						
	Heads (number)	total LSU	Milk (Tons)	Meat (Tons)	Hair (Tons)	Protein (Tons)	
Breeders	64,113,980	4,875,151.0	1,553.0	210,496.2	21,341.3	1,772,545.5	
Replacements	19,464,216	1,006,444.3	n/a	n/a	3,754.8	300,151.3	
Slaughter stock	21,213,759	1,393,042.0	n/a	679,503.8	n/a	395,083.3	
Youngs	87,100,382	3,568,328.7	n/a	n/a	n/a	2,229,784.5	
GRAND TOTAL	191,892,337	10,842,965.9	1,553.0	890,000.0	25,096.1	4,697,564.5	

Manure production	(tons)	82,314,984
Birthing rate	(/cow)	1.4
Offtake rate	(%)	42.7
Average milk yield	(kg/cow)	0.0
Meat output from fallen animals	(tons)	0.00

Buffalo System 1-3 (total)	Results, Demand-driven routine						
	Heads (number)	total LSU	Milk (Tons)	Meat (Tons)	Hides (Tons)	Protein (Tons)	Working animals
Breeders	9,100,000	5,661,363.5	2,200,000.0	270,191.9	36,964.1	1,572,269.3	8,319,850.8
Replacements	1,613,635	702,721.0	n/a	n/a	n/a	195,193.8	1,586.1
Other stock	0	0.0	n/a	0.0	0.0	0.0	n/a
Draught animals	10,581,789	5,690,432.3	n/a	339,062.6	38,653.1	170,386.0	10,581,789.3
Youngs	5,000,000	1,244,255.7	n/a	n/a	n/a	422,257.7	n/a
GRAND TOTAL	26,295,424	13,298,772.6	2,200,000.0	609,254.5	75,617.2	2,360,106.8	18,903,226.2

Manure production	(tons)	73,752,063
Birthing rate	(/cow)	0.6
Offtake rate	(%)	9.3
Females in milk	(heads)	4,000,000.0
Average milk yield	(kg/cow)	550.0
Meat output from fallen animals	(tons)	0.00

Pigs	Results, Demand-driven routine

Combined	**I-Offtake (number)**	**I-Tot Heads**	**I-Meat (Tons)**	**T-Offtake (Number)**	**T-Tot Heads**	**T-Meat (Tons)**	**Gnd.total (heads)**
Producers	97,982,479	49,114,540	7,103,730	393,380,922	330,668,391	28,520,117	379,782,931
Breeders(female)	1,274,181	4,538,998	184,756	5,061,137	27,334,327	642,132	31,873,325
Breeders(male)	50,967	181,560	8,314	404,891	2,186,746	24,951	2,368,306
Replacement(female)	n/a	887,250	n/a	n/a	5,984,396	n/a	6,871,646
Replacement(male)	n/a	35,490	n/a	n/a	478,752	n/a	514,242
GRAND TOTAL	99,307,627	54,757,838	7,296,800	398,846,950	366,652,611	29,187,200	421,410,450

total refLSUs,	Intensive	7,531,370	Grand total	Offtake (hds)	498,154,577	Carcass wt	(kg)
	Traditional	76,276,621		Meat (tons)	36,484,000	intensive	73.2
total refLSUs,	**Trad.+Int.**	83,807,991	Offtake rate	Intensive	181.4	traditional	73.5
No of fallen animals eaten	(head)	0	(%)	traditional	108.8	Total	73.2
Meat output from fallen animals	(tons)	0		total	118.2		

Poultry Combined	**Results, Demand-driven routine**				
	Heads (Number)	**total LSU**	**Meat (Tons)**	**Meat (offtake)**	**Eggs (Tons)**
Village poultry	1,000,000,000	7,000,000	1,760,000	800,000,000	5,000,000
Commercial poultry	2,579,172,058	17,923,881	4,690,000	3,172,189,809	8,414,000
Commercial layers	1,645,363,035	16,972,624	751,981	622,294,003	n/a
Commercial broilers	933,809,023	951,257	3,938,019	2,549,895,805	n/a
------					
GRAND TOTAL	3,579,172,058	24,923,881	6,450,000	3,972,189,809	13,414,000

Commercial layers	Laying hens	762,137,681		**meat / poultry**	**offtake rate**	**egg**	**meat**
	Chicks for breeders	866,065,547	Village	2.200	0.800	37.3%	27.3%
	Breeders (egg)	17,159,807	Com Layer	1.208	0.378	62.7%	11.7%
Commercial broilers	Broilers	906,856,980	Com Broiler	1.544	2.731		61.1%
	Breeders (meat)	26,952,043					

B.4.2 Herd-growth routine
(Dairy cattle - Pastoral area)

Results sheet

1) Select the production system to display:	Dairy Cattle - Pastoral
2) Select the type of routine:	Herd growth routine
3) Select the appropriate breed (if applicable):	holstein
4) Select the projected year to display:	20

Herd Growth	**Base year**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**
Herd size (heads)	1,793,063	2,320,835	2,790,301	2,987,883	3,136,675	3,292,620	3,449,957	3,608,866	3,774,333	3,947,985	4,129,629.3
Breeders	1,123,157	1,110,090	1,102,065	1,163,215	1,228,839	1,283,729	1,340,261	1,402,089	1,467,041	1,534,455	1,604,890.6
Replacements	245,897	248,077	317,539	336,272	340,360	354,729	373,243	390,743	408,279	426,962	446,670.1
Other stock	0	15,013	270,070	346,136	367,846	389,043	411,131	430,957	450,469	471,135	492,898.0
Youngs	424,009	947,654	1,100,627	1,142,259	1,199,629	1,265,119	1,325,322	1,385,077	1,448,544	1,515,432	1,585,170.6
Energy needs (LSUs)	1,184,986	1,353,587	1,580,351	1,696,968	1,783,224	1,868,955	1,957,156	2,047,641	2,141,697	2,240,154	2,343,179.5
Energy shortage (LSUs)		168,601.3	395,365.2	511,982.0	598,238.3	683,969.2	772,170.3	862,654.7	956,711.1	1,055,168.4	1,158,193.5
Milk prod (Tons)	1,515,000.0	1,497,373.5	1,486,548.7	1,569,033.0	1,657,551.7	1,731,591.1	1,807,845.7	1,891,243.5	1,978,856.5	2,069,789.5	2,164,798.3
Increase (%)	0.0%	-1.2%	-0.7%	5.5%	5.6%	4.5%	4.4%	4.6%	4.6%	4.6%	4.6%
Meat prod (Tons)	59,925.0	59,925.0	62,140.3	111,193.3	129,212.6	136,925.7	143,966.4	151,267.8	158,412.7	165,663.5	173,269.6
Increase (%)	0.0	0.0%	3.7%	78.9%	16.2%	6.0%	5.1%	5.1%	4.7%	4.6%	4.6%
Hides	2,049.4	7,451.9	7,365.2	7,312.0	7,717.7	8,153.1	8,517.3	8,892.4	9,302.6	9,733.5	10,180.8

B.5 Constants

(see Section 2.3.1.2 of the guide)

B.5.1 SysLSUs and MEPs

	breeder		replacement		other	draught A	draught A	young		MEPs
	fem	male	fem	male	stock	resting	working	fem	male	
Cattle - Milk	1.000	1.000	0.700	0.700	0.700	0.700	1.200	0.400	0.400	5.000
Cattle - Meat	1.000	1.000	0.700	0.700	0.700	0.700	1.200	0.400		5.000
Buffalo	1.000	1.000	0.700	0.700	0.700	0.700	1.200	0.400	0.400	8.300
Sheep	1.000	1.000	0.800	0.800	0.800			0.600		4.600
Goats	1.000	1.000	0.700	0.700	0.800			0.500		4.600
Pigs - int.	1.000	1.000	**0.800**	**0.800**	**0.800**			0.300		
Pigs - trad.	1.000	1.000	**0.800**	**0.800**	**0.800**			0.300		

(note) SysLSUs for replacement and other stock of pigs are modified (the original = 0.4).

B.5.2 Other constants

Cattle - Milk		
refLSU	35600.000	reference LSUs in MJ
CONM	0.500	sex ratio of new-borns
LSUFAC1	8.300	used for calculation of energy requirements
LSUFAC2	0.091	used for calculation of energy requirements
Cattle - Beef		
CONB	0.500	sex ratio of new-borns
LSUFAC1	8.300	used for calculation of energy requirements
LSUFAC2	0.091	used for calculation of energy requirements
Sheep		
CONS	0.500	sex ratio of new-borns
LSUFAC1	1.800	used for calculation of energy requirements
LSUFAC2	0.100	used for calculation of energy requirements
APRM	7.660	used for calculation of protein requirement for milking (also used for goats)
Goats		
CONG	0.500	sex ratio of new-borns
LSUFAC1	1.800	used for calculation of energy requirements
LSUFAC2	0.100	used for calculation of energy requirements
Buffalo		
REFlsu	35600.000	reference LSUs in MJ
CONBU	0.500	sex ratio of new-borns
LSUFAC1	8.300	used for calculation of energy requirements
LSUFAC2	0.091	used for calculation of energy requirements
Pigs		
CON	0.300	used for calculation of energy requirements (Reference LSU = CON × sysLSU)
Poultry		
ELSU1	0.014	used for Reference LSUs for Commercial layers and breeders
ELSU2	0.002	used for Reference LSUs for commercial broilers (0.01 × carcass weight per bird)
ELSU3	0.007	used for Reference LSUs for village flock and commercial egg culls
PKO	0.700	Dressing fraction (carcass / live weight)
PL	25.000	(not used)

References

Agricultural Research Council Working Party (1980): The Nutrient Requirements of Ruminant Livestock, CAB, England.

Anderson, Frank M. (1993): Report on the Livestock Production Module of K2, internal paper, AGA, FAO, Rome, 39 pages.

Göhl, Bo (1981): Tropical feeds: feed information summaries and nutritive values, FAO, Rome.

Groenewold, Jan (1996): Testing the spreadsheet version of the Livestock Development Planning System ($Ldps^2$) developed for FAO, Draft report, AGA, FAO, Rome, 15 pages.

Hallam, David (1983): Livestock Development Planning: a Quantitative Framework, Centre for Agricultural Strategy, Paper n° 12, Reading, 143 pages.

McDonald et al. (1973): Animal Nutrition, Oliver & Boyd, Edinburgh.

Oli, K.P. (1985): Draught animals in the hill agricultural system, In Livestock in Hills of Nepal (Eds. Morel and Oli), Pakhribas Agricultural Centre, Dhankuta, Nepal.

Sands, Jonathan (1987): Livestock Development Planning System (LDPS): A Micro-Computer Based Planning and Training Tool for Livestock Development Planners, AGDP Working Paper, FAO, Rome, 74 pages.

Steinfeld and Becker (1991): Feed/livestock balances within the context of agricultural statistics and sector planning, FAO quarterly bulletin of statistics 4 (1).