

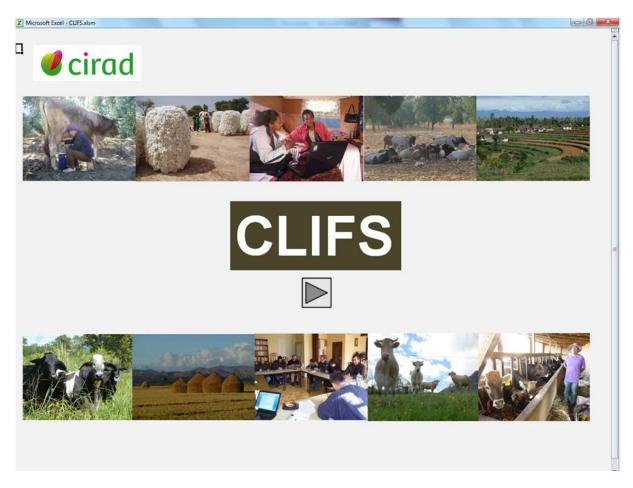
## **CLIFS**

(Crop Livestock Farm Simulator)

# **User manual**

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### **Contents**

A.		Over	view	1
	A.1.	Ob	jectives and implementation process	1
	A.2.		nceptual model	
	A.3.	De	sign principles	2
	A.4.	Ge	neral structure and operation	5
B.		Gene	eral characteristics	7
	B.1.	Us	ing Excel <sup>®</sup> functionalities	7
	B.2.	Ме	asurement units	7
	в.з.	Sh	eet and table sizing	8
	B.4.	Ma	cro buttons	<u>9</u>
	В.	4.1.	Contents sheet	9
	В.	4.2.	Parameter and Input Variable sheets	10
	B.5.	Co	lor codes	10
C.		Com	plete list of the CLIFS sheets as described in the 'Content' sheet	11
D.		Para	meters sheets	13
	D.1.	Co	mmon characteristics	13
	D.2.	Fee	ed contents	14
	D.3.	An	imal type	15
	D.4.	Re	quirements for growing cattle	16
	D.5.	Cro	pp name	17
	D.6.	Cro	pp NPK content	18
	D.7.	NP	K content of fertilisers	19
	D.8.	Inp	out name	20
E.	l n	mut V	/ariables sheets	2.1
	E.1.	•	eating a scenario and selecting the feed value system	
	E.2.		eating an organic fertilizer	
	E.3.		eating a feed concentrate	
	E.3. E.4.		k production	
		IVIII 4.1.	Milk production target	
		4.1. 4.2.	Milk production target	
		4.2. 4.3.	Milk consumption on the farm	
	E.5.		owing ruminants	
	Ŀ.J.	GI	JWING LUMBIANG	Zč

E.6.	Fattening ruminants	30
E.7.	Pig and poultry batches	32
E.8.	Manure production	33
E.9.	Farm structure and cropping pattern	34
E.9.	.1. Family structure	34
E.9.	.2. Cropping pattern	35
E.10.	Technical sequence per crop block	36
E.11.	NPK balance per crop	38
E.12.	Forage yields	39
E.13.	Forage type	40
E.14.	Forage stocks	40
E.15.	Purchase prices of crop inputs	41
E.16.	Purchase prices of livestock inputs	42
E.17.	Fixed costs	42
E.18.	Sale prices	43
F. Re	sults sheets	44
F.1.	Extended cropping pattern	44
F.2.	Herd size	45
F.3.	Green forage balance	46
F.4.	Hay/Silage balance	48
F.5.	Crop residues balance	49
F.6.	Food/market balance	49
F.7.	Organic fertiliser balance	50
F.8.	Economic results	51
F.8.1.	Expenses	51
F.8.2.	Proceeds	51
F.8.3.	Profits	52
F.9.	Economic graphs	53

G.	Appendix	54
G.1.	Index definition	54
G.2.	List of equations	55
Eq.1.	Conversion ratio of green yield into hay and silage yields	55
Eq.2.	NPK content of a created organic fertiliser	55
Eq.3.	Dry matter and feed value of a created concentrate	55
Eq.4.	Cost of a created concentrate	56
Eq.5.	Lactation curve of the average female per batch	56
Eq.6.	Total targeted milk production per lactation of the average female	56
Eq.7.	Number of females per batch	57
Eq.8.	Targeted milk production per batch	57
Eq.9.	Monthly forage saturation due to the diet	58
Eq.10.	Energy and proteins requirements of lactating cows	59
Eq.11.	Daily energy and protein supplied by the monthly diet	61
Eq.12.	Diet-based milk production per batch	63
Eq.13.	Marketable milk production	64
Eq.14.	Growing and fattening ruminants	65
Eq.15.	Manure production	66
Eq.16.	Family size	67
Eq.17.	Cropping pattern	67
Eq.18.	NPK balance	68
Eq.19.	Green forage balance	70
Eq.20.	Hay/Silage balance	72
Eq.21.	Crop residues balance	73
Eq.22.	Food/market balance	74
Eq.23.	Organic fertliser balance	76
Eq.24.	Expenses	77
Eq.25.	Proceeds	82
Eq.26.	Profits	84

#### A. Overview



#### A.1. Objectives and implementation process

CLIFS is a simulation tool developed under Excel®, which aims first and foremost to support farmers managing mixed crop-livestock production systems, whatever their degree or type of specialization, in their reflections regarding the future directions they wish to give their farm. These directions concern both the introduction or expansion of crop and livestock activities, and technical and organizational changes affecting all or part of their farm's operations.

Intended to support farmers in their reflections, CLIFS is part of a strategic advisory process conducted by an advisor, who uses the software, with individual farmers or farmer groups. This approach consists of three steps based on the design, simulation and evaluation of successive scenarios, each scenario corresponding to a given farm configuration (Figure 1). The Initial Scenario results from an analysis conducted with the farmer of the current situation of his/her farm. This analysis allows the advisor to better understand the farmer's objectives and strategies, to characterize the farm's structure, operations and performance, and to calibrate some input variables used in CLIFS which are difficult to obtain, such as pasture productivity. Depending on the available data, several loops are sometimes necessary to arrive at a representation of the farm which the farmer considers to be in line with reality. This representation is then considered valid for the following steps in the process. This validation step is fundamental in order to establish the support process on a basis shared between the farmer and the advisor, and to enable the farmer to discover and understand the structure of CLIFS and the calculations made.

The next step is to design a coherent and balanced Project Scenario corresponding to the farmer's choices regarding the evolution of his/her farm, and to correct imbalances observed during the simulation of the initial scenario. CLIFS makes it possible to identify imbalances between supply and demand for resources, for example between the size and productivity of a dairy herd and the forage resources resulting from the cropping pattern envisaged. At the end of this stage, which may if necessary include several intermediate scenarios, the farmer has a more precise and concrete idea of his/her project and the consequences on the farm's production and economic results.

During the third stage, Alternative Scenarios to the Project Scenario are developed by the farmer and his/her advisor based on these results as well as on proposals for changes or technical innovations considered potentially interesting. This last step remains optional if the farmer is satisfied with the previous step. Nevertheless, it opens the virtual field of possibilities and enriches the reflections of the two participants. It is not uncommon for the farmer to prefer one of these alternatives to the project defined at the end of the second step. It also provides the advisor a way to assess *ex-ante* the value of an innovation at the scale of a given farm.

The loop can be covered as many times as necessary, whether to test new ideas or to assess the sensitivity of a farm configuration to variables such as commodity and input prices or change in yields according to the climate year. Since CLIFS is a static model, these analyses involve multiplying scenarios that vary the values given to these variables. The approach does not, in itself, include a support phase for the possible implementation of the preferred scenario, which falls under a different type of advisory service that is more focused on daily farm management.

CLIFS allows a wide range of issues and farm projects to be addressed, such as the choice and resizing of livestock activities to increase milk production, the choice of a forage system to improve

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<sup>&</sup>lt;sup>1</sup> This option to return to the table of contents is available on each page.



farm autonomy, the introduction of innovations such as catch crops or the partial use of cover plant biomass, and the analysis of the farm's sensitivity to climatic and economic shocks.

In addition to this advisory context, CLIFS can be used by trainers who wish to make learners aware of the operations of mixed crop-livestock farming systems and their possible developments, and by researchers who wish to evaluate *ex-ante* the potential consequences of introducing innovations in real or virtual farms of this type. CLIFS has also been used to simulate the operation of a dairy supply basin<sup>2</sup>.

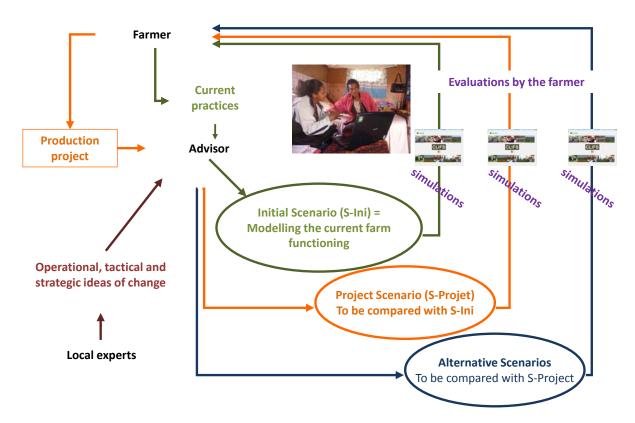


Figure 1. Organization of the advisory approach in three main loops.

#### A.2. Conceptual model

CLIFS is based on a generic representation of mixed crop-livestock farms that is organized around exchanges between crop enterprises, which produce biomass within the farm, and livestock enterprises, which consume biomass and produce organic manure that can be used on crops (Figure 2). The herd can be composed of ruminants and monogastrics. Ruminants include (i) breeding females producing milk that is sold or consumed by their young, (ii) animals kept for renewal, savings, traction and breeding, and (iii) animals that are fattened and then sold. Monogastrics are distinguished by their function: breeder or producer of meat and eggs. All these animals produce faeces, either directly on the plots when they consume the biomass available on site, or when they are stabled in barns or pens. In the latter case, excreta can be mixed with litter supplied by crop residues to produce organic manure. This manure can then be collected by the farmer and spread on the cultivated plots. Only this last practice is taken into account in CLIFS.

<sup>&</sup>lt;sup>2</sup> Zoungrana Sombénéwendé Rasmata, 2020. Conception de scénarios d'amélioration de la production laitière pour approvisionner une laiterie à Madagascar. Mémoire de fin d'études, SupAgro, Cirad, 51 p. + annexes. <a href="https://agritrop.cirad.fr/596838/">https://agritrop.cirad.fr/596838/</a>



Crops potentially present on the farm are grouped into three categories: (i) crops dedicated to feeding the family, whose surpluses are potentially marketable once family needs are covered. Certain products such as grain maize also may be fed to animals, whether as the main feed for monogastrics or as a supplement for ruminants; (ii) crops intended solely or principally for marketing, such as cotton and groundnuts in West African systems; (iii) grassland and forage crops directly dedicated to ruminant feed, whose surpluses may be marketed once the herd's needs are covered. This biomass can be distributed in different forms: green, hay or silage. These resources may be supplemented by crop residues from food crops, such as cereal straw, and marketed crops, such as groundnut leaves. All of these crops can potentially receive the organic manure produced by the farm's herd, in the two forms described above. Rangelands are not considered as part of the farm but their biomass can be included in the ruminants' diet.

The management of crop and livestock production activities mobilises family labour, which the farm manager allocates to different tasks throughout the year. While crop management is determined by crop cycles, seasons and technical practices, livestock farming involves both seasonal work and routine tasks that are repeated every day for all or part of the year (e.g., milking reproductive females and trough feeding)<sup>3</sup>. Mixed crop-livestock farms therefore represent a complex situation in terms of work organisation. Because of this complexity, the choice was made not to include this component in CLIFS. Only the cost of family, permanent and seasonal labour are included, based on the farmer's estimations for a given simulated scenario.

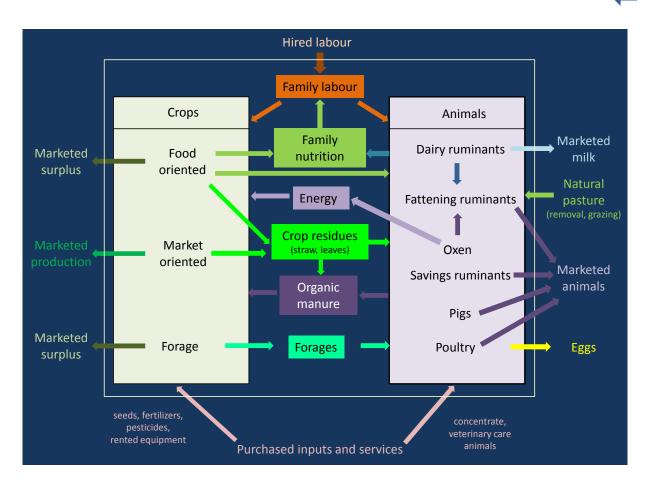
The farm is open to its environment, with which it interacts to (i) generate income by selling its production, according to its commercial strategy, and (ii) obtain goods and services: inputs for crops (seeds, fertilizers, pesticides, mechanized services) and livestock (fattening animals, food supplements, veterinary interventions); seasonal labour to supplement family and permanent labour inputs at certain times of the year according to work demand; natural pastures and biomass on which animals can be fed.

Farmers managing mixed crop-livestock production systems must therefore make strategic and tactical choices concerning (i) the nature of the crop and animal productions they wish to develop in their production system in relation to the degree of specialisation vs diversification to be achieved, (ii) the coordinated sizing of crop and livestock enterprises to achieve the desired degree of autonomy with regard to feeding animals and fertilizing crops, (iii) the way crops and herd will be conducted to achieve a given production objective. The timing of biological cycles is an important consideration in these choices. For crop cycles, this involves the seasons, which determine in particular when biomasses are available to animals and whether or not they need to be stored as hay or silage for later use. For animal breeding cycles, the main consideration is whether or not they are synchronous with the preceding ones. The internal degree of integration between crops and livestock, considered as one of the levers leading towards agroecological production systems, depends on this set of interacting decisions.<sup>4</sup>

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<sup>&</sup>lt;sup>3</sup> Hostiou, N., Dedieu, B., 2012. A method for assessing work productivity and flexibility in livestock farms. Animal 6, 852-862. https://doi.org/10.1017/S1751731111002084

<sup>&</sup>lt;sup>4</sup> Ryschawy, J., Choisis, N., Choisis, J.-P., Gibon, A., 2013. Paths to last in mixed crop-livestock farming: lessons from an assessment of farm trajectories of change. Animal 7, 673-681. https://doi.org/10.1017/S1751731112002091



**Figure 2**. Generic representation of the components and flows between components of a mixed crop-livestock farm.

#### A.3. Design principles

CLIFS translates this conceptual framework into a generic digital tool developed on a spreadsheet (Microsoft Excel® 2010). This format makes it usable and accessible to a wide range of audiences. The overall structure of the tool, its calculation procedures and the output variables were designed in order to be intelligible to the farmer involved in the advisory process, while providing a representation close to his/her farm that he/she could validate. This led to limiting the number of variables to be characterized on each farm and to excluding from the application mechanistic biophysical models, which are often unavailable in many contexts. The only equations related to biological processes concern: (i) for all ruminants, excreta production (Eq.15); and (ii) for cattle only, energy and nitrogen requirements for animal maintenance, for gestation of breeding females, and for production of milk and meat per head (Eq.12, Eq.14) with the choice between two calculation systems independent of the working language of the software user: French (INRA, 2007) and US (NRC, 2001). These equations linking diet and production can be inactivated by the user if he/she does not have the requested data or if he/she uses another food system than those proposed. The other calculations only use the four mathematical operators.

For each farm configuration modelled with CLIFS, the supply-demand balance for resources of three key components of mixed crop-livestock farms are calculated, namely: (i) the annual balance of food and commercial production, between the supply by crop linked to its area and its yield and consumption by the family and the herd (ruminants and monogastrics) (F.6, Eq.19); (ii) the monthly feed balance between the feed system supply (forage cropping pattern and production, crop residues) and ruminant demand, which itself depends on the herd structure (head numbers by animal type), the diet distributed over the 12 months of the year and the reproductive strategy for females (distribution of



births over the 12 months of the year) (F.3 & Eq.19 for green forage; F.4 & Eq.20 for hay and silage; F.5 & Eq.21 for crop residues); (iii) the annual balance of manure according to the manure production of stabled animals and manure quantities spread on crops (F.7 & Eq.23). The calculation of the economic results (variable and fixed expenses, gross and net margins) corresponding to each farm configuration is added to these three balance sheets (F.8, Eq.24, Eq.25 & Eq.26).

This general organization focuses on farms seeking to integrate crop and animal productions. The approach is of little interest to farms with limited or no interaction between these two components, for example: herds fed solely by divagation on natural pastures, or totally off-land rearing enterprises. The software is available in four languages for all of its protected titles: French, English, Spanish and Brazilian. However, its design allows users to enter in their own language the contents of the choice lists linked to certain variables (section D.).

#### A.4. General structure and operation

CLIFS consists of a series of Excel<sup>®</sup> sheets grouped into four modules (Figure 3 and section C for the list of sheets): **1. Parameters** (Section D) grouping the variables whose values are identical for a set of farms, such as characterization of feed (D.2); **2. Input variables**, specific to each farm, with an "animal" sub-module where dairy, fattening and growth batches are characterized (E.2 to E.8), a "crop" sub-module where the cropping pattern of the farm, the technical sequence and the yield per crop block are characterized, by differentiating food, commercial and forage crops (E.9 to E.14), and an economic sub-module (input and service prices, prices of marketed products) (E.15 to E.18); **3. Output variables** grouping all balances and economic calculations derived from the activity sizing, technical choices and production performances (section F); **4. Calculations**, grouping all intermediate calculations between input and output variables (sheets not visible by the user) and described in the calculation equations (Eq.1 to Eq.26).

The calculations are based on the farmer's current or potential practices and do not involve any biotechnical equation outside of cattle feed requirements and ruminant excreta production (A.3). The farm crop yields, commercial or forage, are thus entered by the user with the corresponding technical sequences, which presupposes a good local knowledge of these variables and their relations, whether it comes from the farmer him/herself, from advisors or from experts in the field. Any change in the technical sequence raises questions about its possible impact on yield, and may lead to changing yield value in the scenario under consideration.

The herd is segmented into 11 batches depending on the type of animal: breeding ruminants (two batches), growing ruminants (two batches), fattened ruminants (three batches), poultry and swine (four batches). Milk or meat production from ruminant batches are calculated on the basis of an average individual in weight and lactation stage, rather than on each individual in the batch. The diets are characterized by the amount of forage distributed per day and per average animal, with the possibility of changing the diet monthly, and by the amounts of concentrates, distributed for breeding females according to their stage of lactation. Fattening batches are defined by their duration and setting in the year, the number of animals concerned and the daily forage+concentrates diet considered as uniform for each given period.

**Warning!** Calculating milk and meat production according to the diet is only possible for cattle, based on the two feed systems proposed in D.2. However, CLIFS provides **the option not to process these calculations**, (see D.2, D.4, E.4.2, E.5 & E.6, to proceed), for instance if the user does not know the feed values. In this case, as well as for goats and sheep, the user enters, on one hand, a production objective and, on the other hand, a diet which he/she considers as suitable to achieve this objective.



CLIFS allows herds to be included that combine cattle and small ruminants, for breeding, growing and fattening purposes. Cropping systems are defined per block of area, which may or may not correspond to physical plots. In each block, it is possible to combine two crops (of subsistence-cash or forage types). This structure makes it possible to represent crop associations, whether they are mixed (for example a crop of interest such as maize associated with a cover crop such as *Stylosanthès guianensis*) or in succession the same year on the same block. The definition of each crop block also includes the technical sequence applied and the corresponding yields of up to two crops in the block.

Each farm configuration entered on CLIFS corresponds to a scenario whose simulation takes place over a year. Since the underlying model is static, each change must be entered and generates a new scenario. This design principle allows the user to always retain control over the changes made during the support process. However, it requires a great deal of vigilance regarding the internal coherence of each scenario since the mechanistic links between variables are limited to the production of excreta by ruminants (A.3), and eventually meat and milk production for cattle.

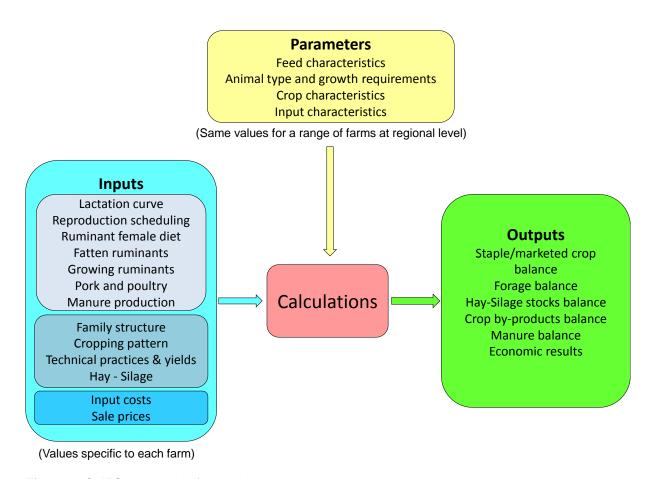


Figure 3. CLIFS structure in four modules.



#### B. General characteristics

### **B.1.** Using Excel® functionalities

When CLIFS is opened, the sheets are automatically viewed in full screen without the line and column references in order to provide more space for their contents to appear.

Clicking on the ESC button opens the main Excel menu bar, where the following functionalities are active for the user to save each scenario, copy and paste some results data to other applications and files, and sort lists of names in the Parameters sheets (section D .

- . Save and Save as file
- . Cut/Copy/Paste (for the unprotected cells)
- . Sort a list (be careful to select all of the variables included in the list)

When these operations are over, the user can come back to the full screen by selecting this in the View menu.

#### Warning!

- . Ctrl+C (Copy) and Ctrl+V (Paste) are inactivated. The user must use the Copy/Paste functions from the Excel bar.
- . The full screen view is applied to any Excel files opened at the same time as CLIFS. It is inactivated when CLIFS is closed.

#### **B.2.** Measurement units

CLIFS includes various categories of variables which use units to be measured (e.g., area, weight, volume, time, money). These units are treated in three ways:

- ➤ Pre-defined units appear in line and column heads with the variable name. Area, weight and volume units follow the metric system. However, the user must be careful when different units are used for the same kind of variable. For instance, weight is usually in kg but can be sometimes in g/kg (e.g., dry matter in D.2) or in kg/ton (in E.2).
- Undefined units with two cases:
  - Monetary units: the user selects the unit according to his/her geographical context. All of the costs and prices to be entered in CLIFS must be valued in the selected unit.
  - Input units (E.10): when "Quantity" is mentioned in the column head. For these inputs, the user must be careful to always use the same units for the dose per ha (E.10) and its price per unit (E.15).
- ➤ Percentages are always in % (e.g., 50 and not 0.5) and calculation formulas take this format into account.



#### B.3. Sheet and table sizing

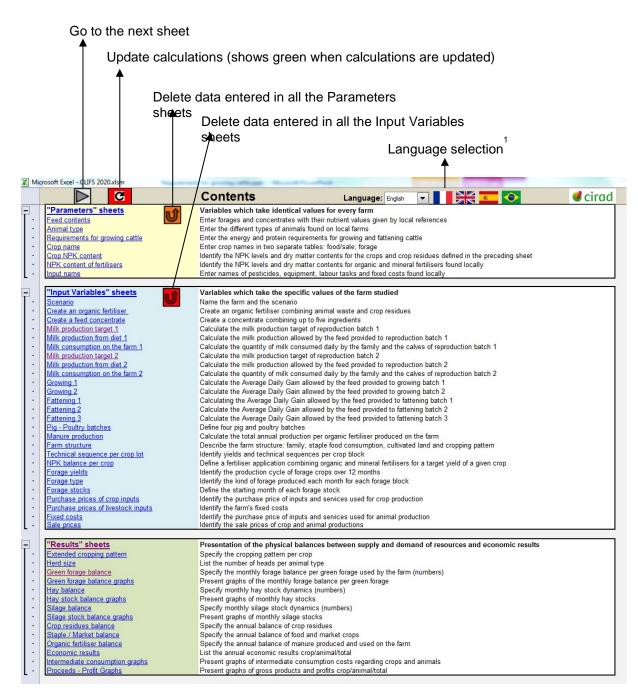
The Excel<sup>®</sup> sheet and table structure leads to limitations in the number of characterizable elements per enterprise. The following sizing was carried out to (i) facilitate the reading of entire tables on the screen (only the sheet 'Technical itinerary per crop block' requires the use of the horizontal cursor), and (ii) allow the representation of a large diversity of production systems, combining cattle, small ruminants and monogastrics on the animal side, food, market and forage crops (including permanent grasslands) in pure, associated or catch form, on the crop side.

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<sup>&</sup>lt;sup>1</sup>For each following input: organic fertilizer, mineral fertilizer, pesticide, hired machinery and hired labour

#### **B.4.** Macro buttons

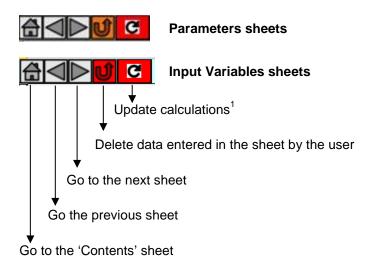
#### **B.4.1.** Contents sheet



<sup>&</sup>lt;sup>1</sup>Used for the names and titles provided by CLIFS. The Parameters module allows users to use their own language when creating their own lists.



#### **B.4.2.** Parameter and Input Variable sheets



<sup>1</sup>The "Update" button is red when CLIFS starts and every time a change is made in the numbers entered. Clicking on it activates all of the calculations in the application, updates the 'Output variables' values and switches the button to green.

To go from one sheet to another, the user can use the and buttons, or go back to the 'Content' sheet with the button and click on the sheet name.

#### **B.5.** Color codes

CLIFS uses some color codes throughout the application which helps the user in his/her manipulations.

Content to be entered by the user (Parameters module - unprotected)

Content to be selected by the user based on a drop-down list previously created or coming from a cell entered elsewhere (Parameters module; unprotected)

Content to be entered by the user (Input Variable module; unprotected)

Content to be selected by the user based on a drop-down list previously created or coming from a cell entered elsewhere (Input Variable module; unprotected)

Content automatically copied from a cell entered previously (protected)

Calculated content (Output Variable module; unprotected in order to be eventually copied)

Content provided by CLIFS (protected)

# C. Complete list of the CLIFS sheets as described in the 'Content' sheet

- 4	

« Parameters » sheets	D.1	Variables which take identical values for every farm
Feed contents	D.2	Enter forages and concentrates with their nutrient values given by local references
Animal type	D.3	Enter the different types of animals found on local farms
Requirements for growing cattle	D.4	Enter the energy and protein requirements for growing and fattening cattle
Crop name	D.5	Enter crop names in two separate tables: food/sale; forage
Crop NPK content	D.6	Identify the NPK levels and dry matter contents for the crops and crop residues defined in the preceding sheet
NPK content of fertilisers	D.7	Identify the NPK levels and dry matter contents for organic and mineral fertilisers found locally
Input name	D.8	Enter names of pesticides, equipment, labour tasks and fixed costs found locally
« Input Variables » sheets	Е	Variables which take the specific values of the farm studied
Scenario	E.1	Name the farm and the scenario
Create an organic fertiliser	E.2	Create an organic fertiliser combining animal waste and crop residues
Create a feed concentrate	E.3	Create a concentrate combining up to five ingredients
Milk production target 1	E.4.1	Calculate the milk production target of reproduction batch 1
Milk production from diet 1	E.4.2	Calculate the milk production allowed by the feed provided to reproduction batch 1
Milk consumption on the farm 1	E.4.3	Calculate the quantity of milk consumed daily by the family and the calves of reproduction batch 1
Milk production target 2	E.4.1	Calculate the milk production target of reproduction batch 2
Milk production from diet 2	E.4.2	Calculate the milk production allowed by the feed provided to reproduction batch 2
Milk consumption on the farm 2	E.4.3	Calculate the quantity of milk consumed daily by the family and the calves of reproduction batch 2
Growing 1	E.5	Calculate the Average Daily Gain allowed by the feed provided to growing batch 1
Growing 2	E.5	Calculate the Average Daily Gain allowed by the feed provided to growing batch 2
Fattening 1	E.6	Calculating the Average Daily Gain allowed by the feed provided to fattening batch 1
Fattening 2	E.6	Calculate the Average Daily Gain allowed by the feed provided to fattening batch 2
Fattening 3	E.6	Calculate the Average Daily Gain allowed by the feed provided to fattening batch 3
Pig - Poultry batches	E.7	Define four pig and poultry batches
Manure production	E.8	Calculate the total annual production per organic fertiliser produced on the farm
Farm structure	E.9	Describe the farm structure: family, staple food consumption, cultivated land and cropping pattern
Technical sequence per crop block	E.10	Identify yields and technical sequences per crop block
NPK balance per crop	E.11	Define a fertiliser application combining organic and mineral fertilisers for a target yield of a given crop
Forage yields	E.12	Identify the production cycle of forage crops over 12 months
Forage type	E.13	Identify the kind of forage produced each month for each forage block
Forage stocks	E.14	Define the starting month of each forage stock
Purchase prices of crop inputs	E.15	Identify the purchase price of inputs and services used for crop production
Purchase prices of livestock inputs	E.16	Identify the farm's fixed costs
Fixed costs	E.17	Identify the purchase price of inputs and services used for animal production
Sale prices	E.18	Identify the sale prices of crop and animal productions

"Results" sheets	F	Presentation of the physical balances between supply and demand of resources and economic results
Extended cropping pattern	F.1	Specify the cropping pattern per crop
Herd size	F.2	List the number of heads per animal type
Green forage balance	F.3	Specify the monthly forage balance per green forage used by the farm (numbers)
Green forage balance graphs	F.3	Present graphs of the monthly forage balance per green forage
Hay balance	F.4	Specify monthly hay stock dynamics (numbers)
Hay stock balance graphs	F.4	Present graphs of monthly hay stocks
Silage balance	F.4	Specify monthly silage stock dynamics (numbers)
Silage stock balance graphs	F.4	Present graphs of monthly silage stocks
Crop residues balance	F.5	Specify the annual balance of crop residues
Food / Market balance	F.6	Specify the annual balance of food and market crops
Organic fertiliser balance	F.7	Specify the annual balance of manure produced and used on the farm
Economic results	F.8	List the annual economic results per crop/animal/total
Intermediate consumption graphs	F.9	Present graphs of intermediate consumption costs regarding crops and animals
Proceeds - Profit Graphs	F.9	Present graphs of gross products and profits per crop/animal/total

#### **D.** Parameters sheets

All of the sheets are illustrated by the case of a virtual Malagasy dairy farm.

#### D.1. Common characteristics

The 'Parameters' sheets provide the contents of the drop-down lists that will be used in the 'Input Variables' sheets (E) when a selection of name is requested. They also provide some quantitative values for later use in calculations.

All of the yellow cells in the Parameters sheets are empty when the user opens CLIFS for the first time.

The user can use any language to enter names since there is no connection with the language selected in the 'Contents' sheet (D.1).

Parameters sheets must be filled in before switching to the 'Input Variables' module.

New items can be added when necessary, for instance when new practices are encountered on farms or are proposed by experts.





#### D.2. Feed contents

Feed contents														
Forage		INRA NRC Concentrates								INRA			NRC	
Name	DM content (g/kg)	UFL	PDIN	PDIE	VEF (UE/kgMS)	NEL (Meal)	CP (%)	Name	DM content (g/kg)	UFL	PDIN	PDIE	NEL (Mcal)	CP (%)
Alfafa (green)	232	0,81	149	131	1,10			Farm concentrate	886	1	87	80		
Alfafa hay	952	0,73	110	100	1,20									
Banagrass	190	0,67	83	85	1,10									
Barley (green)	155	0.71	75	75	1,00									
Bersim	100	0,50	50	60	1,10			Cassava	870	0,97	10,5	35		
Brachiaria ruziziensis	273	0,60	55	73	1,21			Coconut cake	900	0.89	167	167		
Chloris	250	0.64	83	93	1,20			Cotton cake	910	0,84	287	193		
Chloris hay	870	0,64	74	79	1,20			Faba bean	920	1,06	151	101		
Cowpea	200	0.75	137	110	1,10			Fish powder	920	0,98	403	298		
Oolique	200	0,77	119	151	1,10			Groudnut cake	910	1,12	315	175		
Groundnut hay	832	0,64	123	130	1,20			Maize bran	890	0,87	67	100		
ikuyu	210	0.77	111	114	1,08			Maize	860	1,08	71	103		
Maize (green forage)	200	0,60	55	85	1,10			Milk powder	955	1,13	184	136		
Maize silage	350	0.85	88	76	1,15			Rice bran	900	0.78	65	62		
Maize straw	870	0,57	29	50	1,50			Soya cake	900	1,1	312	216		
Dat	210	0,84	102	74	1,00			Sunflower cake	900	0.59	196	99		
asture Jan-May	250	0,60	35	35	1,20			Sweet potato	270	1,13	29	67		
Pasture June-Sept	270	0,40	17	17	1,30			Wheat bran	920	0,97	110	100		
Pasture Oct-dec	220	0,60	54	54	1,10									
Pasture rice field	220	0.50	29	29	1,20									
Penissetum kizozi	160	0,68	75	82	1,20									
Radish (fodder)	210	0.85	62	86	1,15									
Ray Grass	270	0,91	87	73	1,10									
Ray Grass hay	850	0,91	87	73	1,10									
Rice straw	900	0.44	39	51	1,49									
Sorghum	170	0,62	70	80	1,50									
Stylosanthės guianensis	424	0,80	83	63	0,95									
Stylosanthès guianensis hay	900	0.80	83	63	1,10									
Sugarcane	200	0,70	14	57	1,13									
/etch	189	0.89	152	106	0,94									
Vheat straw	954	0,48	18	47	2,00									
Vild grass dry season	510	0,65	65	70	1,10									
Vild grass rainy season	290	0.69	95	98	1,00									

The feed contents sheet is split into two tables: one for the Forages and one for the Concentrates. Two feed systems are proposed: INRA (French) and NRC (USA). Usually only one will be used by the user. The meaning of and correspondance between the French and American feed value systems are given in the table below. The feed intake capacity (FIC) is provided only by the French system. FIC is used for evaluating the % of saturation of a given diet.

INRA	NRC	Meaning
Poids vif	Live weight	
$UF^1$	NEL	Energy
PDIN; PDIE <sup>2</sup>	CP	Protein
GMQ	ADG	Average Daily Gain (g/day)
VEF	-	Ballast value of forage
CI	-	Feed intake capacity of cattle

<sup>&</sup>lt;sup>1</sup> Forage unit: calculated as the energy content of 1kg of a given feed divided by the energy content of 1kg of barley, both measured in calories.

Warning! If the user does not wish to link milk and meat production with diets for cattle, the columns characterizing feed values can remain empty. However, it is still required to enter the names of forage and concentrates with their dry matter content.

The four upper lines of the Concentrate table are filled in automatically from the content of the 'Create a feed concentrate' sheet (E.3), where these concentrates are defined.

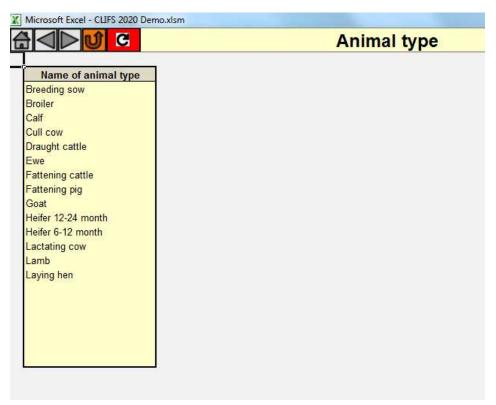
**Warning!** When a concentrate can be produced on-farm, its name must be the same as the corresponding crop defined in the 'Crop name' sheet (D.5). For instance, maize, whose grains can be consumed by both humans and animals.

Up to 68 forages, 64 basic concentrates and 4 mixed concentrates produced by the farm can be characterized. It is advisable to sort the list in alphabetical order to facilitate the search for a feed in the subsequent drop-down lists of choice.

<sup>&</sup>lt;sup>2</sup> The "protein" content of each feed is assessed by two variables PDIN and PDIE corresponding to the quantity of digestible proteins (measured in grams) allowed by respectively the protein and energy content of the feed.



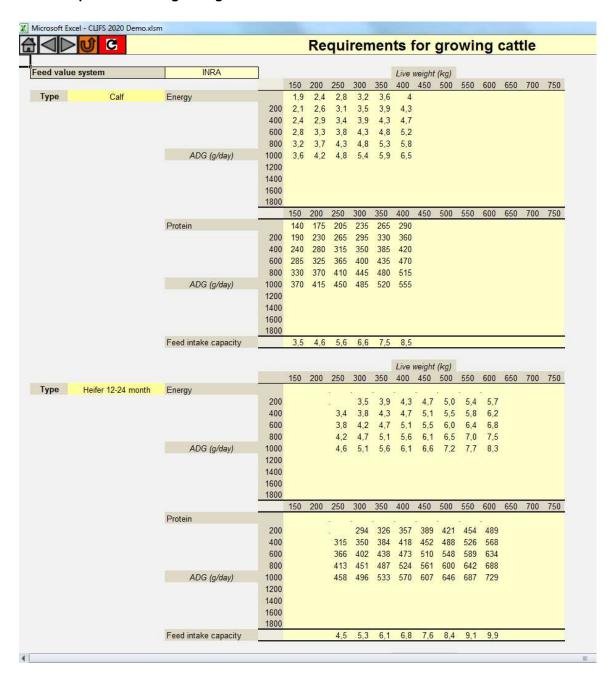
### D.3. Animal type



In this table, the user enters the names of the types of livestock likely to be found on the farms he/she works with. As shown here, these names can cover a wide range of types since CLIFS allows both ruminants and monogastrics to be included in the scenarios.



#### D.4. Requirements for growing cattle



Contrary to lactating cows, for which requirements are calculated based on equations (E.4.2), energy and protein requirements for growing cattle are based on tables depending on the type of animal. Each value corresponds to a given live weight and a targeted ADG (Average Daily Gain). The user can select the feed system used in the tables (INRA or NRC) at the top of the sheet. This information is just a reminder with no relation to the tables themselves and the subsequent calculations. Up to 10 tables corresponding to 10 different types of animals are provided.

**Nota bene:** the selection of the feed system is made in the sheet 'Scenario' (E.1). It conditions the calculations made in the livestock sheets.

**Warning!** If the user does not wish to link meat production with diet for growing and fattening cattle, he/she should just **leave these tables blank**.



#### D.5. Crop name

Microsoft Excel - CLIFS 202	0 Demo.xlsm								
			Crop nam	ne					
Food and market crops  Crop name	Residues name	Ratio Grain/Residues (raw material)	Forage crops Use	Crop name	Green forage name	Hay name	Silage name	Conversion Green-Hay	Conversion Green- Silage
Bean			Silage	Alfafa	Alfafa (green)	Alfafa hay		0,244	
Cabbage			Hay	Banagrass	Banagrass				
Cassava			THE STATE OF THE S	Barley	Barley (green)				
Cowpea				Bersim	Bersim				
Groundnut	Groundnut hay	2,00		Brachiaria ruz	Brachiaria ruziziensis				
Maize	Maize straw	1,25		Chloris	Chloris	Chloris hay		0,287	
Potato				Kikuyu	Kikuyu Iviaize (green				
Rice paddy	Rice straw	1,00		Maize green forage	forago)				
Sorghum				Maize silage	Maize silage		Maize silage		1,000
Soya (grain)				Oat	Oat				
Sweet potato				Penni. kizozi	Penissetum kizozi				
Tomato				Radish (fodder)	Radish (fodder)				
Wheat	Wheat straw	3,00		Ray Grass	Ray Grass	Ray Grass hay	l.	0,318	
				Sorghum	Sorghum				
				Stylosanthès g.	Stylosanthès guianensis	Stylosanthès guianensis hay		0,471	
				Sugarcane	Sugarcane				
				Vetch	Vetch				

CLIFS split crops into two types: (i) food and market crops that are consumed by the family or sold, and which may produce residues that can be consumed by ruminants, and (ii) forage crops that are only used to feed ruminants and can be consumed green or as hay or silage.

The names of food and market crops are directly entered here, while their corresponding residues names are selected in the list of forages already defined in the "Feed contents" sheet (D.2). When a residue is defined for a crop, the ratio grain weight/residue weight in raw material has to be entered. It will be used to calculate the residue biomass produced according to the crop yield in terms of grain or equivalent product.

**Warning!** When a crop product can be used directly as a concentrate, the crop name must be the same as the corresponding concentrate name defined in the 'Feed contents' sheet (D.2). For instance, maize, whose grains can be consumed both by humans and animals.

Likewise, the forage crop names are directly entered here, and their equivalent forages (green and eventually hay and silage) names are selected in the list of forages defined in D.2. The conversion of green yield into hay and silage yields is based on a ratio calculated automatically (Eq.1).

Up to 68 names per type of crop can be entered.



#### D.6. Crop NPK content

Crop NPK content														
xport of nutrient pe	r ton of dr	y matter	produced	l (kg/t DM)						1 (4)				
Fo	od and m	arket cro	ps		C	rop resid	ues				Forage of	rops		
Crop name	N	Р	к	DM content (g/kg)	Residues name	N	Р	к	DM content (g/kg)	Crop name	N	Р	к	DM content (g/kg)
Bean	37,5	4,5	21,5		-					Alfafa	20,0	4,0	4,0	350,0
Cabbage	20,0	2,5	8,0							Banagrass				
Cassava	4,5	0,7	3,5							Barley				
Cowpea					-			i.		Bersim			10 10	
Groundnut	45,0	4,0	6,0	800,0	Groundnut hay	20,0	5,0	5,0	832,0	Brachiaria ruz				
Maize	20,0	3,5	3,5	860,0	Maize straw	14,0	1,5	22,5	870,0	Chloris				
Potato	4,5	1,8	4,5							Kikuyu				
Rice paddy	16,0	3,5	2,5	850,0	Rice straw	6,0	1,0	3,0	900,0	Maize green forage				
Sorghum	16,5	3,5	2,5					Ü		Maize silage			2	
Soya (grain)	75,0	8,0	17,5					8		Oat			.s	ś
Sweet potato	5,0	1,0	5,5							Penni. kizozi				
Tomato	1,5	0,4	1,3			2				Radish (fodder)			2	
Wheat	27,5	4,0	7,0		Wheat straw				954,0	Ray Grass				
(4)					*			8		Sorghum	27,5	2,5	20,0	424,0
727					127					Stylosanthès g.	27,5	3,0	10,0	190,0
180										Sugarcane				
(14)					-					Vetch				

CLIFS proposes the calculation of apparent NPK balances as a way to check the consistency of fertilizer doses applied to crops with their yields (E.11.). These balances compare the amount of NPK exported by the crop according to its yield and its NPK content with the NPK quantities provided by the fertilisation applied.

This sheet allows the user to enter the NPK contents of the crops listed in the 'Crop name' sheet D.5 (kg/ton DM of product). The names appear automatically in the sheet, split into food and market crops, residues, and forage crops.

As shown in this example, it can be difficult to find the NPK figures for each case. However, missing data have no impact on the main outputs of CLIFS since NPK balance calculations are optional and disconnected from the rest of the software.



#### D.7. NPK content of fertilisers

	s (kg/ton DM)					
Name	N	Р	к	DM content (g/kg)	Daily quantity of excret	ta produced by pigs and poult
reated fertiliser (cf. 'Creat	te an organic fert	iliser' sheet)			Name	Quantity (kg/day/head)
Farm cow manure	10	3	7	500	Breeding sow	3
Sewage powder	13	3	6	800	Broiler	0
Pure pig manure	5	4	5	200	Fattening pig	
Chicken manure	20	35	20	700	Laying hen	0
Fattening pig manure	6	3	4	500		
-						
-						
-						
-						
aw animal excreta						
Cattle faeces	19	8	17	400		
Ewe faeces	10	10	5	700		
Pig manure	5	4	5	100		
Chicken manure (dry)	20	35	20	900		
lineral fertilisers	400					
Jrea	460	- 420				
3-13-0	130	130	* ,			
mmonium phosphates	18	46	- 40			
3-26-13	13	26	13			
		-	-			
-						

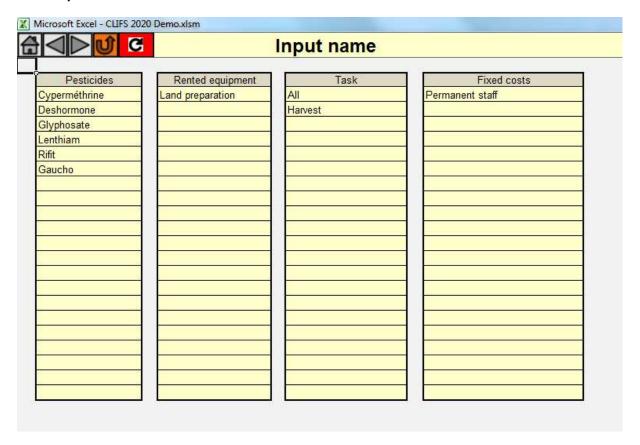
The NPK contents of fertilisers required to calculate the nutrients input applied on a crop are entered in this sheet according to the kind of fertiliser, i.e., raw animal excreta produced by herds and mineral fertilisers.

Moreover, CLIFS includes the possibility to create on a given farm organic fertilisers mixing excreta and crop residues like rice straw (E.2). The names of these fertilisers as well as their corresponding NPK contents are automatically reported here.

The user must also enter here the quantities of excreta produced by the categories of pigs and poultry present, assuming these types of animals are encountered on the farms with which he/she works.



### D.8. Input name



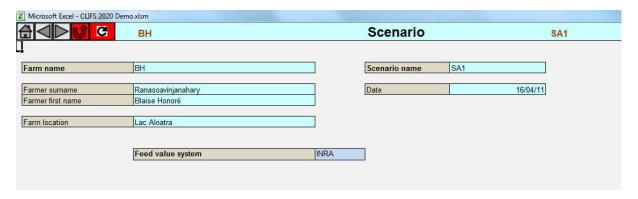
This sheet is dedicated to the input names found in the user's working area and likely to appear on a given farm. It is split into pesticides (herbicides, fungicides, insecticides, others), whether synthetic or organic, rented equipment (defined either by the equipment itself or by the task which uses it), tasks employing hired labour, and fixed costs.



### E. Input Variables sheets

This section regroups all the sheets used for characterizing a scenario on a given farm.

#### E.1. Creating a scenario and selecting the feed value system



The 'Input Variables' module starts with the 'Scenario' sheet where the designed scenario is characterized by the farm name and location, the farmer's surname and first name, the scenario name and its date of creation.

From this point on, the name of the farmer and of the scenario appear on the upper bar of each sheet of the 'Input Variables' and 'Results' modules.

This sheet also includes the choice (between the French INRA system and the American NRC system) of the feed value system dedicated to cattle. This selection must be consistent with the feed values entered in the 'Feed contents' sheet (D.2), assuming the user works only with one of these two systems. This choice determines the nature of the equations used to calculate milk and meat production for a given diet (E.4; E.5; E.6).

This choice has no impact on the calculations if the user has inactivated these equations in the sheets D.2, D.4, E.4.2, E.5 & E.6.

INRA (Ed.), 2007. Alimentation des bovins, ovins et caprins. Besoins des animaux- Valeur des aliments. Tables INRA 20 07. Quae Editions, Paris, France.

NRC, 2001. Nutrient Requirements of Dairy Cattle, 7th revised edition. National Academy of Sciences, Washington, DC, USA. <a href="https://doi.org/10.17226/9825">https://doi.org/10.17226/9825</a>



#### E.2. Creating an organic fertiliser

Fertiliser name						kg/ton DM (analyzed)			kg/ton DM (calculated)			
	Excreta	%	Straw	%	DM content (g/kg)	N	Р	к	N	Р	к	
arm cow manure	Cattle faeces	30,0	Rice straw	70,0	500				10	3	7	
Sewage powder	Cattle faeces	100,0			800	12,8	2,5	5,6	13	3	6	
⊃ure pig manure	Pig manure	100,0			200				5	4	5	
Chicken manure	Chicken manure (dry)	100,0			700				20	35	20	
Fattening pig manure	Pig manure	50,0	Rice straw	50,0	500				6	3	4	
					, i				2			1

This sheet allows the user to create organic fertilisers specific to the farm studied and the scenario designed. The user gives a name to each fertilizer used on the farm or likely to be used, and characterizes it with (i) its excreta name selected from the list entered in D.7., (ii) the excreta proportion in the fertilizer, (iii) the straw eventually used in combination with excreta, selected amongst the residues defined in D.5.

With these three data, CLIFS calculates automatically the NPK content of the created fertilizer according to the nutrient content of each of its components (Eq.2). These figures can be replaced by figures drawn from farm analyses when they differ from the one calculated.

Entering the dry matter content of the fertilizer is optional but required if NPK balances per crop are to be calculated.

**Warning!** When a fertiliser is composed of only one type of excreta without any other addition, it also must be created in this sheet to appear in the list of organic fertiliser that can be used on the farm and in the organic fertiliser balances (e.g., 'Pure pig manure' and 'chicken manure' in the example above).



#### E.3. Creating a feed concentrate

				Compositi	ion (for 100 kg Raw	Matter)					
Name	Ingredient 1		Ingredient 2 Ingredient			3 Ingredient 4			Ingredient !	Total	
	Name 1	kg 1	Name 2	kg 2	Name 3	kg 3	Name 4	kg 4	Name 5	kg 5	1
Farm concentrate	Maize	22	Cassava	22	Rice bran	43	Groudnut cake	13			1
	11031120										
		-				-		-			
				( )							
				ed value			r.				
Name	DM content (g/kg RM)										
Ivame		UFL	PDIN	PDIE	NE <sub>L</sub>	CP					
Farm concentrate	886	0,93	87	80							
	5-21/22										
• 5											
Name	Cost per kg	Cost per UFL	Cost per PDIN	Cost per NEL	Cost per CP						
Farm concentrate	400	429.18	4,61								
-											
				*		1					

Farmers may prefer to make their own concentrates rather than buying them, either with basic ingredients bought on the market or with their own crop production. CLIFS provides the possibility to create four on-farm concentrates, each concentrate consisting of up to five compounds.

The user starts by giving a name to each created concentrate. This name will appear in D.2 and in every drop-down list used when a concentrate name is required. He/she then selects the name of each ingredient from the list of basic concentrates defined in the 'Feed content' sheet (D.2) and enters its proportion (in kg for 100 kg of raw matter). The sum of all of the quantities of ingredients must be equal to 100. Otherwise, the total cell is red. Once these data are entered, CLIFS calculates automatically the dry matter content and the feed value of the created concentrate that appear in D.2 (Eq.3).

It also calculates the cost of the concentrate (per kg and per unit of energy and protein), assuming that the unit prices of the ingredients have been entered in the 'Purchase prices of livestock inputs' E.16 (Eq.4). At this stage, the calculation considers that all of the quantities have to be purchased on the market. The objective is to compare the price of the produced concentrate with the price of similar feed on sale outside the farm.

**Warning!** The total cost of concentrates calculated in the 'Economic results' sheet (F.8.1.) takes into account the annual balance of each ingredient produced on the farm according to its consumption by the family and the livestock. If the balance is positive, CLIFS considers that the cost of this ingredient is null. If it is negative, the purchase price is applied to the missing quantities.



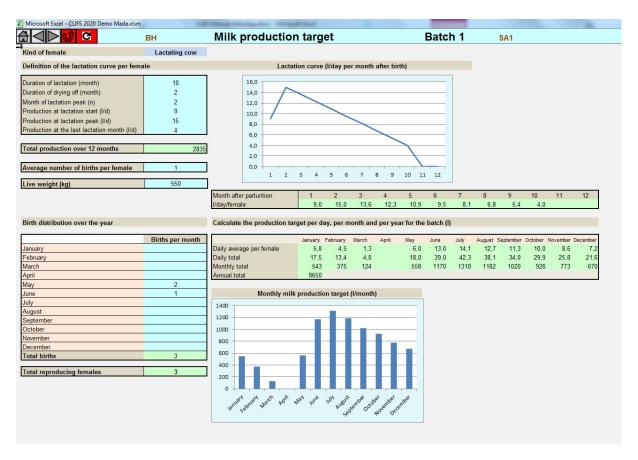
#### E.4. Milk production

CLIFS provides the possibility to create two batches of breeding females that may be lactating cows (dairy or suckler), goats, ewes, or even other species (camelids for example). The calculation of monthly milk production from each batch is based on three sheets per batch:

- . 'Milk production target' (E.4.1) calculates the monthly production of the batch that the farmer aims to achieve considering the batch size, the milk production curve of its average female, and the birth distribution from January to December.
- . 'Milk production from diet' (E.4.2) calculates the monthly production of the batch according to the daily diet supplied to the average female from January to December. This production is equal to the production target when equation Eq.12 is inactivated for cattle, and always for the other species.
- . 'Milk consumption on the farm' (E.4.3) subtracts from the previous sheet the milk consumption by the suckling young and the family. That sheet provides the quantities of milk that can be sold monthly on the market or to dairies.



#### E.4.1. Milk production target



The user starts by selecting the type of female characterizing the batch from the list of animal types defined in the 'Animal type' sheet (D.3.).

The user then defines the lactation curve of the average breeder by entering the following five values, which produce a simplified curve in three segments:

- Duration of lactation (months)
- Duration of drying-off (months)
- Month after birth of lactation peak
- Production of milk at lactation start (I/day)
- Production of milk at lactation peak (I/day)
- Production of milk at the end of lactation (I/day)

The lactation curve is then calculated and displayed both as a table and as a graph on the sheet (Eq.5).

**Warning!** To make crop and livestock cycles coincide, the lactation curve cannot exceed 12 months. When dairy farmers keep their cows in production over a longer period, the user has to create a "virtual" curve providing the same amount of milk during 12 months.

The total targeted milk production for the lactation of the average female of the batch is then calculated (Eq.6).

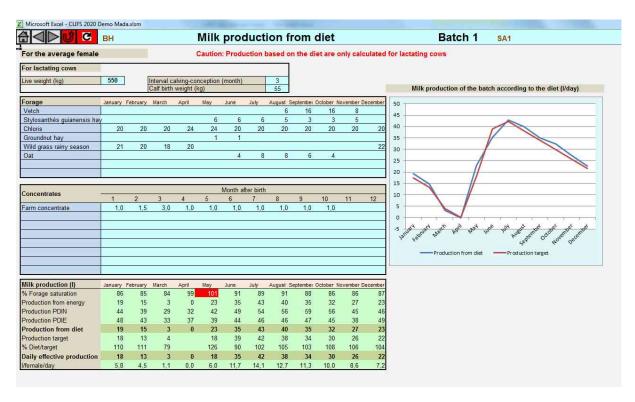
The average number of births per female is then entered. It is usually one for cows, but it can be more for ewes and goats, for instance.



The live weight in kg of the average female is then entered, and the births are distributed monthly between January and December.

Based on these data, CLIFS calculates (i) the number of reproducing females (Eq.7), (ii) the average daily milk production per female, and (iii) the daily, monthly and total milk production of the batch (Eq.8). The monthly production of the batch is displayed in a graph.

#### E.4.2. Milk production from diet



This sheet has two objectives: (i) to characterize the diet distributed throughout the year to the animals in a batch as part of the balance calculation for forage and food/market crop productions at the farm level; (ii) **for cows only** to calculate the milk production of the batch by comparing the milk production from the diet and the target defined in E.4.1. In this respect, two variables are entered: (i) interval between calving and conception in months, and (ii) weight of calf at birth (kg). These data are used to calculate the forage saturation due to the diet (Eq.9) and the gestation requirements according to the month after calving (Eq.10).

The percentage of forage saturation of the daily diet is used to evaluate its relevancy in terms of ingestion by the average cow of the batch. A percentage superior to 100 indicates a diet that is too voluminous to be ingested. In this case, the corresponding cell turns red and the user must diminish some of the quantities distributed to achieve a ratio inferior to 100.

**Warning!** The concentrate quantities are not included in the calculation of this percentage. It consequently is recommended to target a forage saturation below 95%.



Warning! To inactivate these calculations the user does not enter any value for the two variables "Interval calving-conception" and "Calf birth weight". In this case, as well as for ewes and goats, for which these equations are unavailable, the milk production is always the target one. Then it is assumed that the diet entered in the sheet is sufficient to achieve this target and adapted to the feed intake capacity of the average animal.

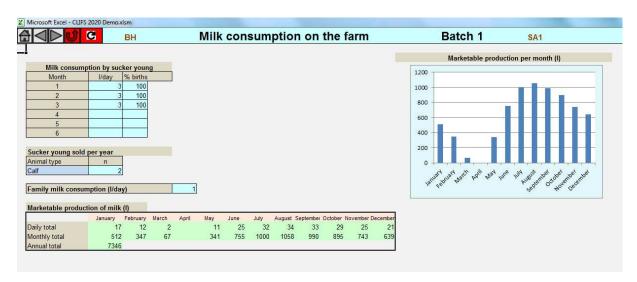
The diet is entered monthly for the average reproducing female, in **kg gross matter of feed per day**. Two tables are used: the forage feeds are entered according to the calendar month (January to December) and the concentrates according to the month after calving. This difference is justified by the fact that dairy farmers usually adapt concentrate quantities to the females' lactation stages. Up to eight forages and eight concentrates can be entered for each batch.

For the cows only, monthly milk production from the diet is then calculated (Eq.12) based on the energy and protein supply of the diet (Eq.11).

Five monthly milk productions are then displayed in the table: energy-based, protein-based (two values in the INRA system, one in the NRC one), diet-based (minimum of energy and protein-based), target-based, and effective (minimum of the diet and target-based).

CLIFS displays the monthly milk production curves due to the diet (red line) and targeted (blue line) on the same graph. The user can then compare the two curves and attempt to adjust them by correcting the diet. A production deficit indicates a lack of nutritional intake or an overly ambitious target, while an excess indicates that the diet is too rich or that the target is too low.

#### E.4.3. Milk consumption on the farm



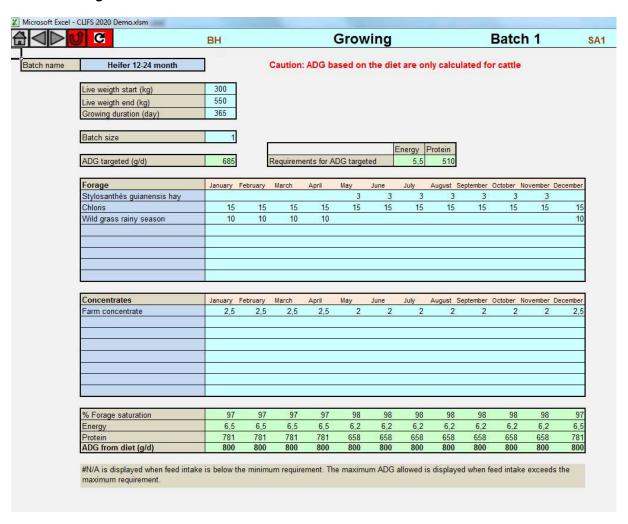
Milk produced by lactating females can have three destinations: (i) suckling young kept on the farm for up to 6 months; (ii) family consumption, and (iii) sale. CLIFS calculates these three components once the user has entered (i) the daily consumption of milk per suckling from month 1 to month 6 after birth jointly with the proportion (%) of young kept on the farm each month, and (ii) the family daily consumption of milk (Eq.13).

The monthly amount of marketable milk is displayed on a graph.

On the same sheet, the user enters the number of young marketed during the year. This value will be included in the animal economic proceeds (Eq.25) once the sale price per head is entered (E.18).



#### **E.5.** Growing ruminants



CLIFS allows the user to include two batches of growing livestock on the farm (sheets 'Growing 1' and 'Growing 2). This category includes various types of animals whose names have to be defined in D.3, such as young females kept to eventually replace reproductive ones, male breeders, traction animals or living savings livestock. They consume feed during this growing phase, which has to be included in the balances calculated at the farm level.

To characterize these two batches, the user enters the following variables:

- . The name of animal type a, selected from the list created in D.3;
- . The starting and ending live weight of the average animal in kg. The two values can be equal, when the animal maintains the same weight throughout its duration in the batch (ADG=0);
- . The duration in the batch in days;
- . The batch size (head number);
- . The forage and concentrates quantities supplied daily to the average animal from January to December (kg gross matter).



The following calculations are then made for the average animal of the batch (Eq.14) for cattle only and if the user has filled the table of feed requirement corresponding to the selected animal type (D.4):

Targeted Average Daily Gain (ADG)

**Warning!** The two cells concerning energy and protein requirements linked to the targeted ADG display #N/A when the calculated ADG is below the values entered in the tables D.4. The user has to readjust the starting and ending live weight and the growing duration in days in order to get a value for the targeted ADG included in the table corresponding to the selected animal type.

- Energy and protein requirements linked to the targeted ADG
- Monthly forage saturation (%)
- Daily energy and protein supplied by the diet
- Corresponding ADG allowed by the diet

Nota bene 1: in the INRA system the calculations are made twice for protein (PDIE and PDIN) and the minimum ADG is considered.

Nota bene 2: if the amount of energy or protein supplied is higher than the maximum found in the table for the average live weight considered, CLIFS takes these maximums into account in the calculation of the ADG allowed by the diet.

*Nota bene 3:* for simplicity, CLIFS does not consider the monthly increase of live weight throughout the growing period but takes only the average between the start and end.

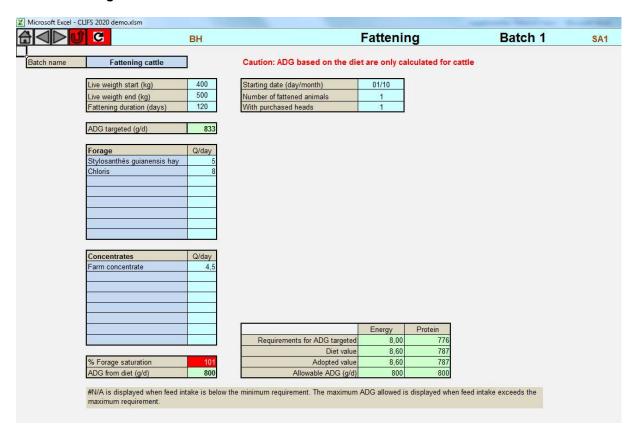
The value displayed in the bottom table can be compared by the user with the targeted ADG. In case of a wide gap, the diet can be adjusted for the two values to coincide.

**Warning!** The 'ADG from diet' cells may display #N/A when data are entered. The user must click on the Update button to make the calculated value appear in each cell.

If the user has not filled in the requirement tables, as well as for goats and sheep, there is no calculation of ADG from the diet. It is assumed that the diet entered is compliant with the targeted ADG.



#### E.6. Fattening ruminants



CLIFS allows the inclusion of three batches of fattening ruminants on the farm (sheets 'Fattening 1', 'Fattening 2 and Fattening 3). These animals are supposed to stay on the farm for a given period when they are fed to gain weight before sale. The feed consumed during this fattening period has to be included in the balances calculated at the farm level, and the animal sales in the economic results.

CLIFS considers that these animals receive the same diet during the entire fattening period, corresponding to their average live weight. If the period is too long for this assumption to be relevant, the user can split it in two or three sub-periods corresponding to two or three batches with the same animals at various starting and ending weights.

The variables to be entered and the calculations made are similar to those for growing batches (Eq.14):

- . The name of the animal type, selected from the list created in D.3.
- . The starting and ending live weight of the average animal in kg
- . The growing duration in days
- . The starting date of the fattening period (day/month: dd/mm)
- . The number of fattened animals in the batch
- . The forage and concentrates supplied daily to the average animal throughout the fattening period (kg gross matter).
- . An additional variable is required for the number of animals in the batch purchased outside the farm in order to be fattened.

Nota bene: since only one diet is simulated for the batch, CLIFS provides three values of energy and protein: (i) the values required to achieve the targeted ADG, (i) the energy and protein values provided by the diet, and (iii) the values adopted according to the comparison between the diet values and the values required to achieve the maximum ADG corresponding to the average live weight.



**Warning!** The ADG from diet cells may display #N/A when data are entered. The user must click on the Update button to make the calculated value appear in each cell.

As in E.5, **if the user has not filled in the feed requirement tables**, as well as for goats and sheep, there is no calculation of ADG from the diet. It is assumed that the diet entered is compliant with the targeted ADG.



#### E.7. Pig and poultry batches



CLIFS allows the inclusion of four batches of monogastric animals selected in the list of names the user has created in D.3.

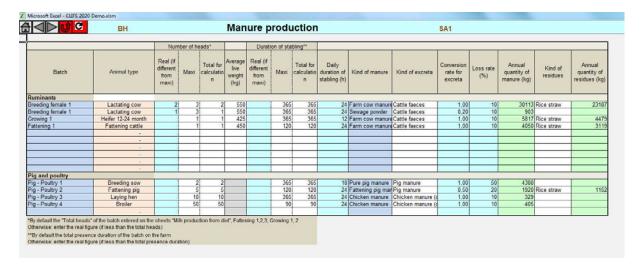
Each batch is composed of permanent and possibly purchased animals that stay for a given period during which they receive a given diet before eventually being sold. This structure is characterized with the following variables:

- . Name of the animal type
- . Number of permanent heads
- . Number of purchased heads
- . Number of sold heads
- . Duration in the batch (days)
- . Distributed feed selected within the concentrate list in D.2. For simplicity the values entered are the **annual quantity per concentrate for the whole batch** (kg). Up to 8 concentrates can be entered.
- . The total number of eggs sold during the year.

These variables will be used to calculate the quantity of manure produced by each batch, the balances of food/market production and the economic results of the farm.

**Warning!** Permanent heads stay on the farm throughout the year, while sold heads stay only during the duration of fattening or production. An individual is either permanent or sold and the total size of the batch is equal to the permanent plus the sold head numbers.





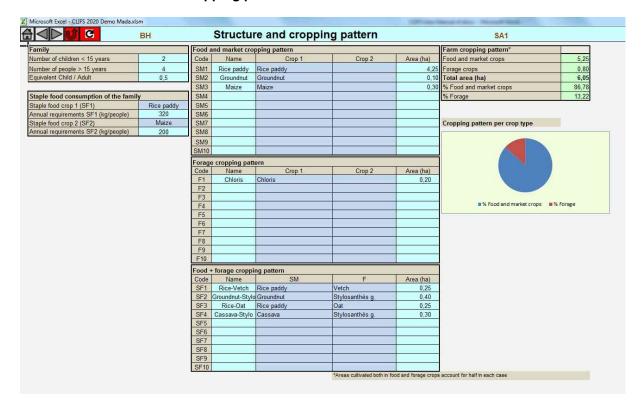
Organic manure production is calculated from a set of variables entered in the sheet of the same name which is split into two parts, one for ruminants (milk production, growing and fattening batches), and one for monogastrics. This separation is due to the fact that the quantities of excreta produced by ruminants are calculated based on an equation (Eq.15), while those produced by monogastrics are based on daily quantities per head entered in D.7. However, the variables to be entered in both parts are the same:

- . Name of the batch selected in the batch list. The corresponding animal type appears automatically.
- . Number of heads involved in manure production in the selected batch. The number has to be entered if it is less than the batch size ( $b^*$  index in Eq.15). Otherwise CLIFS takes this size directly into account.
- . Average live weight, which is used for calculating the cattle manure production, is recalled automatically (not applicable for monogastrics).
- . *Duration of stabling in days*. This variable has to be entered if the duration of stabling is different from the total duration period of the batch. Otherwise, CLIFS takes this duration directly into account for growing and fattening batches. For reproducing females, the duration is always equal to 365 days.
- . Daily duration of stabling (hours). This variable is comprised between 1 and 24 hours according to the way animals are managed during the day. This value is considered to be homogenous during the duration of the stabling period.
- . Type of manure selected from the list of organic fertilisers defined in E.2. The 'Excreta type' and 'Straw type' columns are filled in automatically from this sheet.
- . *Conversion rate for excreta* = 1.00 if the unprocessed excreta is used, < 1.00 if excreta is dried when the manure is processed.
- . Loss rate (%). The losses concern only the quantity of manure produced and not the corresponding quantity of residues used.

Based on this set of variables, CLIFS calculates the total annual amount of manure produced by the selected batch and the total corresponding amount of crop residue required (Eq.15).



#### E.9. Farm structure and cropping pattern



This sheet characterizes (i) the structure of the family living on the farm, (ii) the family's staple food requirements and (iii) the farm's cultivated area and cropping pattern. Points (i) and (ii) provides the data required to calculate the family's demand for staple food (Eq.22). Point (iii) provides the crop distribution required for calculating crop production supply at the farm level (Eq.22).

#### E.9.1. Family structure

CLIFS considers two kind of family members: children under the age of 15 and adults 15 years old and over. The user must enter the number of persons per category, plus the conversion rate between the two. CLIFS then calculates the total number of equivalent adults in the family (Eq.16).

In the second table, the user can select two staple foods from the list of crop names defined in D.5. The quantity required to feed one adult for the year is entered for each staple food.

**Warning!** To calculate staple food balances, the quantity of staple food entered must be consistent with the crop production and not with the food actually consumed when there is a processing stage between the two. For instance, in the case of rice, human needs are often given in husked rice while the crop is paddy rice. The user has to apply a conversion ratio between husked and paddy rice to evaluate the quantity of paddy rice to be entered.



#### E.9.2. Cropping pattern

The cultivated area of the farm is split into crop blocks, each crop block being defined by:

- > up to two crops cultivated on the same block over the year, whether they are associated at the same time or in succession during the year
- An uniform crop management sequence (described in E.10)
- A yield per crop included in the block

For calculation reasons, CLIFS regroups crops likely to be cultivated on any farm into three groups corresponding to the three tables displayed in the sheet: (i) food/market crops; (ii) forage crops; (iii) food/market and forage crops in association or succession. The last group concerns for instance the combination of a food/market crop (e.g., maize) with a cover crop used as a forage (e.g., Stylosanthès) or a succession of a food/market crop (e.g., paddy rice) with a forage crop (e.g., vetch).

Up to 10 blocks can be defined per group.

For each block, the user gives a name to the block<sup>5</sup>, selects the crops concerned in the two lists of crop defined in D.5. (food/market and forage) and enters its area in hectares. Based on these data, CLIFS calculates the simplified cropping pattern of the farm between food/market and forage crops. Block areas of associated crops are divided by two, each half being assigned to one type (Eq.17).

<sup>&</sup>lt;sup>5</sup> The name can be the same as the crop. However, in case of two or more blocks bearing the same crop but which are managed differently in terms of technical sequence and yield, the name selected must differ for each of these blocks. For instance, 'Low input maize' and 'High input maize' to differentiate two blocks of maize with contrasted levels of inputs and yields on the same farm. Or 'Rain-fed rice' and 'Irrigated rice' in case of blocks differing in terms of water access.



#### E.10. Technical sequence per crop block

This sheet regoups all of the variables describing the management of the crop blocks defined in E.9.2. Due to the number of variables involved, it is the only table which cannot be fully displayed on the computer screen. The user must use the horizontal slider provided by Excel® to enter the data for all of the variables.

This sheet also includes the yield per crop1 and crop2 for each block. These values must be consistent with their corresponding technical sequence and the soil and climate context specific to each scenario and block. Since CLIFS does not include any sort of mechanistic equations between yields and agricultural practices, this consistency is based on the knowledge of experts such as farmers, technicians and researchers.

**Warning!** When two crops are combined on the same block, the area considered to calculate the production of each crop remains the total one as entered in E.9.2. In these cases, the user must adjust the yields entered per crop should they be lower or higher compared to each crop cultivated on its own.

The first four columns on the left copy the data entered in E.9.2. (name and crops per block). The variables to be characterized are listed below in the order they appear in the table (from left to right). The input values are used to calculate the costs related to crop management (F.8.1) once their prices per unit have been entered in E.15. The input types are selected from the lists created in D.8.

- . Yields of crop 1 and 2
- . Proportion of residues exported for crop 1 and 2 (%): these quantities will be usable for feeding animals and producing manure.
- . Seed quantities for crop 1 and 2 (type and quantity per hectare)
- . Organic fertiliser (type and kg per hectare): repeated thee times per block
- . Mineral fertiliser (type and quantity per hectare): repeated thee times per block
- . Pesticides (type and quantity per hectare) : repeated thee times per block
- . Rented machinery (type and quantity per hectare): repeated thee times per block
- . Hired labour (type of task and quantity per hectare) : repeated thee times per block
- . Irrigation : m<sup>3</sup> per hectare

Warning! In case of an irrigated block where there are water fees, the user must enter a quantity of water consumed per ha, even if the charge is a flat rate per ha (E.15.). When the water is free of charge, no value has to be entered.

*Nota bene 1*: due to the limitations in lines and colums in Excel<sup>®</sup> tables, some variables have been repeated three times (indicated with an asterix in the table).

*Nota bene 2*: for the variables characterized by a "quantity" without any specified unit (highlighted in violet in the following table), the user uses the unit he/she prefers but must be careful to **use the same unit** for the price variables (E.15) (see also B.2).

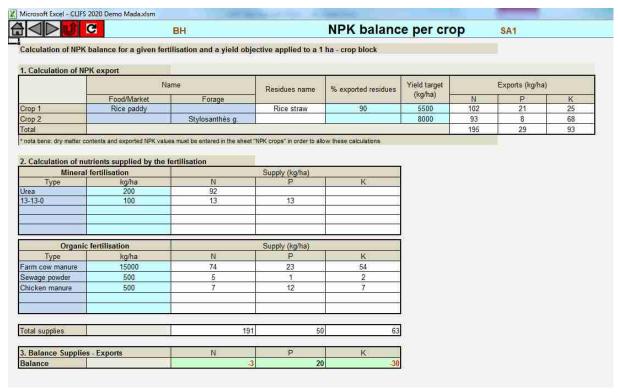


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Code	Name	Crop 1	Crop 2	Crop 1 yield	Crop 2 yield	Harvested r			residues 2	Seed 1	Seed 2	Organic fer	tiliser ∩1	Organic fert	ilisar O2	Organic fe	rtiliser 03	Minoral f	ertiliser M1	Ε
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	Rice-Oat	Rice paddy	Oat	5 500	20 000	Rice straw	90	4		15	60	Farm cow manu	8000	Pure pig manu	8000		į.	Urea	75	1
F4	Cassava-Stylo	Cassava	Stylosanthès g.	1 700	4 700	180				3333	1									4
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F6		*:				275														4
F7	*	*	*																	1
F8	¥ ]	745	2																	4
SF9			-			(%)														4

(partial view)



#### E.11. NPK balance per crop



This sheet allows the user to check if the fertilisation entered in E.10 covers the NPK exports of the corresponding crop or combination of two crops. It has no functional link with other sheets in CLIFS except for 'Crop NPK content' (D.6), where the user has entered NPK contents of each crop when available. Otherwise the balance cannot be calculated.

When there is a surplus or deficit of nutrients, the user can search for a better balance by changing fertilisation or yields. Then he/she has to enter this new value in the E.10 sheet.

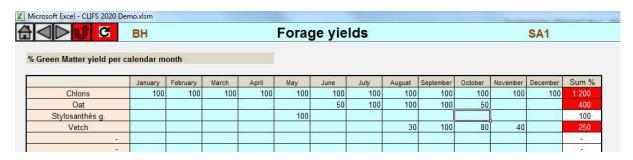
*Nota bene*: the balance is simplified since inputs and losses linked to soil characteristics, nutrient dynamics, nitrogen fixation by legumes, etc., are not taken into account (Eq.18). The values provided are just a way to estimate the gap between exports and inputs.

**Warning!** To keep the same weight units in the calculations fertiliser's doses are entered in kg/ha, while the user can select its own units in E.10. Yields and quantities of organic fertilisers are entered in gross weight and not in dry matter.



#### E.12. Forage yields

#### Method 1



#### Method 2



Many green forage crops produce biomass over several months, and their monthly production depends on seasonal conditions (temperature and rainfall particularly). This sheet allows the user to characterize the monthly production curve of each green forage produced by the farm by entering the monthly percentage of the total gross yield entered in E.10.

Two methods are possible, which provide the same result in terms of the forage quantity available each month.

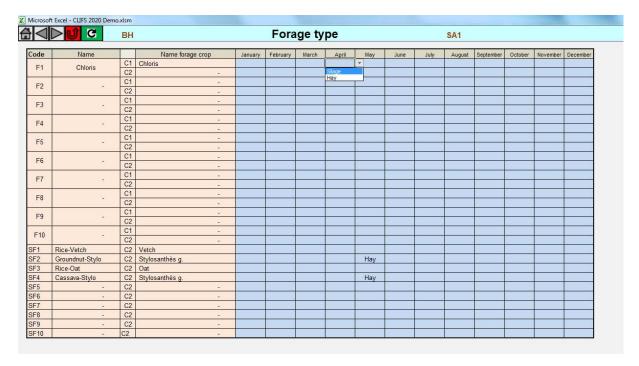
- Method 1 is based on the maximum monthly yield achievable during the production period (shown below): the user enters the percentage of the maximum yield achieved for a given month (i.e., 100% when the maximum yield is achieved, less otherwise).
- Method 2 is based on the monthly percentage of the total annual yield. In this case, the sum of the 12 percentage values must be equal to 100%.

Method 2 may appear easier, but it assumes that the user or the farmer knows how to distribute the annual forage production between the 12 months of the year.

**Warning!** The user must activate the Update button in order to make the names of forage crops included in the cropping pattern appear in the first column of the table before entering the yield values.



#### E.13. Forage type

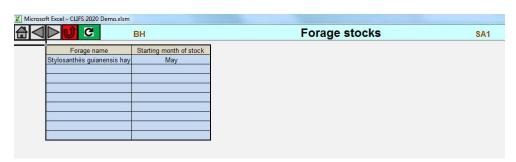


Green forage can be processed and stored as hay or silage, which is a way to carry forward green forage production from one period of the year to another.

This sheet allows the user to select the green forage, the month and the type of processed forage among the green forage crops entered in E.9.2 and displayed here.

**Warning!** The entire production of the green forage and month selected will be processed into hay or silage and will be added to the corresponding stock.

#### E.14. Forage stocks



For calculation reasons (circular reference), the user also must indicate on this sheet the month when the corresponding stock starts. It is usually the first month of hay/silage production, knowing that hay or silage can be produced over several months during the production period of the corresponding green forage.



#### E.15. Purchase prices of crop inputs



All of the inputs used in the scenario (E.10) plus the staple foods mentioned in E.9.1. appear in the tables displayed on this sheet in order for the user to enter their unit price (u.p.). These prices will be used to calculate (i) the costs attached to the quantities of inputs used and (ii) the quantity of staple food to be bought in case of a deficit between the family's needs and the corresponding crop supply (Eq.24).

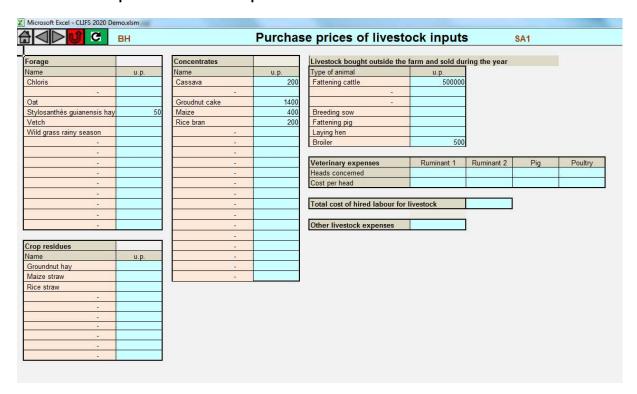
Irrigation water can be priced according to three modes prevailing in the irrigation sector: (i) per m³ only, in relation with the quantities of water to be entered in E.10. (ii) per ha only, in relation with the area of the block entered in E.9.2., and (iii) binomial with a component per ha and the other per m³. According to the selected mode, the user enters a price respectively per m³ only (i), per ha only (ii), or per m³ and per ha.

*Nota bene*: entering prices is not compulsory and depends on the existence of a market dedicated to the input considered in the area where the farm is located. For instance, in the example above no value is given to organic fertilisers, which reflects an absence of commercial exchanges for these products. However, free exchanges may occur.

**Warning!** The price per unit values entered in E.15, E.16. and E.18. must correspond to the units of quantity used in the previous sheets (see also B.2).



#### E.16. Purchase prices of livestock inputs



This sheet dedicated to livestock inputs is similar to the previous one dedicated to crops. Forage and residues are not systematically associated with a price, depending on the existence of local markets.

The purchase prices of bought animals (fattening cattle, pig and poultry) can be limited to the types actually purchased in the scenario, or extended to all of the types mentioned in E.6. and E.7. since their inclusion in the economic results of the farm will depend on the quantity bought entered in these two sheets.

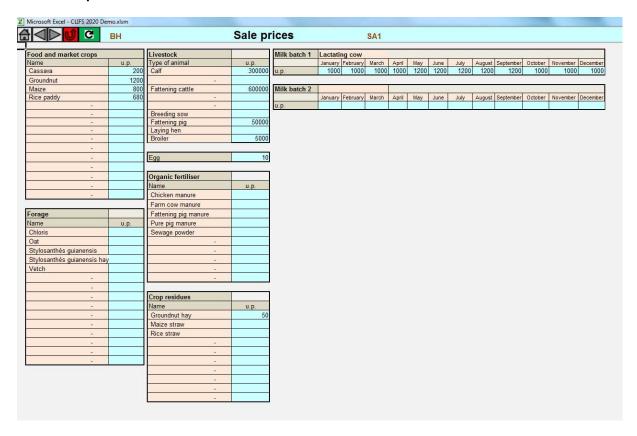
#### E.17. Fixed costs



This sheet lists all of the fixed costs to be included in the farm scenario. Names are selected from the list defined in D.8. and the total costs are entered for the whole year.



#### E.18. Sale prices



This sheet recapitulates all of the outputs produced by the farm that may be sold assuming there is a market for them. The user is free to enter a value or not depending these local marketing conditions.

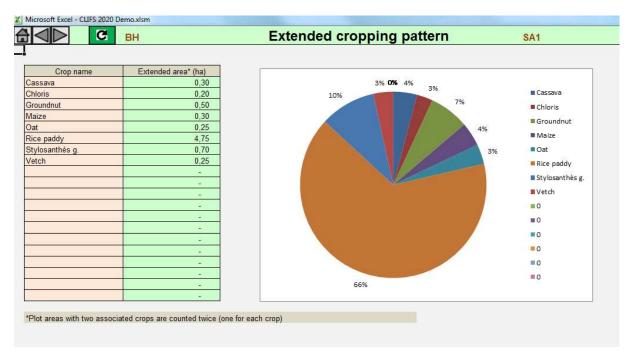
Milk is valued only if it is sold to a buyer (dairy, retailer, consumer) and not when it is consumed by suckling livestock. Its price per liter is entered monthly in order to take into account seasonal price variations. This allows scenarios to be designed which try to increase the share of milk produced during high price periods by modifying the distribution of births over the year and the diets and crop rotation accordingly.



# F. Results sheets

The green coloured sheets provide all of the results calculated by CLIFS that have not already been presented in any blue coloured sheet. The result tables can be copied for transfer to other Excel files for further processing (e.g., scenario comparison).

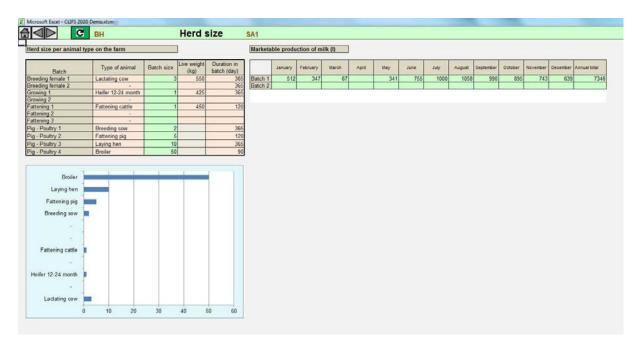
# F.1. Extended cropping pattern



This sheet displays the cropping pattern characterized in E.9.2. by considering that each block area bearing two crops will be counted twice (extended cropping pattern). The circle chart then provides a visual representation of the distribution of the cultivated area between crops for the simulated scenario.

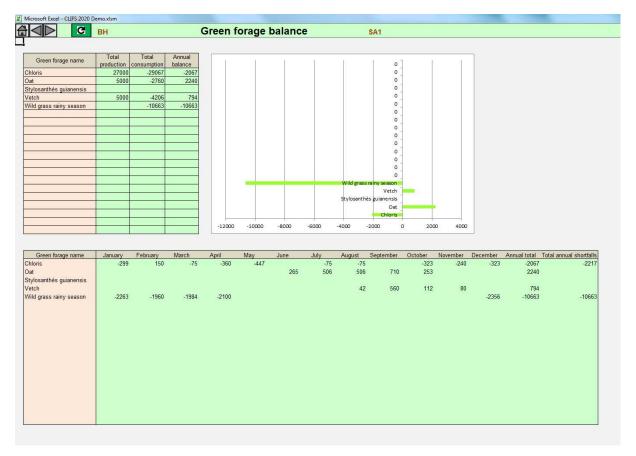


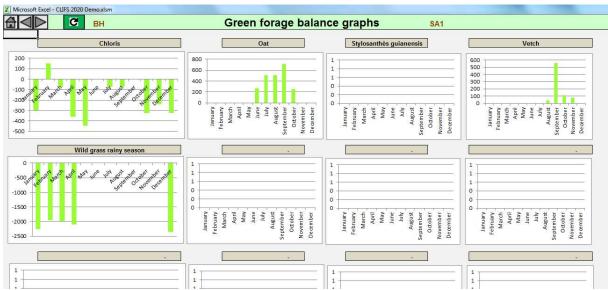
#### F.2. Herd size



This sheet recapitulates the characteristics of the 11 livestock batches potentially present on the farm, with their animal type, size and duration on the farm, plus the monthly marketable production of milk.

# F.3. Green forage balance





This sheet provides the annual and monthly balances for each green forage included in the diets of the various animal batches on the farm (Eq.19). The results are displayed in both tables and graphs, annually and monthly.

A positive balance indicates a surplus that can be marketed if a sale price is mentioned by the user (E.18). Otherwise, the diets can be changed in order to make use of these surpluses in the various batches to increase milk or meat production.



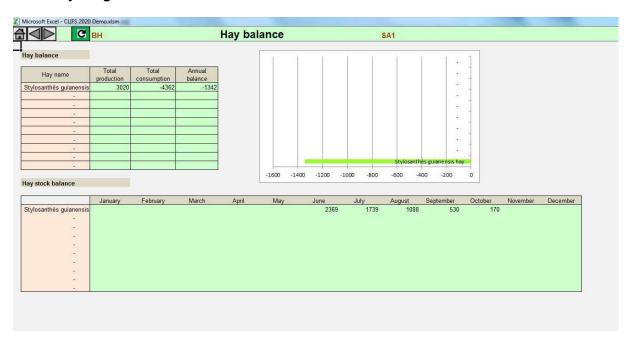
A negative balance indicates that the farmer has to find the missing quantities, either by receiving this as a gift from another farmer or by purchasing them (assuming a purchase price is entered in E.16, which means that such forage can be found on the local market). Otherwise, the diets must be adjusted by reducing the quantities delivered to the various batches.

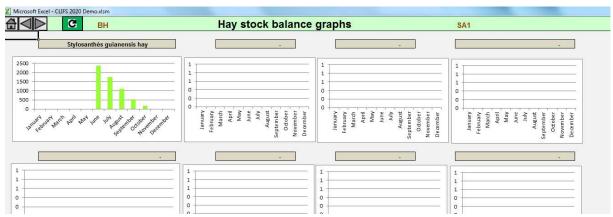
Nota-bene 1: CLIFS considers that an excess of green forage produced in a given month cannot be carried forward to the following month. Therefore, **balances have to be analyzed monthly**, especially since a positive or negative annual balance may include monthly surpluses or deficits. Monthly graphs are particularly useful in this respect. CLIFS therefore calculates both the annual balance between the total production and the total consumption, and the sum of all the monthly deficits which can be higher than the annual balance (Eq.19). This second variable is used to calculate the corresponding expense in the case that forage is purchased (Eq.24).

Nota-bene 2: In the example below, Stylosanthès guianiensis appears without any production or consumption since its production is totally processed in hay (E.13.).



#### F.4. Hay/Silage balance





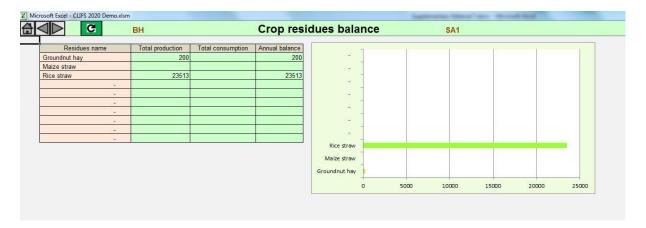
The 'Hay balance' sheet provides (i) the annual balance of each hay forage defined by the user in E.13 & E.14, and (ii) the evolution of stock by deducting each month its consumption based on the diets supplied to the various batches and by adding extra production when another month of hay production has been defined in E.13 (Eq.20). Monthly negative values are not presented since they are unrealistic. However, the user can identify the month when the stock is null and evaluate the deficit with the annual balance.

Similar sheets, calculations and graphs are included for silage forages in the 'Silage balance' and 'Silage balance graphs' sheets.

*Nota bene*: The stock calculation starts the month after the harvest month (for example, in June if the harvest took place in May) and includes the forage consumed by livestock during the harvest month.

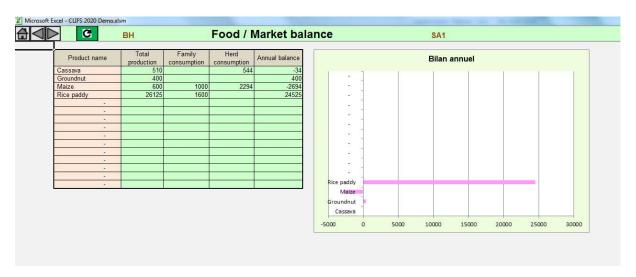


#### F.5. Crop residues balance



CLIFS calculates the annual balance for each crop residue produced and consumed on the farm (Eq.21). The residues potentially available given the cropping pattern of the farm are listed in the first column even if they are not produced or consumed, such as the maize straw in the following example.

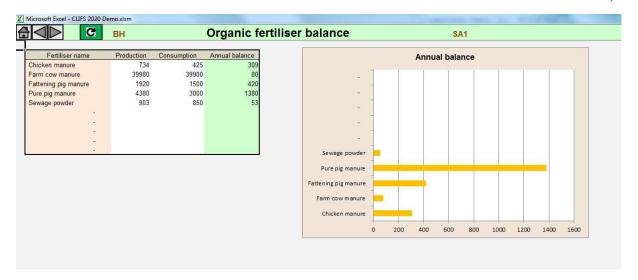
#### F.6. Food/market balance



These annual balances concern all of the food and market crops cultivated on the farm (Eq.22). These productions are used to feed the family and, for some of the crops, the livestock. A positive balance can be sold assuming a sale price has been entered in E.18. A negative balance can lead to a purchase if a purchase price has been entered in E.15., or to a reduction in livestock diets which will impact animal production.

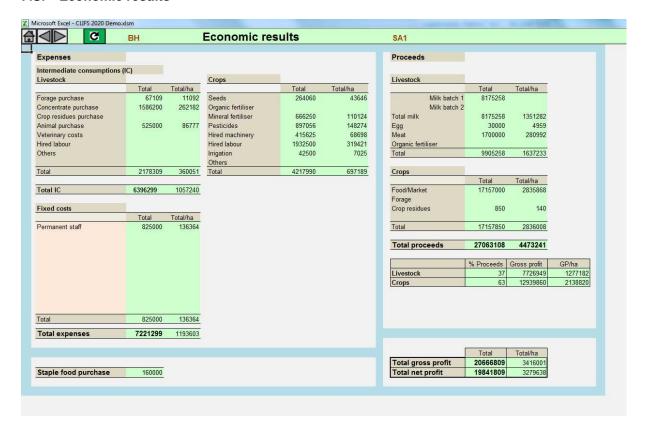
#### F.7. Organic fertiliser balance





This balance compares the production and consumption of each organic fertiliser produced on the farm with the animal dejections (Eq.23). A surplus may eventually be sold assuming a sale price is entered (E.15). But it can also lead to larger quantities being applied to each crop block, and better corresponding yields as estimated by the farmer and the user. A deficit requires a decrease in the amount applied per ha and a corresponding reduction in yields.

#### F.8. Economic results



This last 'Results' sheet displays the economic results resulting from the scenario configuration. A basic structure has been chosen, which does not take into account the diversity of accounting rules and economic indicators at the farm level that can be found in various contexts. Indeed, these calculations aim essentially to provide the user and his/her target audience the economic trends of each scenario when comparing the scenarios.

The results therefore are usually split into three categories: expenses, proceeds and profits. Expenses and proceeds are presented separately for crops and livestock. Moreover, expenses are divided into intermediate consumption, corresponding to the inputs used for productions, and fixed costs as entered in E.17. The total gross profit and the net profit are then calculated.

All results are presented in total and per ha, without any monetary unit as mentionned in B.2.

#### F.8.1. Expenses

Two kinds of expenses are considered: (i) expenses directly linked to input use or animal purchase, and (ii) expenses linked to negative balances of biomass produced on the farm (forage, crop residues, food crop, and organic fertiliser). All of them lead to a cost assuming a purchase price has been entered in E.15 and E.16. (Eq.24).

#### F.8.2. Proceeds

CLIFS calculate proceeds **only for productions sold outside the farm**. Production consumed either by the family or by the livestock are not taken into account. Consequently, the gross and net profits calculated correspond to the cash generated by each simulated scenario. Should the farmer includes his/her salary in expenses it will be entered in the fixed costs. Otherwise, his/her labour will be remunerated from the profits.



Farm productions can then be classified according to the table below. Each proceed equals the marketable volume (**if positive**) multiplied by the product's sale price per unit (E.18). This price is positive if the product is marketable or null if it is not sold outside the farm, either because there is no market for it or because it is only dedicated to farm/family consumption (Eq.25).

Type of production	Family / Crop	Animal	Marketable <sup>1</sup>	Sale price per unit
	consumption	Consumption		applied to
Milk (dairy)	X	X	X	Milk volume
Milk (suckler)		Х		0
Livestock				_
sold			X	Livestock head
kept				0
Egg				_
sold			X	Egg unit
consumed only	X			0
Organic fertiliser				
marketable	X		X	Manure weight
not marketable	X			0
Food/Market				_
marketable	X	Χ	X	Crop weight
not marketable	X			0
Forage				
marketable <sup>2</sup>		Χ	X	Forage weight
not marketable		Х		0
Crop residue				
marketable		X	X	Residue weight
not marketable		Χ		0

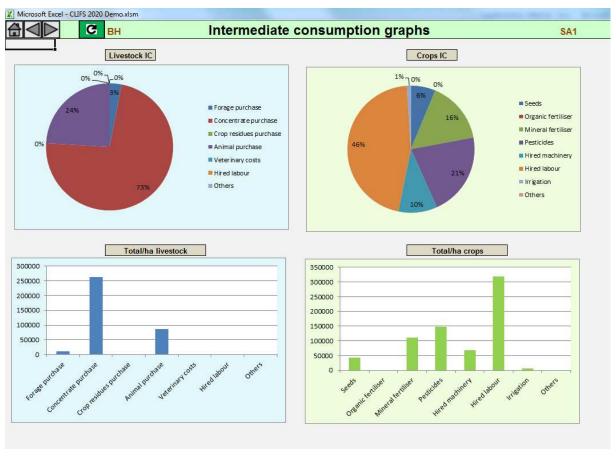
<sup>&</sup>lt;sup>1</sup>Existence of a market for the corresponding product (Mk)

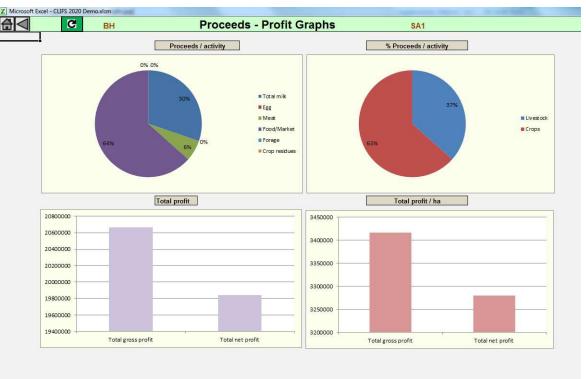
#### F.8.3. Profits

Gross profits are calculated separetely for crop and livestock activities and then for the whole farm. Fixed expenses are deducted from this total to calculate the net profit of the simulated scenario (Eq.26).

<sup>&</sup>lt;sup>2</sup>Green, hay, silage forage

#### F.9. Economic graphs





CLIFS provides two series of graphs respectively for intermediate consumption and for proceeds and profits, knowing that the user can copy all of the results and make his/her own graphs on Excel or another software if requested.

# **G.** Appendix

The appendix provides the complete list of equations used in CLIFS to conduct its calculations.

The definitions of indexes used in the equations are given in G.1.

Equations are presented in G.2 in the order they appear in the manual with the variables they use.

#### G.1. Index definition

The following table provides the signification of indexes used in the variables and equations described in G.2.

1. 1.	0115
Index	Signification
а	Animal type
b	Livestock batch
b*	Livestock sub-batch (for manure production)
С	Concentrate
cf	Farm concentrate
d	Pesticide
е	Type of fixed cost
f	Green forage (crop and corresponding forage)
g	Month after fertilisation [1,9]*
h	Hay forage
i	Mineral fertiliser
k	Month after birth [1 to 12]*
1	Crop block
m	Calendar month [January to December]
0	Crop**
р	Food/market crop
r	Crop residue
S	Silage forage
и	Manure
W	Hired labour
X	Excreta
У	Hired machinery

<sup>\*</sup> For cows only

<sup>\*\*</sup> Used for identical variables for food/market and forage crops



#### G.2. List of equations

# Eq.1. Conversion ratio of green yield into hay and silage yields

$$Conv_{f,h} = DM_f \div DM_h$$

$$Conv_{f,s} = DM_f \div DM_s$$

Variable	Signification	CLIFS sheet
$Conv_{f,h}$	Conversion biomass ratio between green forage <i>f</i> and hay forage <i>h</i>	Crop name
$Conv_{f,s}$	Conversion biomass ratio between green forage <i>f</i> and silage forage <i>s</i>	Crop name
$DM_f$	Dry matter green forage f (g/kg)	Feed contents
$DM_h$	Dry matter hay forage h (g/kg)	Feed contents
$DM_s$	Dry matter silage forage s (g/kg)	Feed contents

#### Eq.2. NPK content of a created organic fertiliser

$$Q_{-}N_{u} = (Q_{-}N_{x} \times \%Exc_{x,u} + Q_{-}N_{r} \times \%Res_{r,u}) \div 100$$

$$Q_{-}N_{u} = (Q_{-}P_{x} \times \%Exc_{x,u} + Q_{-}P_{r} \times \%Res_{r,u}) \div 100$$

$$Q_{-}K_{u} = (Q_{-}K_{x} \times \%Exc_{x,u} + Q_{-}K_{r} \times \%Res_{r,u}) \div 100$$

$$\%Res_{r,u} = 100 - \%Exc_{x,u}$$

Variable	Signification	CLIFS sheet
$Q_N_u$ ; $Q_P_u$ ; $Q_K_u$	Quantity of respectively N, P K for manure <i>u</i> (kg/ton DM)	Create an organic fertiliser
$Q\_N_x$ ; $Q\_P_x$ ; $Q\_K_x$	Quantity of respectively N, P K for excreta <i>x</i> (kg/ton DM)	NPK content of fertilisers
$Q\_N_r$ ; $Q\_P_r$ ; $Q\_K_r$	Quantity of respectively N, P K for crop residue <i>r</i> (kg/ton DM)	Crop NPK content
$\%Exc_{x,u}$	Proportion of excreta x in manure u (%)	Create an organic fertiliser
$\%Res_{r,u}$	Proportion of crop residue $r$ in manure $u$ (%)	Create an organic fertiliser

#### Eq.3. Dry matter and feed value of a created concentrate

$$DM_{cf} = (\sum_{c} DM_{c} \times Q_{c,cf}) \div 100$$

$$EN_{cf} = (\sum_{c} EN_{c} \times Q_{c,cf}) \div 100$$

$$NI_{cf} = (\sum_{c} NI_{c} \times Q_{c,cf}) \div 100$$

Variable	Signification	CLIFS sheet
$DM_{cf}$	Dry matter of farm concentrate cf (g/kg)	Create a feed concentrate
$EN_{cf}$	Energy content of farm concentrate cf	Create a feed concentrate
$Ni_{cf}^{*}$	Protein content of farm concentrate cf	Create a feed concentrate
$Q_{c,cf}$	Quantity of concentrate c in farm concentrate cf (kg/100 kg)	Create a feed concentrate
$DM_c$	Dry matter of concentrate c (g/kg)	Feed contents
$En_c$	Energy value of concentrate <i>c</i> per kg of dry matter	Feed contents
Ni <sub>c</sub>	Protein value of concentrate <i>c</i> per kg of dry matter	Feed contents

<sup>\*</sup>Two equations in the French system (PDIE and PDIN)



$$Cost\_U_{cf} = (\sum_{c} Cost\_U_{c} \times Q_{c,cf}) \div 100$$

$$Cost\_EN_{cf} = Cost\_U_{cf} \div EN_{cf}$$

$$Cost\_NI_{cf} = Cost\_U_{cf} \div NI_{cf}$$

Variable	Signification	CLIFS sheet
$Cost\_U_{cf}$	Cost per kg of farm concentrate cf	Create a feed concentrate
$Cost\_EN_{cf}$	Cost per energy unit of farm concentrate cf	Create a feed concentrate
$Cost_NI_{cf}^*$	Cost per protein unit of farm concentrate cf	Create a feed concentrate
$Cost_{-}U_{c}$	Cost per kg of concentrate c	Purchase prices of livestock inputs

<sup>\*</sup>Only for PDIN in the French system

#### Eq.5. Lactation curve of the average female per batch

$$\begin{aligned} &\text{IF } k \leq Lact\_Peak_b \\ &\text{THEN } Milk_{b,k} = a1_b \times k + \ b1_b \\ &\text{IF } k > Lact\_Peak_b \\ &\text{THEN } Milk_{b,k} = a2_b \times k + \ b2_b \end{aligned}$$

With:

$$a1_b = (Milk\_Peak_b - Milk\_Start_b) \times 30 \div (Lact\_Peak_b - 1)$$

$$b1_b = Milk\_Start_b \times 30 - a1_b$$

$$a2_b = (Milk\_End_b - Milk\_Peak_b) \times 30 \div (Dur\_Lact_b - Lact\_Peak_b)$$

$$b2_b = Milk\_Peak_b \times 30 - a2_b \times Lact\_Peak_b$$

Variable	Signification*	CLIFS sheet
Dur_Lact <sub>b</sub>	Duration of lactation (months)	Milk production target batch 1 & 2
$Dur\_Dry_b$	Duration of drying-off (months)	Milk production target batch 1 & 2
$Lact\_Peak_b$	Month after birth of lactation peak	Milk production target batch 1 & 2
$Milk\_Start_b$	Production of milk at lactation start (I)	Milk production target batch 1 & 2
Milk_Peak <sub>b</sub>	Production of milk at lactation peak (I)	Milk production target batch 1 & 2
$Milk\_End_b$	Production of milk at the end of lactation (I)	Milk production target batch 1 & 2

<sup>\*</sup>All variables concern the average female of batch b

#### Eq.6. Total targeted milk production per lactation of the average female

$$Milk\_Lact_b = \sum_{k=1}^{12} Milk_{b,k}$$

Variable	Signification	CLIFS sheet
$Milk_{b,k}$	Quantity of milk produced daily by the average animal for the month <i>k</i> after birth (liter)	Milk production target batch 1 & 2
Milk_Lact <sub>b</sub>	Total targeted milk production for the lactation of the average female (liter)	Milk production target batch 1 & 2

# Eq.7. Number of females per batch

$$n\_fem_b = \left(\sum_{m=Iv}^{Dc} n\_birth_{m,b}\right) \div Av\_Birth_b$$

Variable	Signification	CLIFS sheet
$n\_birth_{m,b}$	Number of birth during month m	Milk production target batch 1 & 2
$Av\_Birth_b$	Average number of birth per reproducing female of batch <i>b</i>	Milk production target batch 1 & 2
$n\_fem_b$	Number of reproducing females of batch b	Milk production target batch 1 & 2

# Eq.8. Targeted milk production per batch

$$Milk\_Tgt\_D_{b,m} = \sum_{k=1}^{12} n\_fem_{b,m,k} \times Milk_{b,k}$$

$$\mathit{Milk\_Tgt\_D\_fem}_{b,m} = \mathit{Milk\_Tgt\_D}_{b,m} \div n\_\mathit{fem}_b$$

$$Milk\_Tgt\_M_{b,m} = Milk\_Tgt\_D_{b,m} \times Day_m$$

$$Milk\_Tgt\_A_b = \sum_{m=1}^{12} Milk\_Tgt\_M_{b,m}$$

Variable	Signification	CLIFS sheet
variable	<u> </u>	CLIFS SHEEL
$Milk\_Tgt\_D\_fem_{b,m}$	Daily average targeted milk production per	
	reproducing female of batch b during month	Milk production target batch 1 & 2
	m	
$Milk\_Tgt\_D_{b,m}$	Daily targeted milk production of batch <i>b</i> for month <i>m</i>	Milk production target batch 1 & 2
$Milk\_Tgt\_M_{b,m}$	Monthly targeted milk production of batch <i>b</i> for month <i>m</i>	Milk production target batch 1 & 2
$Milk\_Tgt\_A_b$	Annual targeted milk production of batch b	Milk production target batch 1 & 2
$n\_fem_{b,m,k}$	Number of reproducing females of batch <i>b</i> at month <i>k</i> after parturition during calendar month <i>m</i>	Not displayed
$Day_m$	number of days of month m	Not displayed



#### Eq.9. Monthly forage saturation due to the diet

#### Eq.9.1. Daily feed intake capacity for the average cow of batch b

$$FIC_{b,k} = 13.9 + 1.5 \times (LW_b - 600)/100 + 0.15 \times Milk_{b,k}$$

Variable	Signification	CLIFS sheet
$FIC_{b,k}$	Daily feed intake capacity for the average cow of batch <i>b</i> during month <i>k</i> after parturition (kg)	Not displayed
$LW_b$	Live weight of the average cow of batch b (kg)	Milk production from diet 1 & 2

#### Eq.9.2. Total daily feed intake capacity of batch b for month m (kg)

$$FIC\_tot_{b,m} = \sum_{k=1}^{12} n\_fem_{b,m,k} \times FIC_{b,k}$$

Variable	Signification	CLIFS sheet
$FIC\_tot_{b,m}$	Total daily feed intake capacity of the batch $b$ for month $m$ (kg)	Not displayed

# Eq.9.3. Total ballast (kg) of batch b due to the daily diet delivered each month m to the average cow

# > INRA

$$Ball\_tot_{b,m} = (\sum_{f} Q_{f,m,b} \times Ball_{f} \times DM_{f} \div 1000) \times n\_fem_{b}$$
Variable

Variable	Signification	CLIFS sheet
$Ball\_tot_{b,m}$	Total ballast of batch b for month m	Not displayed
$Q_{f,m,b}$	Quantity of forage <i>f</i> provided daily per female during month <i>m</i> for batch <i>b</i> (kg green matter)	Milk production from diet 1 & 2
Ball <sub>f</sub>	Ballast value of forage f (VEF; see D.2)	Feed contents
$DM_f$	Dry matter of forage f (g per kg green matter)	Feed contents

#### > NRC

$$Ball\_tot_{b,m} = (\sum_{f} Q_{f,m,b} \times DM_{f} \div 1000) \times n\_fem_{b}$$

### Eq.9.4. Monthly percentage of forage saturation (%)

$$\%FS_{b,m} = 100 \times Ball\_tot_{b,m} \div FIC\_tot_{b,m}$$

Variable	Signification*	CLIFS sheet
$\%FS_{b,m}$	Percentage of forage saturation for month <i>m</i> in batch <i>b</i>	Milk production from diet 1 & 2

<sup>\*</sup>If  $\%FS_{b,m} > 100$  the simulated diet is physiologically not correct. Then CLIFS highlights the corresponding cell in red. The user can discuss the issue with the farmer in order to respect this threshold by changing the diet.



# Eq.10. Energy and proteins requirements of lactating cows

Eq.10.1. Daily maintenance requirements for the average cow of batch b1

	INRA	NRC
$EMR_b$	$5 + ((LW_b - 600) \div 100) \times 0.6$	$0.079 \times LW_b^{0.75}$
$NIMR_b$	$395 + ((LW_b - 600) \div 100) \times 50$	$3.8 \times LW_b^{0.75}$

<sup>&</sup>lt;sup>1</sup> LW is considered as constant throughout the year.

Variable	Signification	CLIFS sheet
$EMR_b$	Energy requirement for the daily maintenance of the average cow of batch <i>b</i>	Not displayed
$NIMR_b$	Protein requirement for the daily maintenance of the average cow of batch <i>b</i>	Not displayed

# Eq.10.2. Pregnancy requirements

The daily pregnancy requirements for the average cow of batch *b* are calculated according to the following equations (INRA and NRC systems):

	INRA	NRC
$EPR\_D_{b,g}$	$0.00072 \times CBW_b \times e^{(0.116 \times g \times 4.33)}$	g<7:0 $g$ >6: $(0.00318 \times DAF_a - 0.0352) \times (CBW_b \div 45) \div 0.218$
$NIPR\_D_{b,g}$	g<7: 0 g =7: 0.18 × NIMR <sub>b</sub> g=8: 0.33 × NIMR <sub>b</sub> g=9: 0.50 × NIMR <sub>b</sub>	$g$ <8: 0 $g$ >7: $((0.69 \times DAF_g) - 69.2) \times (CBW_b \div 45) \div 0.33$

Variable		Signification					С	LIFS shee	t
$EPR\_D_{b,g}$		Daily energy requirement for gestation of the average cow of batch <i>b</i> according to its month after fertilisation <i>g</i>					No	ot displaye	d
$NIPR\_D_{b,g}$		Daily protein requirement for gestation of the average cow of batch <i>b</i> according to its month after fertilisation <i>g</i>					No	ot displaye	d
$CBW_b$		Calf Birth W	eight for b	atch <i>b</i> (kg)	)		Milk produc	ction from	diet 1 & 2
$DAF_g$		Day after fertilisation (day number; see table below)					No	ot displaye	d
g	1	2	3	4	5	6	7	8	9
$\mathit{DAF}_g$	15	45	75	105	135	165	200	230	260



The total daily requirements for batch b are then calculated according to the various gestation stages g of the  $n_{-}fem_{b}$  cows of the batch b:

$$\begin{split} n\_fem\_Gest_{b,m,g} &= n\_fem_{b,m,g+ICF_b} \\ EPR_{b,m} &= \sum_{g=1}^{9} EPR\_D_{b,g} \times n\_fem\_Gest_{b,m,g} \\ NIPR_{b,m} &= \sum_{g=1}^{9} NIPR\_D_{b,g} \times n\_fem\_Gest_{b,m,g} \end{split}$$

Variable	Signification	CLIFS sheet
$EPR_{b,m}$	Total daily energy requirement for gestation of batch $b$ during month $m$	Not displayed
$NIPR_{b,m}$	Total daily protein requirement for gestation of batch <i>b</i> during month <i>m</i>	Not displayed
$n\_fem\_Gest_{b,m,g}$	Number of cows of batch $b$ at $g^{th}$ month of gestation during month $m$	Not displayed
$ICF_b$	Interval Calving - Fertilisation for the average cow of batch <i>b</i> (months)	Milk production from diet 1 & 2

Eq.10.3. Production requirements for one liter of milk

-	INRA	NRC
Energy	0.44	0.699
Protein	48	0.05



#### Eq.11. Daily energy and protein supplied by the monthly diet

The daily energy and protein<sup>6</sup> provided each calendar month m by the daily diet delivered to the average cow of batch b are calculated based on the following steps.

#### Eq.11.1. Forage per cow

$$\begin{split} ENF_{b,m} &= (\sum_{f} Q_{f,m,b} \times En_{f} \times DM_{f} \div 1000) \\ NIF_{b,m} &= (\sum_{f} Q_{f,m,b} \times Ni_{f} \times DM_{f} \div 1000) \end{split}$$

Variable	Signification	CLIFS sheet
$ENF_{b,m}$	Total daily amount of energy provided to the average cow calendar month $m$ by the forages supplied in the diet of batch $b$	Not displayed
$NIF_{b,m}$	Total daily amount of protein provided to the average cow calendar month $m$ by the forages supplied in the diet of batch $b$	Not displayed
$En_f$	Energy value of forage f per kg of dry matter	Feed contents
$Ni_f$	Protein value of forage f per kg of dry matter	Feed contents

#### Eq.11.2. Concentrates per cow

$$ENC_{b,k} = (\sum_{c} Q_{-}fem_{c,k,b} \times En_{c} \times DM_{c} \div 1000)$$

$$NIC_{b,k} = (\sum_{c} Q_{-}fem_{c,k,b} \times Ni_{c} \times DM_{c} \div 1000)$$

Variable	Signification	CLIFS sheet
$ENC_{b,k}$	Total daily amount of energy provided to the average cow month <i>k</i> after calving by the concentrates supplied in the diet of batch <i>b</i>	Not displayed
$NIC_{b,k}$	Total daily amount of protein provided to the average cow month <i>k</i> after calving by the concentrates supplied in the diet of batch <i>b</i>	Not displayed
$Q\_fem_{c,k,b}$	Quantity of concentrate <i>c</i> provided daily per reproductive female during month <i>k</i> after parturition for batch <i>b</i> (kg raw material)	Milk production from diet 1 & 2
$En_c$	Energy value of concentrate <i>c</i> per kg of dry matter	Feed contents
$Ni_c$	Protein value of concentrate <i>c</i> per kg of dry matter	Feed contents

\_

<sup>&</sup>lt;sup>6</sup> In the INRA system the "NI" equations described here are doubled for PDIN and PDIE.



$$\begin{split} & \succ \mathsf{Energy} \\ & \mathit{ENF\_tot}_{b,m} = \mathit{ENF}_{b,m} \times \mathit{n\_fem}_b \\ & \mathit{ENC\_tot}_{b,m} = \sum_{k=1}^{12} \mathit{n\_fem}_{b,m,k} \times \mathit{ENC}_{b,k} \end{split}$$

$$EN\_tot_{b,m} = ENF\_tot_{b,m} + ENC\_tot_{b,m}$$

$$\begin{split} NIF\_tot_{b,m} &= NIF_{b,m} \times n\_fem_b \\ NIC\_tot_{b,m} &= \sum_{k=1}^{12} n\_fem_{b,m,k} \times NIC_{b,k} \\ NI\_tot_{b,m} &= NIF\_tot_{b,m} + NIC\_tot_{b,m} \end{split}$$

Variable	Signification	CLIFS sheet
$ENF\_tot_{b,m}$	Total daily amount of energy provided by forage to batch <i>b</i> during month m	Not displayed
$ENC\_tot_{b,m}$	Total daily amount of energy provided by concentrate to batch <i>b</i> during month <i>m</i>	Not displayed
$EN\_tot_{b,m}$	Total daily amount of energy provided to batch <i>b</i> during month <i>m</i>	Not displayed
$NIF\_tot_{b,m}$	Total daily amount of protein provided by forage to batch <i>b</i> during month m	Not displayed
$NIC\_tot_{b,m}$	Total daily amount of protein provided by concentrate to batch <i>b</i> during month <i>m</i>	Not displayed
$NI\_tot_{b,m}$	Total daily amount of protein provided to batch <i>b</i> during month <i>m</i>	Not displayed





□ At first CLIFS calculates the total energy and protein available daily to the batch for producing milk by deducting the maintenance and gestation requirements from the total energy and protein supplied daily by the diet each given month.

$$ENM\_tot_{b,m} = EN\_tot_{b,m} - (EMR_b \times n\_fem_b) - EPR_{b,m}$$
  
 $NIM\_tot_{b,m} = NI\_tot_{b,m} - (NIMR_b \times n\_fem_b) - NIPR_{b,m}$ 

Variable	Signification	CLIFS sheet
$ENM\_tot_{b,m}$	Total energy available for daily milk production of batch <i>b</i> during month <i>m</i>	Not displayed
$NIM\_tot_{b,m}$	Total protein available for daily milk production of batch <i>b</i> during month <i>m</i>	Not displayed

☐ Then CLIFS transforms energy and protein available daily for milk production into milk according to the two feed systems.

	INRA	NRC
Energy Milk_D_E <sub>b,m</sub>	$\textit{ENM\_tot}_{b,m} \div 0.44$	$ENM\_tot_{b,m} \div 0.699$
Protein $Milk_D_N_{b,m}$	$NIM\_tot_{b,m} \div 48$	$NIM\_tot_{b,m} \div 0.05$

☐ The milk production allowed by the diet is equal to the minimum of these two values. And the effective milk production of the batch is equal to the minimum of this value and the corresponding targeted value for each given month.

$$\begin{split} &\textit{Milk\_D\_Diet}_{b,m} = \text{Min } (\textit{Milk\_D\_E}_{b,m}, \textit{DMilk\_D\_N}_{b,m}) \\ &\textit{Milk\_D}_{b,m} = \text{Min } (\textit{Milk\_D\_Diet}_{b,m}, \textit{Milk\_Tgt\_D}_{b,m}) \\ &\textit{Milk\_D\_fem}_{b,m} = \textit{Milk\_D}_{b,m} \div \textit{n\_fem}_{b} \end{split}$$

Variable	Signification	CLIFS sheet
$Milk\_D\_fem_{b,m}$	Average daily milk production per cow of batch <i>b</i> during month <i>m</i>	Milk production from diet 1 & 2
$Milk\_D_{b,m}$	Daily milk production of batch b during month m	Milk production from diet 1 & 2
$Milk\_D\_Diet_{b,m}$	Daily milk production of batch <i>b</i> allowed by diet supplied during month <i>m</i>	Milk production from diet 1 & 2
$Milk\_D\_E_{b,m}$	Daily milk production of batch <i>b</i> allowed by energy supply during month <i>m</i>	Milk production from diet 1 & 2
$Milk\_D\_N_{b,m}$	Daily milk production of batch <i>b</i> allowed by protein supply during month <i>m</i>	Milk production from diet 1 & 2

☐ Two others variables are added to the table.

$$\label{eq:distance} \begin{split} \% Diet\_Target_{b,m} &= 100 * Milk\_D\_Diet_{b,m} \div Milk\_Tgt\_M_{b,m} \\ Milk\_D\_fem_{b,m} &= Milk\_D_{b,m} \div n\_fem_b \end{split}$$

Variable	Signification	CLIFS sheet	
$%Diet\_Target_{b,m}$	Ratio between the milk production from the diet and the target one	Milk production from diet 1 & 2	
$Milk\_D\_fem_{b,m}$	Daily average milk production per reproducing female of batch <i>b</i> during month <i>m</i>	Milk production from diet 1 & 2	

# Eq.13. Marketable milk production

$$\begin{split} \mathit{Milk\_D\_Suck}_{b,m} &= \sum_{k=1}^{6} \mathit{Milk\_Suck}_{k} \times \mathit{n_{fem}}_{b,m,k} \times \mathit{Av_{Birth}}_{b} \times \%\mathit{Young\_Kept}_{k} \div 100 \\ \mathit{Milk\_D\_Sale}_{b,m} &= \mathit{Milk\_D}_{b,m} - \mathit{Milk\_D\_Suck}_{b,m} - \mathit{Milk\_D\_Fam}_{b} \\ \mathit{Milk\_Sale}_{b,m} &= \mathit{Milk\_D\_Sale}_{b,m} \times \mathit{Day}_{m} \\ \mathit{Milk\_Sale}_{b} &= \sum_{m=Jn}^{Dc} \mathit{Milk\_Sale}_{b,m} \end{split}$$

Variable	Signification	CLIFS sheet
$Milk_D_Sale_{b,m}$	Daily amount of marketable milk month <i>m</i> for batch <i>b</i> (liter)	Milk consumption on the farm 1 & 2
$Milk\_Sale_{b,m}$	Monthly amount of marketable milk month <i>m</i> for batch <i>b</i> (liter)	Milk consumption on the farm 1 & 2
Milk_Sale <sub>b</sub>	Annual amount of marketable milk for batch <i>b</i> (liter)	Milk consumption on the farm 1 & 2
$Milk\_Suck_k$	Daily amount of suckled milk by one young month <i>k</i> after parturition (I/day)	Milk consumption on the farm 1 & 2
$%Young\_Kept_k$	Proportion of young kept month <i>k</i> after calving (%)	Milk consumption on the farm 1 & 2
$Milk\_D\_Suck_{b,m}$	Daily amount of suckled milk month <i>m</i> for batch <i>b</i> (I/day)	Not displayed
Milk_D_Fam <sub>b</sub>	Daily amount of milk consumed by family throughout the year (I/day)	Milk consumption on the farm 1 & 2

#### Eq.14. Growing and fattening ruminants



#### Eq.14.1. Targeted Average Daily Gain

$$ADG\_Tgt_{a,b} = (LW\_End_{a,b} - LW\_Start_{a,b}) \times 1000 \div Dur\_Grow_{a,b}$$

Variable	Signification	CLIFS sheet
$ADG\_Tgt_{a,b}$	Targeted average daily gain (g/day) for the average animal of batch b	Growing 1 & 2
$LW\_Start_{a,b}$	Initial Live weight (kg) of the average animal of batch b	Growing 1 & 2
$LW\_End_{a,b}$	Final live weigth (kg) of the average animal of batch b	Growing 1 & 2
$Dur\_Grow_{a,b}$	Growing duration (days) of batch b	Growing 1 & 2

CLIFS searches for the energy and protein requirements linked to  $ADG\_Tgt_{a,b}$  in the D.4 table corresponding to animal type a.

#### Eq.14.2. Diet-based Average Daily Gain

Monthly forage saturation  $\%FS_{b,m}$  is calculated as detailed in Eq.9.

Daily energy  $ENF_{b,m}$  and protein  $NIF_{b,m}$  supplied by the forage part of the diet to the average animal are calculated as detailed in Eq.11.

Daily energy  $ENC_{b,m}$  and protein  $NIC_{b,m}$  supplied by the concentrate part are calculated differently than for lactating cow since their supply depends only on calendar month:

$$ENC_{b,m} = (\sum_{c} Q_{c,m,b} \times En_{c} \times DM_{c} \div 1000)$$

$$NIC_{b,m} = (\sum_{c} Q_{c,m,b} \times Ni_{c} \times DM_{c} \div 1000)$$

Total energy  $EN\_An_{b,m}$  and protein  $NI\_An_{b,m}$  supplied by the diet to the average animal are then calculated as follows and displayed in the table at the bottom of the sheet.

$$EN\_An_{b,m} = ENF_{b,m} + ENC_{b,m}$$

$$NI\_An_{h.m} = NIF_{h.m} + NIC_{h.m}$$

CLIFS searches for the ADG corresponding to each couple per month  $\{EN\_An_{b,m} ; NI\_An_{b,m}\}$  in the table of animal type a filled in D.4 by proceeding as follows:

$$LW_Av_{a,b} = (LW_End_{a,b} - LW_{Start_{a,b}}) \div 2$$

$$ADG\_Diet_{a,b} = Min(ADG\_E_{a,b}[LW\_Av_{a,b}\,;\,EN\_An_{b,m}\,]; ADG\_N_{a,b}[LW\_Av_{a,b}\,;\,NI\_An_{b,m}\,])$$

Variable	Signification	CLIFS sheet
$ADG\_Diet_{a,b}$	Average daily gain (g/day) allowed by the diet for the average animal of batch b	Growing 1 & 2
$LW\_Av_{a,b}$	Average Live weight (kg) of the average animal of batch b*	Not displayed
$ADG\_E_{a,b}$	Average daily gain (g/day) allowed by the energy supply for the average animal of batch b	Not displayed
$ADG\_N_{a,b}$	Average daily gain (g/day) allowed by the protein supply for the average animal of batch b	Not displayed

<sup>\*</sup>for simplicity CLIFS does not consider the monthly increase of live weight throughout the growing period but takes only the average between its start and end.

## Eq.15. Manure production

# Eq.15.1. Daily production of excreta by one animal (ruminants only<sup>7</sup>)

$$QD\_Exc_{x,a,b*} = LW_{a,b*} \times 0.01 \div DM\_Exc_x$$

The coefficient '0.01' is based on the following assumptions:

- A ruminant eats 2.5% DM of its live weight
- The diet has an average digestibility of 60%
- The dried excreted quantities =  $LW_{a,b*} \times 0.025 \times (1 0.60)$

# Eq.15.2. Annual production of excreta by one animal of a sub-batch b\*

$$QY\_Exc_{x,a,b*} = QD\_Exc_{x,a,b*} \times Dur\_Stab_{a,b*} \times (HD\_Stab_{a,b*} \div 24)$$

#### Eq.15.3. Annual production of manure u of sub-batch b\*

$$Prod\_Manure_{u,b*} = QY\_Exc_{x,a,b*} \times n\_man_{a,b*} \times Conv\_Exc_{x,b*} \times ((100 - Loss\_Exc_{u,b*}) \div 100) \div ((100 - \%Exc_{x,u}) \div 100)$$

# Eq. 15.4. Annual quantity of residue required to produce $Prod_{\_}Manure_{u.b*}$

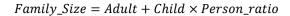
$$Q\_Man\_Res_{u,r,b*} = Prod\_Manure_{u,b*} \times (100 - \%Res_{r,u}) \div 100 \times (100 + Loss_{Exc_{u,b*}}) \div 100$$

Variable	Signification	CLIFS sheet
$Prod\_Manure_{u,b*}$	Annual quantity of manure <i>u</i> produced by batch <i>b</i> *	Manure production
$Q_{-}Man_{-}Res_{u,r,b*}$	Annual quantity of crop residue $r$ required to produce manure $u$ of batch $b^*$	Manure production
$QD\_Exc_{x,a,b*}$	Daily quantity of excreta $x$ produced by animal $a$ of batch $b^*$	Not displayed
$QY\_Exc_{x,a,b*}$	Annual quantity of excreta $x$ produced by animal $a$ of sub-batch $b^*$	Not displayed
$DM_{-}Exc_{x}$	Dry matter of excreta x	NPK content of fertilisers
$n\_man_{a,b*}$	Number of heads of animal a in batch b*	Manure production
$Dur\_Stab_{a,b*}$	Duration of stabling (days) of animal a in batch b*	Manure production
$HD\_Stab_{a,b*}$	Daily duration of stabling (hours) animal $a$ in batch $b^*$	Manure production
$Conv\_Exc_{x,b*}$	Conversion rate for excreta x in batch b*	Manure production
$Loss\_Exc_{u,b*}$	Loss rate (%) of manure <i>u</i> in batch <i>b</i> *	Manure production

-

<sup>&</sup>lt;sup>7</sup> For pig and poultry  $QD\_Exc_{x,a,b*}$  is directly entered and found in Table D.7.

# Eq.16. Family size



Variable	Signification	CLIFS sheet
Family_Size	Size of the family (adult-equivalent)	Not displayed
Adult	Number of adults ≥ 15 years of the family	Structure and cropping pattern
Child	Number of children < 15 years of the family	Structure and cropping pattern
Person_ratio	Equivalent Child/Adult	Structure and cropping pattern

#### Eq.17. Cropping pattern

$$Surf\_Tot\_Food = \sum_{l} Surf\_Food_{p,l} + \sum_{l} Surf\_Food\_Forage_{p,l} \div 2$$
 
$$Surf\_Tot\_Forage = \sum_{l} Surf\_Forage_{f,l} + \sum_{l} Surf\_Food\_Forage_{f,l} \div 2$$
 
$$Surf\_Tot = Surf\_Tot\_Food + Surf\_Tot\_Forage$$
 
$$\% Surf\_Tot\_Food = 100 * Surf\_Tot\_Food \div Surf_{Tot}$$
 
$$\% Surf\_Tot\_Forage = 100 * Surf\_Tot\_Forage \div Surf_{Tot}$$

Variable	Signification	CLIFS sheet
Surf_Tot	Total area of the farm (ha)	Structure and cropping pattern
Surf_Tot_Food	Total area of food/market crop (ha)	Structure and cropping pattern
Surf_Tot_Forage	Total area of forage crop ha)	Structure and cropping pattern
%Surf_Tot_Food	% of food /market crops	Structure and cropping pattern
%Surf_Tot_Forage	% of forage crops	Structure and cropping pattern
$Surf\_Food_{p,l}$	Area of food/market crop <i>p</i> block <i>l</i> <sup>1</sup>	Structure and cropping pattern
$Surf\_GF_{f,l}$	Area of green forage crop $f$ block $f$	Structure and cropping pattern
$Surf\_Food\_GF_{p,f,l}$	Area of food+forage $\{p,f\}$ crop block $f^3$	Structure and cropping pattern

These blocks can bear up to two food-market crops p

 $<sup>^2</sup>$  These blocks can bear up to two forage crops f

 $<sup>^{3}</sup>$  These blocks bear one food/market crop p and one forage crop f

### Eq.18. NPK balance



#### Eq.18.1. Exports per crop (kg/ha) (similar equations for P & K)

#### Food/market crop

$$\begin{aligned} & Export\_N_p = N\_Content_p \times (DM_p \div 1000) \times (Yield\_Target_p \div 1000) \\ & Export\_N_r = N\_Content_r \times (DM_r \div 1000) \times ((Yield\_Target_p \div 1000) \div Grain\_Res_{p,r}) \times \%Res_r \div 100 \\ & Export\_N_{p,r} = Export\_N_p + Export\_N_r \end{aligned}$$

#### > Forage crop

$$Export\_N_f = N\_Content_f \times (DM_f \div 1000) \times (Yield\_Target_f \div 1000)$$

#### > Total

$$Export\_Total\_N = \sum_{p} Export\_N_{p,r} + \sum_{f} Export\_N_{f}$$

Variable	Signification	CLIFS sheet
Export_Total_N	Total export of N (respectively P & K) for the combination of	NPK balance per crop
	crop <i>p</i> and crop forage <i>f</i> (kg/ha)	
$Export\_N_{p,r}$	Export of N (respectively P & K) for crop $p$ with residue $r$ (	NPK balance per crop
- ",	kg/ha)	
$Export\_N_f$	Export of N (respectively P & K) for forage crop f	NPK balance per crop
$Export\_N_p$	Export of N (respectively P & K) for crop p (kg/ha)	Not displayed
$Export\_N_r$	Export of N (respectively P & K) for residue r (kg/ha)	Not displayed
$Yield\_Target_p$	Yield target of crop p (kg/ha)	NPK balance per crop
$Yield\_Target_f$	Yield target of forage crop f (kg/ha)	NPK balance per crop
$%Res_r$	% biomass of residue <i>r</i> exported	NPK balance per crop
N_Content <sub>p</sub>	N content (respectively P & K) of crop p (kg/ton)	Crop NPK content
$DM_p$	Dry matter of crop $p$ (g/kg)	Crop NPK content
$N_{Content_{r}}$	N content (respectively P & K) of residue <i>r</i> (kg/ton)	Crop NPK content
$DM_r$	Dry matter of residue <i>r</i> (g/kg)	Crop NPK content
$Grain\_Res_{p,r}$	Ratio grain / residues for crop <i>p</i> and residue <i>r</i>	Crop NPK content
$N_{Content_{f}}$	N content (respectively P & K) of forage crop f (kg/ton)	Crop NPK content
$DM_f$	Dry matter of forage crop f (g/kg)	Crop NPK content

# Eq.18.2. Fertlisation supply (kg/ha) (similar equations for P & K)

#### Mineral fertilisation

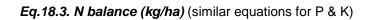
 $Supply\_N_i = N\_Content_i \times Q\_Mineral_i \div 1000$ 

#### > Organic fertilisation

$$Supply\_N_u = N\_Content_u \times (Q\_Manure_u \div 1000) \times (DM_u \div 1000)$$

# > Total supply

$$Supply\_Total\_N = \sum_{i} Supply\_N_i + \sum_{u} Supply\_N_u$$





 $N\_Balance = Supply\_Total\_N - Export\_Total\_N$ 

Variable	Signification	CLIFS sheet
N_Balance	N balance (respectively P & K)	NPK balance per crop
Supply_Total_N	Total N supply (respectively P & K)	NPK balance per crop
$Supply_N_i$	N supply for mineral fertiliser <i>i</i> (respectively P & K)	NPK balance per crop
$Supply_N_u$	N supply for organic fertilizer <i>u</i> (respectively P & K)	NPK balance per crop
$N_{Content_{i}}$	N content of mineral fertilizer <i>i</i> (respectively P & K)	NPK content of fertiliser
$N_{-}Content_{u}$	N content for organic fertilizer <i>u</i> (respectively P & K)	Create an organic fertiliser
$DM_u$	Dry matter of organic fertilizer <i>u</i> (respectively P & K)	Create an organic fertiliser

#### Eq.19. Green forage balance



#### Eq.19.1. Green forage production

The monthly and annual production of each green forage cultivated in the farm is calculated based on the following equations:

$$\begin{split} &Prod\_GF_{f,m} = \sum_{l} Surf\_GF_{f,l} \times Yield_{f,l} \times \%Yield_{f,m} \div \sum\nolimits_{m=1}^{12} \%Yield_{f,m} \\ &Prod\_GF_{f} = \sum\limits_{m=1}^{12} Prod\_GF_{f,m} \end{split}$$

Variable	Signification	CLIFS sheet
$Prod\_GF_f$	Annual production of green forage f	Green forage balance
$Prod\_GF_{f,m}$	Total production of green forage f month m	Green forage balance
$Yield_{f,l}$	Total gross yield of green forage <i>f</i> on crop block <i>l</i> (kg/ha)	Technical sequence per crop block
%Yield <sub>f,m</sub>	Percentage of the total gross yield of forage <i>f</i> for month <i>m</i>	Forage yields

## Eq.19.2. Monthly and annual green forage consumption

For each green forage supplied to the herd, the total quantity distributed per month and annually is calculated as follows for the reproductive female and growing batches, for which forage is distributed throughout the year:

$$Q_{-}GF_{f,m} = \sum_{b} Q_{f,m,b} \times Day_{m} \times n_{b}$$

$$Q_{-}GF_{f} = \sum_{m=1}^{12} Q_{-}GF_{f,m}$$

Variable	Signification	CLIFS sheet
$Q\_GF_f$	Total annual consumption of green forage f	Green forage balance
$Q\_GF_{f,m}$	Total daily consumption of green forage <i>f</i> during month <i>m</i>	Not displayed
$n_b$	Number of heads in each of the seven ruminant batches <sup>1</sup>	Herd size

<sup>&</sup>lt;sup>1</sup>for reproductive female batches  $n_b = n_f e m_b$ 

For the fattening ruminants batches CLIFS starts calculating the number of days per month  $Day'_m$  during which the animals are fattened according to the starting date of fattening and its duration<sup>8</sup>.

$$\begin{array}{ll} Day_m' = 0 & \text{IF } m < m_{Start\_fat_b} \text{ and } m > m_{End\_fat_b} \\ Day_m' = Day_m - J_{Start_{fat_b}} + 1 & \text{IF } m = m_{Start\_fat_b} \\ Day_m' = J_{End\_fat_b} & \text{IF } m = m_{End\_fat_b} \\ Day_m' = Day_m & \text{IF } m > m_{Start\_fat_b} \text{ and } m < m_{End\_fat_b} \end{array}$$

<sup>&</sup>lt;sup>8</sup> The calculations are made by using the DATEVAL function of Excel, which transforms dates into number.



Variable	Signification	CLIFS sheet
$Day'_m$	Number of days per month of fattening	Not displayed
$m_{Start\_fat_b}$	Starting month of fattening for batch b	Fattening 1,2,3
$J_{Start\_fat_b}$	Starting day of fattening for batch b	Fattening 1,2,3
$Start\_fat_b$	Date of fattening start for batch $b J_{Start\_fat_h} / m_{Start\_fat_h}$	Fattening 1,2,3
$J_{End\_fat_h}$	Ending day of fattening for batch b	Not displayed
$m_{End\_fat_h}$	Ending month of fattening for batch b	Not displayed
$Dur\_Fat_{a,b}$	Duration of fattening for batch b	Fattening 1,2,3

# Eq.19.3. Monthly and annual forage balance

$$Bal\_GF_{f,m} = Q\_GF_{f,m} - Prod\_GF_{f,m}$$

$$Bal\_GF_f = Q\_GF_f - Prod\_GF_f$$

$$\label{eq:def_gr} \textit{Def}\_\textit{GF}_f = \textstyle \sum_{m=1}^{12} \textit{Bal}\_\textit{GF}_{f,m} \qquad \text{ with } \textit{Bal}\_\textit{GF}_{f,m} < 0$$

Variable	Signification	CLIFS sheet
$Def\_GF_f$	Total annual deficit of green forage f	Green forage balance
$Bal\_GF_f$	Annual balance of green forage f	Green forage balance
$Bal\_GF_{f,m}$	Monthly balance of green forage f	Green forage balance

## Eq.20. Hay/Silage balance



#### Eq.20.1. Monthly hay or silage production

The monthly production of hay or silage is calculated for respectively the months  $m_h$  or  $m_s$  indicated in E.13. as follows:

$$\begin{aligned} & Prod\_HF_{h,m_h} = \sum_{l} Surf\_Forage_{f,l} \times Yield_{f,l} \times \%Yield_{f,m_h} \div 100 \times Conv_{f,h} \\ & Prod\_SF_{s,m_s} = \sum_{l} Surf\_Forage_{f,l} \times Yield_{f,l} \times \%Yield_{f,m_s} \div 100 \times Conv_{f,s} \end{aligned}$$

Variable	Signification	CLIFS sheet
$Prod\_HF_{h,m_h}$	Total production of hay forage $h$ month $m_h$	Hay forage balance
$Prod\_SF_{s,m_s}$	Total production of silage forage $s$ month $m_s$	Silage forage balance
$m_h$	Harvest month of hay forage h	Forage type
m <sub>s</sub>	Harvest month of silage forage s	Forage type

Eq.20.2. Monthly stock of hay or silage (not displayed for silage – replace h with s)

$$\begin{split} Stock\_Initial_{h,m_{h\_c}+1} &= Prod\_HF_{h,m_{h\_c}} - Q_{h,m_{h\_c}} \\ Stock_{h,m} &= Stock_{h,m-1} - Q_{h,m-1} + Prod\_HF_{h,m-1} \\ \text{or} &\quad Stock_{h,m} = 0 \quad \text{if} \quad Stock_{h,m-1} - Q_{h,m-1} + Prod_{HF_{h,m-1}} < 0 \\ Prod\_HF_{h,m-1} &= Prod\_HF_{h,m_h} \\ \text{or} &\quad Prod\_HF_{h,m-1} = 0 \quad \text{if} \quad m-1 \neq m_h \end{split}$$

$$Q_{h,m} = \sum_{b=1}^{7} Q_{h,m,b} \times Day_m \times n_b$$

Variable	Signification	CLIFS sheet
$Stock\_Initial_{h,m_{h}}$ $_{c}^{+1}$	Initial stock of hay forage h	Hay forage balance
$Stock_{h,m}$	Stock of hay forage <i>h</i> month <i>m</i>	Hay forage balance
$m_{h\_c}$	First month of production of hay forage <i>h</i> (starting from January)	Forage stocks
$Q_{h,m_{h}}$	Quantity of hay forage $h$ consumed month $m_{h_c}$	Not displayed
$Q_{h,m}$	Total quantity of hay forage $h$ consumed month $m$	Not displayed

#### Eq.20.3. Annual balance of hay or silage forage (not displayed for silage - replace h with s)

$$Prod\_HF_h = \sum_{m_h} Prod\_HF_{h,m_h}$$
 
$$Q\_HF_h = \sum_{m=1}^{12} Q_{h,m}$$
 
$$Bal\_HF_h = Q\_HF_h - Prod\_HF_h$$

Variable	Signification	CLIFS sheet
$Bal\_HF_h$	Annual balance of hay forage h	Hay forage balance
$Q\_HF_h$	Annual quantity of hay forage h consumed by livestock	Hay forage balance
$Prod\_HF_h$	Total quantity of hay forage <i>h</i> produced during the year	Hay forage balance

## Eq.21. Crop residues balance



$$\begin{aligned} & Prod\_Res_{r,l} = Yield_{p,l} \times \%Res_{r,l} \times Grain\_Res_{p,r} \times Surf\_Food_{p,l} \\ & Prod\_Res_{r} = \sum_{l} Prod\_Res_{r,l} \end{aligned}$$

Variable	Signification	CLIFS sheet
Prod_Res <sub>r</sub>	Total annual production of crop residue <i>r</i>	Crop residues balance
$Prod\_Res_{r,l}$	Production of crop residue $r$ for block $l$	Not displayed
$Yield_{p,l}$	Yield of food/market crop p in block I	Technical sequence per crop block
$\%Res_{r,l}$	% of biomass of residue <i>r</i> on block <i>l</i> harvested by the farmer	Technical sequence per crop block
Grain_Res <sub>p,r</sub>	Grain/residues ratio (raw material)	Crop name

## Eq.21.2. Annual consumption per crop residue

 $\succ$  For animal feed: crop residue r becomes a forage f (D.2) For commodity f index has been replaced by r index in the following equations.

$$\begin{aligned} Q\_Res_{r,m} &= \sum_{b=1}^{7} Q_{r,m,b} \times Day_m \times n_b \\ Q\_Res_r &= \sum_{m=1}^{12} Q\_Res_{r,m} \end{aligned}$$

For organic fertiliser

$$Q\_Man\_Res_r = \sum_{u,b^*} Q\_Man\_Res_{u,r,b^*}$$

I otal

$$Q\_Tot\_Res_r = Q\_Res_r + Q\_Man\_Res_r$$

Variable	Signification	CLIFS sheet
$Q\_Tot\_Res_r$	Total annual quantity of residue <i>r</i> used on the farm	Crop residues balance
$Q\_Man\_Res_r$	Total annual quantity of residue r consumed for	Not displayed
	manure production	
$Q\_Res_r$	Total annual quantity of residue <i>r</i> consumed for	Not displayed
	feeding livestock	
$Q$ _ $Res_{r,m}$	Total quantity of residue <i>r</i> consumed month <i>m</i>	Not displayed

## Eq.21.3. Annual balance per crop residue

$$Bal\_Res_r = Q\_Res_r - Prod\_Res_r$$

Variable	Signification	CLIFS sheet
Bal_Res <sub>r</sub>	Annual balance of crop residue r	Crop residues balance

#### Eq.22. Food/market balance



$$Prod\_FM_p = \sum_{l} Yield_{p,l} \times Surf\_Food_{p,l}$$

## Eq.22.2. Food/market consumption

Eq.22.2.1. Family consumption

$$Q_Food_p = Q_Pers_Food_p \times Family_Size$$

Variable	Signification	CLIFS sheet
$Q\_Food_p$	Quantity of food crop <i>p</i> required to feed the family	Food/Market balance
•	over a year	
$Q_Pers_Food_n$	Quantity of food crop <i>p</i> required to feed one adult	Structure and cropping pattern
r	over a year	

Eq.22.2.2. Animal consumption

When it is used for animal feed, crop production p is considered as a concentrate c (E.4.2; E.5; E.6; E.7). It can be used either directly or as a compound of concentrate cf (E.3).

- · Reproductive females (ruminants)
  - Direct usage of p

$$Q\_Fem_{p,m} = \sum_{b} \sum_{k} Q\_fem_{c,k,b} \times n\_fem_{b,m,k} \times Day_m$$

Compound of cf

$$\begin{aligned} Q\_Fem_{p,m} &= \sum_{b} \sum_{k} Q\_fem_{cf,k,b} \times n\_fem_{b,m,k} \times (Q_{c,cf} \div 100) \times Day_m \\ Q\_Fem_{p} &= \sum_{m=1}^{12} Q\_Fem_{p,m} \end{aligned}$$

- Growing animals (Ruminants)
- Direct usage of p

$$Q\_Grow_{c,m} = \sum_{b} Q\_Grow_{c,m,b} \times n\_grow_{a,b} \times Day_{m}$$

Compound of cf

$$Q\_Grow_{c,m} = \sum_{b} Q\_Grow_{cf,m,b} \times n\_grow_{a,b} \times (Q_{c,cf} \div 100) \times Day_{m}$$

$$Q\_Grow_{c} = \sum_{m=1}^{12} Q\_Grow_{c,m}$$

- Fattening animals (Ruminants)
  - Direct usage of p

$$Q\_Fat_p = \sum_{b} Q\_Fat_{c,b} \times n\_fat_{a,b} \times Dur\_Fat_{a,b}$$

Compound of cf

$$Q\_Fat_p = \sum_b Q\_Fat_{cf,b} \times n\_fat_{a,b} \times (Q_{c,cf} \div 100) \times Dur\_Fat_{a,b}$$

Pig and poultry

$$Qtot\_mono_p = \sum_{b} Qtot\_mono_{p,b}$$

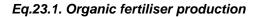
$$Q\_Conc_p = Q\_Fem_p + Q\_Grow_p + Q\_Fat_p + Qtot\_mono_p$$

## Eq.22.2.3 Food/market balance

$$Bal\_FM_p = Prod\_FM_p - Q\_Food_p - Q\_Conc_p$$

Variable	Signification	CLIFS sheet
$Bal\_FM_p$	Annual balance of food/market crop p	Food/market balance
$Prod\_FM_p$	Annual production of food/market crop <i>p</i>	Food/market balance
$Q\_Food_p$	Annual family consumption of food/market crop <i>p</i>	Food/market balance
$Q\_Conc_p$	Annual animal consumption of food/market crop p	Food/market balance
$Q\_Fem_{p,m}$	Monthly quantity of food/market crop <i>p</i> consumed by reproductive female ruminants	Not displayed
$Q\_Fem_p$	Annual quantity of food/market crop <i>p</i> consumed by reproductive female ruminants	Not displayed
$Q\_Grow_{p,m}$	Monthly quantity of food/market crop <i>p</i> consumed by growing ruminants	Not displayed
$Q\_Grow_p$	Annual quantity of food/market crop <i>p</i> consumed by growing ruminants	Not displayed
$Q\_Fat_p$	Annual quantity of food/market crop <i>p</i> consumed by fattening ruminants	Not displayed
$Qtot\_mono_p$	Annual quantity of food/market crop <i>p</i> consumed by pig and poultry	Not displayed
$Qtot\_mono_{p,b}$	Annual quantity of concentrate <i>c</i> distributed in pig and poultry batch <i>b</i>	Pig and poultry
$Q\_Fat_{c,,b}$	Daily quantity of concentrate <i>c</i> distributed in fattening batch <i>b</i>	Fattening 1,2,3
$n\_fat_{a.b}$	Number of animal a in fattening batch b	Fattening 1,2,3
$Q\_Grow_{c,m,b}$	Daily quantity of concentrate $c$ distributed month $m$ in growing batch $b$	Growing 1,2
$n\_grow_{a,b}$	Number of animal <i>a</i> in growing batch <i>b</i>	Growing 1,2

## Eq.23. Organic fertliser balance



$$Prod\_Manure_u = \sum_{b^*} Prod\_Manure_{u,b^*}$$

## Eq.23.2. Organic fertiliser consumption

$$Q\_Manure_u = \sum_{l} Q\_Manure_{u,l} \times Surf_l$$

## Eq.23.3. Organic fertiliser balance

 $Bal\_Manure_u = Prod\_Manure_u - Q\_Manure_u$ 

Variable	Signification	CLIFS sheet
$Bal\_Manure_u$	Annual balance of manure <i>u</i> (kg)	Organic fertiliser balance
$Prod\_Manure_u$	Annual production of manure <i>u</i> (kg)	Organic fertiliser balance
$Q\_Manure_u$	Annual consumption of manure <i>u</i> (kg)	Organic fertiliser balance
$Surf_l$	Area of block I (ha) $Surf_l = Surf_F ood_{p,l}$ for food plots $Surf_l = Surf_G F_{f,l}$ for forage plots $Surf_l = Surf_F ood_G F_{p,f,l}$ for food+forage plots	Farm structure

#### Eq.24. Expenses



The equations providing the amounts per ha from the total amounts are not detailed in this section. The total area considered is the physical one  $(Surf\_Tot)$  and not the developed one presented in F.1.<sup>9</sup>

### Eq.24.1. Livestock expenses

- Forage purchase (excepted crop residues)
  - Green  $TotalCost\_GF = \sum_{f} Def\_GF_{f} \times UPurch\_GF_{f}$

■ Hay If 
$$Bal\_HF_h < 0$$
 Then  $Cost\_HF_h = -1 \times Bal\_HF_h \times UPurch\_HF_h$  Else  $Cost\_HF_h = 0$   $TotalCost\_HF = \sum_h Cost\_HF_h$ 

• Silage If 
$$Bal\_SF_s < 0$$
 Then  $Cost\_SF_s = -1 \times Bal\_SF_s \times UPurch\_SF_s$  Else  $Cost\_SF_s = 0$   $TotalCost\_SF = \sum_s Cost\_SF_s$ 

Total TotalCost\_Forage = TotalCost\_GF + TotalCost\_HF + TotalCost\_SF

Variable	Signification	CLIFS sheet
TotalCost_Forage	Total cost of forage purchase	Economic results
TotalCost_GF	Total cost of green forage purchase	Not displayed
TotalCost_HF	Total cost of hay forage purchase	Not displayed
TotalCost_SF	Total cost of silage forage purchase	Not displayed
$Cost\_HF_h$	Annual purchase cost of hay forage h	Not displayed
$Cost\_SF_s$	Annual purchase cost of silage forage s	Not displayed
$UPurch\_GF_f$	Purchase price per kg of green forage f	Purchase prices of livestock inputs
$UPurch\_HF_h$	Purchase price per kg of hay forage h	Purchase prices of livestock inputs
UPurch_SF <sub>s</sub>	Purchase price per kg of silage forage s	Purchase prices of livestock inputs

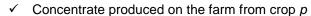
#### Concentrate purchase

Concentrate come (i) from products bought outside the farm or (ii) products produced on the farm. The latter can be only dedicated to animal consumption or they can have a mixed usage (family and animal consumption) such as maize.

Calculation depends on the kind of product and balance:

✓ Concentrate bought outside the farm  $Cost\_Conc_c = Q\_Conc_c \times UPurch\_Conc_c$ 

<sup>&</sup>lt;sup>9</sup> Idem for proceeds and profits.



- No family consumption  $Cost\_Conc_p = Bal\_FM_p \times UPurch\_Conc_p$
- $\begin{array}{lll} \bullet & \text{Family consumption} \\ & \text{If } \textit{Prod}\_\textit{FM}_p \textit{Q}\_\textit{Food}_p < 0 & \text{Then} & \textit{Cost}\_\textit{Conc}_p = \textit{Q}\_\textit{Conc}_p \times \textit{UPurch}\_\textit{Conc}_p \\ & \text{If } \textit{Prod}\_\textit{FM}_p \textit{Q}\_\textit{Food}_p \geq 0 & \text{Then} & \textit{Cost}\_\textit{Conc}_p = \textit{Bal}\_\textit{FM}_p \times \textit{UPurch}\_\textit{Conc}_p \\ \end{array}$

$$TotalCost\_Conc = \sum_{c} Cost\_Conc_{c} + \sum_{p} Cost\_Conc_{p}$$

Variable	Signification	CLIFS sheet
TotalCost_Conc	Total cost of concentrate	Economic results
$Cost\_Conc_c$	Annual purchase cost of concentrate <i>c</i> bought outside the farm	Not displayed
$Cost\_Conc_p$	Annual purchase cost of concentrate $p$ produced on the farm	Not displayed
$UPurch\_Conc_c$	Purchase price per kg of concentrate $c$ (or $p$ when produced on the farm)	Purchase prices of livestock inputs

#### Crop residues purchase

If  $Bal\_Res_r < 0$  Then  $Cost\_Res_r = -1 \times Bal\_Res_r \times UPurch\_Res_r$  Else  $Cost\_Res_r = 0$ 

$$TotalCost\_Res = \sum_{r} Bal\_Res_{r}$$

Variable	Signification	CLIFS sheet
TotalCost_Res	Total cost of crop residues	Economic results
$Cost\_Res_r$	Annual purchase cost of crop residue r	Not displayed
UPurch_Res <sub>r</sub>	Purchase price per kg of crop residue <i>r</i>	Purchase prices of
or ui cii_kes <sub>r</sub>		livestock inputs

## Animal purchase

 $TotalCost\_An = \sum_b n\_head\_Purch_{a,b} \times UPurch\_An_a$ 

Variable	Signification	CLIFS sheet
TotalCost_An	Total cost of animal purchased	Economic results
$n\_head\_Purch_{a,b}$	Head number of animal a purchased in batch b	Fattening 1,2,3 Pig/Poultry 1,2,3,4
$UPurch\_An_a$	Purchase price of one head of animal type a	Purchase prices of livestock inputs

## Veterinary costs

 $TotalCost\_Vet = \sum_{a} n\_head_a \times UPurch\_Vet_a$ 

Variable	Signification	CLIFS sheet
TotalCost_Vet	Total veterinary costs	Economic results
$n\_head_a$	Head number of animal type a	Purchase prices of livestock inputs
UPurch_Vet <sub>a</sub>	Veterinary cost per head of animal type a	Purchase prices of
		livestock inputs



#### Total livestock expenses (intermediate consumption)

 $TotalCost\_Live = TotalCost\_Forage + TotalCost\_Conc + TotalCost\_Res + TotalCost\_An + TotalCost\_Vet + TotalCost\_HLab\_Live + OtherCosts\_Live$ 

Variable	Signification	CLIFS sheet
TotalCost_Live	Total costs of intermediate consumption for the livestock component of the farm	Economic results
TotalCost_HLab_Live	Total cost of hired labour dedicated to livestock	Purchase prices of livestock inputs
OtherCosts_Live	Other livestock costs	Purchase prices of livestock inputs

## Eq.24.2. Crop expenses 10

#### Seeds

$$\begin{aligned} & \textit{Cost\_Seed}_p = \sum_{l} \textit{Q\_Seed}_{p,l} \times (\textit{Surf\_Food}_{p,l} + \textit{Surf\_Food\_GF}_{p,f,l}) \times \textit{UPurch\_Seed}_p \\ & \textit{Cost\_Seed}_f = \sum_{l} \textit{Q\_Seed}_{f,l} \times (\textit{Surf\_GF}_{f,l} + \textit{Surf\_Food\_GF}_{p,f,l}) \times \textit{UPurch\_Seed}_f \\ & \textit{TotalCost\_Seed} = \sum_{l} \textit{Cost\_Seed}_p + \sum_{f} \textit{Cost\_Seed}_f \end{aligned}$$

Variable	Signification	CLIFS sheet
TotalCost_Seed	Total cost of seeds	Economic results
$Cost\_Seed_p$	Total cost of seed for food/market crop p	Not displayed
$Cost\_Seed_f$	Total cost of seed for forage crop f	Not displayed
UPurch_Seed <sub>p</sub>	Purchase price per unit of seed p	Purchase prices of crop inputs
UPurch_Seed <sub>f</sub>	Purchase price per unit of seed f	Purchase prices of crop inputs
$Q\_Seed_{o,l}$	Quantity of seeds per ha for crop o on block l <sup>1</sup>	Technical sequence per crop block

<sup>&</sup>lt;sup>1</sup>repeated twice per block

### Organic fertilisers

If  $Bal\_Manure_u < 0$  Then  $Cost\_Manure_u = -1 \times Bal\_Manure_u \times UPurch\_Manure_u$  Else  $Cost\_Manure_u = 0$ 

 $TotalCost\_Manure = \sum_{u} Cost\_Manure_u$ 

VariableSignificationCLIFS sheetTotalCost\_ManureTotal cost of manureEconomic resultsCost\_Manure\_uTotal cost of manure uNot displayedUPurch\_Manure\_uPurchase price per kg of manure uPurchase prices of crop inputs

<sup>&</sup>lt;sup>10</sup> For calculation simplification expenses linked to forage crops are included in this component of the farm although they could be charged to the livestock component as well.

#### Mineral fertilisers

$$Cost\_Mineral_i = \sum_{l} Q\_Mineral_{i,l} \times (Surf\_Food_{p,l} + Surf\_GF_{f,l} + Surf\_Food\_GF_{p,f,l}) \times UPurch\_Mineral_i$$

$$TotalCost\_Mineral_i = \sum_{l} Q\_Mineral_{i,l} \times (Surf\_Food_{p,l} + Surf\_GF_{f,l} + Surf\_Food\_GF_{p,f,l}) \times UPurch\_Mineral_i$$

$$TotalCost\_Mineral = \sum_{i} Cost\_Mineral_{i}$$

Variable	Signification	CLIFS sheet
TotalCost_Mineral	Total cost of mineral fertilisers	Economic results
Cost_Mineral <sub>i</sub>	Total cost of mineral fertilizer i	Not displayed
UPurch_Mineral <sub>i</sub>	Purchase price per unit of mineral fertilizer i	Purchase prices of crop inputs
$Q\_Mineral_{i,l}$	Quantity of mineral fertilizer $i$ per ha spread on block $l^1$	Technical sequence per crop block

<sup>&</sup>lt;sup>1</sup>Repeated three times per block

#### Pesticides

$$Cost\_Pesticide_d = \sum_{l} Q\_Pesticide_{d,l} \times (Surf\_Food_{p,l} + Surf\_GF_{f,l} + Surf\_Food\_GF_{p,f,l}) \times UPurch\_Pesticide_d = \sum_{l} Q\_Pesticide_{d,l} \times (Surf\_Food_{p,l} + Surf\_GF_{f,l} + Surf\_Food\_GF_{p,f,l}) \times UPurch\_Pesticide_d = \sum_{l} Q\_Pesticide_{d,l} \times (Surf\_Food_{p,l} + Surf\_GF_{f,l} + Surf\_Food\_GF_{p,f,l}) \times UPurch\_Pesticide_d = \sum_{l} Q\_Pesticide_{d,l} \times (Surf\_Food_{p,l} + Surf\_GF_{f,l} + Surf\_Food\_GF_{p,f,l}) \times UPurch\_Pesticide_d = \sum_{l} Q\_Pesticide_{d,l} \times (Surf\_Food_{p,l} + Surf\_GF_{f,l} + Surf\_Food\_GF_{p,f,l}) \times UPurch\_Pesticide_d = \sum_{l} Q\_Pesticide_{d,l} \times (Surf\_Food_{p,l} + Surf\_GF_{f,l} + Surf\_Food\_GF_{p,f,l}) \times UPurch\_Pesticide_{d,l} \times (Surf\_Food_{p,l} + Surf\_GF_{f,l} + Surf\_Food_{p,l} + Surf\_GF_{f,l}) \times UPurch\_Pesticide_{d,l} \times (Surf\_Food_{p,l} + Surf\_GF_{f,l} + Surf\_GF_{f,l}) \times UPurch\_Pesticide_{d,l} \times (Surf\_Food_{p,l} + Surf\_GF_{f,l} + Surf\_GF_{f,l}) \times UPurch\_Pesticide_{d,l} \times (Surf\_GF_{f,l} + Surf\_GF_{f,l} + Surf\_GF_{f,l} + Surf\_GF_{f,l}) \times UPurch\_Pesticide_{d,l} \times (Surf\_GF_{f,l} + Surf\_GF_{f,l} + Surf_GF_{f,l} + Surf_GF_{f,l} + Surf_GF_{f,l} + Surf_GF_{f,l} + Surf$$

$$TotalCost\_Pesticide = \sum_{d} Cost\_Pesticide_{d}$$

Variable	Signification	CLIFS sheet
TotalCost_Pesticide	Total cost of pesticides	Economic results
$Cost\_Pesticide_d$	Total cost of pesticide d	Not displayed
$UPurch\_Pesticide_d$	Purchase price per unit of pesticide d	Purchase prices of crop inputs
$Q\_Pesticide_{d,l}$	Quantity of pesticide $d$ per ha spread on block $l^1$	Technical sequence per crop block

<sup>&</sup>lt;sup>1</sup>Repeated three times per block

#### Hired machinery

$$Cost\_Machin_y = \sum_{l} Q\_Machin_{y,l} \times (Surf\_Food_{p,l} + Surf\_GF_{f,l} + Surf\_Food\_GF_{p,f,l}) \times UPurch\_Machin_y = \sum_{l} Q\_Machin_{y,l} \times (Surf\_Food_{p,l} + Surf\_GF_{f,l} + Surf\_Food\_GF_{p,f,l}) \times UPurch\_Machin_y = \sum_{l} Q\_Machin_{y,l} \times (Surf\_Food_{p,l} + Surf\_GF_{f,l} + Surf\_Food\_GF_{p,f,l}) \times UPurch\_Machin_y = \sum_{l} Q\_Machin_{y,l} \times (Surf\_Food_{p,l} + Surf\_GF_{f,l} + Surf\_Food\_GF_{p,f,l}) \times UPurch\_Machin_y = \sum_{l} Q\_Machin_{y,l} \times (Surf\_Food_{p,l} + Surf\_GF_{f,l} + Surf\_Food\_GF_{p,f,l}) \times UPurch\_Machin_y = \sum_{l} Q\_Machin_{y,l} \times (Surf\_Food_{p,l} + Surf\_GF_{f,l} + Surf\_Food\_GF_{p,f,l}) \times UPurch\_Machin_y = \sum_{l} Q\_Machin_{y,l} \times (Surf\_Food_{p,l} + Surf\_GF_{f,l} + Surf\_GF_{f,l}) \times UPurch\_Machin_y = \sum_{l} Q\_Machin_{y,l} \times (Surf\_Food_{p,l} + Surf\_GF_{f,l} + Surf\_GF_{f,l}) \times UPurch\_Machin_y = \sum_{l} Q\_Machin_{y,l} \times (Surf\_GF_{f,l} + Surf\_GF_{f,l} + Surf\_GF_{f,l}) \times UPurch\_Machin_y = \sum_{l} Q\_Machin_{y,l} \times (Surf\_GF_{f,l} + Surf\_GF_{f,l} + Surf\_GF_{f,l}) \times UPurch\_Machin_y = \sum_{l} Q\_Machin_{y,l} \times (Surf\_GF_{f,l} + Surf\_GF_{f,l} + Surf\_GF_{f,l}) \times UPurch\_Machin_y = \sum_{l} Q\_Machin_{y,l} \times (Surf\_GF_{f,l} + Surf\_GF_{f,l} + Surf_GF_{f,l} + S$$

$$TotalCost\_Machin = \sum_{y} Cost\_Machin_{y}$$

Variable	Signification	CLIFS sheet
TotalCost_Machin	Total cost of hired machinery	Economic results
Cost_Machin <sub>y</sub>	Total cost of hired machinery y	Not displayed
UPurch_Machin <sub>y</sub>	Purchase price per unit of hired machinery y	Purchase prices of crop inputs
$Q\_Machin_{y,l}$	Quantity of hired machinery $y$ per ha used on block $l^1$	Technical sequence per crop block

<sup>&</sup>lt;sup>1</sup>Repeated three times per block

#### Hired labour

$$\textit{Cost\_Labour}_{w} = \sum_{l} \textit{Q\_Labour}_{w,l} \times (\textit{Surf\_Food}_{p,l} + \textit{Surf\_GF}_{f,l} + \textit{Surf\_Food\_GF}_{p,f,l}) \times \textit{UPurch\_Labour}_{w}$$

$$TotalCost\_Labour = \sum_{w} Cost\_Labour_{w}$$

Variable	Signification	CLIFS sheet	
TotalCost_Labour	Total cost of hired labour	Economic results	
$Cost\_Labour_w$	Total cost of hired labour w	Not displayed	
UPurch_Labour <sub>w</sub>	Purchase price per unit of hired labour w	Purchase prices of crop inputs	
$Q\_Labour_{w,l}$	Quantity of hired labour $w$ per ha used on on block $l^1$	Technical sequence per crop block	

Repeated three times per block

## Irrigation

$$Cost\_Irrig_l = Q\_Irrig_l \times UPurch\_m3 + Surf_l \times Cost\_Irrig\_Ha$$
 
$$TotalCost\_Irrig = \sum_l Cost\_Irrig_l$$

Variable	Signification	CLIFS sheet	
TotalCost_Irrig	Total cost of irrigation	Economic results	
Cost_Irrig <sub>l</sub>	Total cost of irrigation for block /	Not displayed	
UPurch_m3	Cost of one m <sup>3</sup> of irrigation water	Purchase prices of crop inputs	
Cost_Irrig_Ha	Flat cost per irrigated ha	Purchase prices of crop inputs	
$Q\_Irrig_l$	Quantity of water irrigation used on block / (m³/ha)	Technical sequence per crop block	

### Total crop expenses (intermediate consumption)

 $TotalCost\_Crop = TotalCost\_Seed + TotalCost\_Manure + TotalCost\_Mineral + TotalCost\_Pesticide \\ + TotalCost\_Machin + TotalCost\_Labour + TotalCost\_Irrig + OtherCosts\_Crop$ 

Variable	Signification	CLIFS sheet	
TotalCost_crop	Total costs of intermediate consumption for the crop component of the farm	Economic results	
OtherCosts_Crop	Other crop costs	Purchase prices of crop inputs	

#### Eq.24.3. Fixed costs

$$TotalFixedCost = \sum_{e} FixedCost_{e}$$

Variable	Signification	CLIFS sheet
TotalFixedCost	Total fixed costs	Economic results
$FixedCost_e$	Annual amount of fixed cost e	Fixed costs

### Eq.24.4. Staple food purchase

This item is not included in the farming expenses *per se*, but is provided in the economic results as an assessment of the farm capacity to cover the family needs regarding staple food as defined in E.9.1. The amount of money required to cover a possible deficit is calculated as follows. Practically this amount should be covered by the net profit of the farm.

$$\label{eq:cost_food} \begin{array}{ll} \text{If } Prod_{\mathit{FM}_p} - Q_{\mathit{Food}_p} < 0 & \text{Then } Cost\_Food_p = -1 \times (Prod\_FM_p - Q\_Food_p) \times UPurch\_Food_p \\ \text{Else } Cost\_Food_p = 0 & \text{Then } Cost\_Food_p = -1 \times (Prod\_FM_p - Q\_Food_p) \times UPurch\_Food_p \\ \end{array}$$

$$TotalCost\_Food = \sum_{p} Cost\_Food_{p}$$

Variable	Signification	CLIFS sheet	
TotalCost_Food	Total purchase cost of staple food	Economic results	
$Cost\_Food_p$	Total purchase cost of staple food p	Not displayed	
$UPurch\_Food_p$	Purchase cost per kg of staple food p	Purchase prices of crop inputs	

## Eq.25. Proceeds



 $TotalCrop\_Proceed = AnnualFM\_Sale + AnnualForage\_Sale + AnnualRes\_Sale$ 

 $Total\_Proceed = TotalLive\_Proceed + TotalCrop\_Proceed$ 

 $\%Live\_Proceed = 100 * TotalLive\_Proceed \div Total\_Proceed$ 

 $\%Crop\_Proceed = 100 * TotalCrop\_Proceed \div Total\_Proceed$ 

Variable	Variable Signification	
Total_Proceed	Total annual proceed for the given scenario	Economic results
%Live_Proceed	Proportion of total proceed made by livestock activity (%)	Economic results
%Crop_Proceed	Proportion of total proceed made by crop activity (%)	Economic results
TotalLive_Proceed	Total annual proceed of livestock activity	Economic results
TotalCrop_Proceed	Total annual proceed of crop activity	Economic results

See also table next page.



Type of production	Variable	Family / Crop consumption	Animal Consumption	Marketable <sup>1</sup>	Calculation of marketable volume <sup>2</sup>	Sale price per unit
Milk (dairy)	AnnualMille Cala 3	Х	Х	Х	Milk_Sale <sub>b.m</sub>	USale_Milk <sub>b.m</sub>
Milk (suckler)	AnnualMilk_Sale <sub>b</sub> 3		Χ		., .	0
Livestock sold				Х	$n\_head\_Sold_{a,b} =$	USale_An <sub>a</sub>
	AnnualMeat_Sale <sup>4</sup>				$\{n\_fat_{a,b}; \ n\_mono\_Sold_{a,b}\}$	
Livestock kept						0
Egg sold	AmmualEaa Calo			Х	$TotEgg\_Sold$	USale_Egg
Egg consumed only	$AnnualEgg\_Sale$	X				0
Organic fertiliser Mk	AnnualManure_Sale <sup>6</sup>	Χ		Х	$Bal\_Manure_u$	$\mathit{USale\_Manure}_u$
Organic fertiliser no Mk	AnnualManure_Sale	X				0
Food/Market Mk	Associated Cala	Х	Х	Х	$Bal\_FM_p$	USale_FM <sub>p</sub>
Food/Market no Mk	AnnualFM_Sale	X			•	0
Forage Mk			Х	Х	$Exc\_{GF_f}^7$	$USale\_GF_f$
	4				$Bal\_H\acute{F}_h$	$\mathit{USale\_HF}_h$
	AnnualForage_Sale <sup>8</sup>				$Bal\_SF_s$	$USale\_SF_s$
Forage no Mk			X			0
Crop residue Mk	4 15 6 1 9		Х	Х	$Bal\_Res_r$	USale_Res <sub>r</sub>
Crop residue no Mk	AnnualRes_Sale <sup>9</sup>		X			0

<sup>&</sup>lt;sup>1</sup>Existence of a market for the corresponding product (Mk)

<sup>&</sup>lt;sup>2</sup> If positive value

 $<sup>^3</sup>$ For the two batches of reproductive female:  $AnnualMilk\_Sale_b = \sum_{m=1}^{12} Milk\_Sale_{b,m} \times USale\_Milk_{b,m}$ 

 $<sup>^4</sup>$ For the bactches of fattening ruminants and of pig and poultry:  $AnnualMeat\_Sale = \sum_{a,b} n\_head\_Sold_{a,b} \times USale\_An_a$ 

<sup>&</sup>lt;sup>5</sup> AnnualManure\_Sale =  $\sum_{u}$  Bal\_Manure<sub>u</sub> × USale\_Manure<sub>u</sub>

<sup>&</sup>lt;sup>6</sup> AnnualFM\_Sale =  $\sum_{v} Bal_{FM_{v}} \times USale_{FM_{v}}$ 

 $<sup>^{7}</sup>Exc\_GF_f = \sum_{m=1}^{12} Bal\_GF_{f,m}$  with  $Bal\_GF_{f,m} > 0$ 

 $<sup>^{8}</sup>AnnualForage_{Sale} = \sum_{f} Exc_{GF_{f}} \times USale_{GF_{f}} + \sum_{h} Bal\_HF_{h} \times USale\_HF_{h} + \sum_{s} Bal\_SF_{s} \times USale\_SF_{s}$ 

 $<sup>^{9}</sup>$  AnnualRes\_Sale =  $\sum_{r}$  Bal\_Res\_r  $\times$  USale\_Res\_r

# Eq.26. Profits

 $Live\_GP = TotalLive\_Proceed - TotalCost\_Live$ 

 $Crop\_GP = TotalCrop\_Proceed - TotalCost\_Crop$ 

 $Total\_GP = Live\_GP + Crop\_GP$ 

 $Total\_NetProfit = Total\_GP - TotalFixedCost$ 

Variable	Signification	CLIFS sheet
Total_NetProfit	Total annual net profit for the given scenario	Economic results
Total_GP	Total annual gross profit for the given scenario	Economic results
Live_GP	Total annual gross profit made by livestock activity	Economic results
Crop_GP	Total annual gross profit made by crop activity	Economic results