Deliverable D5.1: Development of the IAT and ORFEE models for simulating mixed livestock farms

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Climate change and depletion of natural resources calls for a more sober and carbon neutral agriculture. Farmers are also challenged by climate change with more frequent and severe droughts and heat waves in an economic context often difficult. Mixed farming systems are gaining interest both as a risk management strategy and to apply agroecological principles. Diversity in organic farming systems is particularly important since those farms have limited access to external inputs and more frequently use direct marketing. According to Dumont *et al.* (2020), diversity of system components and interactions among these components can increase productivity, resource-use efficiency and farm resilience. The complementarities between livestock and crops offer levers to close local nutrient cycles, reduce GHG emissions intensities and increase carbon storage. The complementarity between two animal species appears as a promising leverage to use more efficient plant resources and to stabilize farm performance which has been little studied until now (Martin *et al.* 2020). In the MixEnable projet, we want to analyse how organic mixed livestock farming systems are resilient and sustainable and how their farming systems could be adapted to reduce their vulnerability.

Modelling offers a comprehensive way to understand complex farms in which exogenous and endogenous factors affect farm sustainability and robustness. Compared with real farm data analysis, modelling offers the possibility to do virtual experiments to test and compare strategies under modified climate or economic conditions and to disentangle the processes involved. Few farm models target organic systems (Olesen *et al.* 2006; Kerselaers *et al.* 2007) or offer the possibility to simulate different livestock species (Kerselaers *et al.* 2007; Lengers *et al.* 2014) and none of them provide enough flexibility to explore the variety of management options in a mixed livestock farm. Two existing models

(Lisson *et al.* 2010; Mosnier *et al.* 2017a) have useful characteristics and could be further developed for modelling organic mixed livestock farms. The IAT model (Lisson *et al.* 2010) was developed to be used in a participatory way with smallholder crop-livestock farmers. The model of Mosnier et al. (2017) is more detailed, and better suited to desktop analysis. In the deliverable, we first compare the main attribute of each model relative to the needs of the project and then present the main developments made in Orfee that has been eventually used in MixEnable.

1 Comparison of the model features

1.1 General characteristics

Orfee (Fig. 1) represents annual production of a livestock farm at equilibrium which means that crop production, animals, machinery and labour are the same from year to year under average climate conditions (Mosnier et al., 2017). Orfee can be used to simulate monthly decisions about herd size, ration composition, pasture use, and feed purchases and decisions related to crop rotation, machines and building or labour. These decisions can either be fixed by the operator or optimized to maximize an objective function of profit (expected profit plus an indicator of profit risk) under biological, structural and economic constraints. Economic results obtained from this equilibrium production are calculated under different economic contexts. Different indicators are calculated to estimate the economic and technical performance of the farm, and the economic, social and environmental sustainability. It was created in France in Inrae and mostly applied to French livestock production systems (Table 1). Orfee runs on the General Algebraic Modeling System (GAMS Development Corporation, Washington, DC, USA) and uses the Mixed Integer Programming solver CPLEX. Most of the input and output files are in Excel.

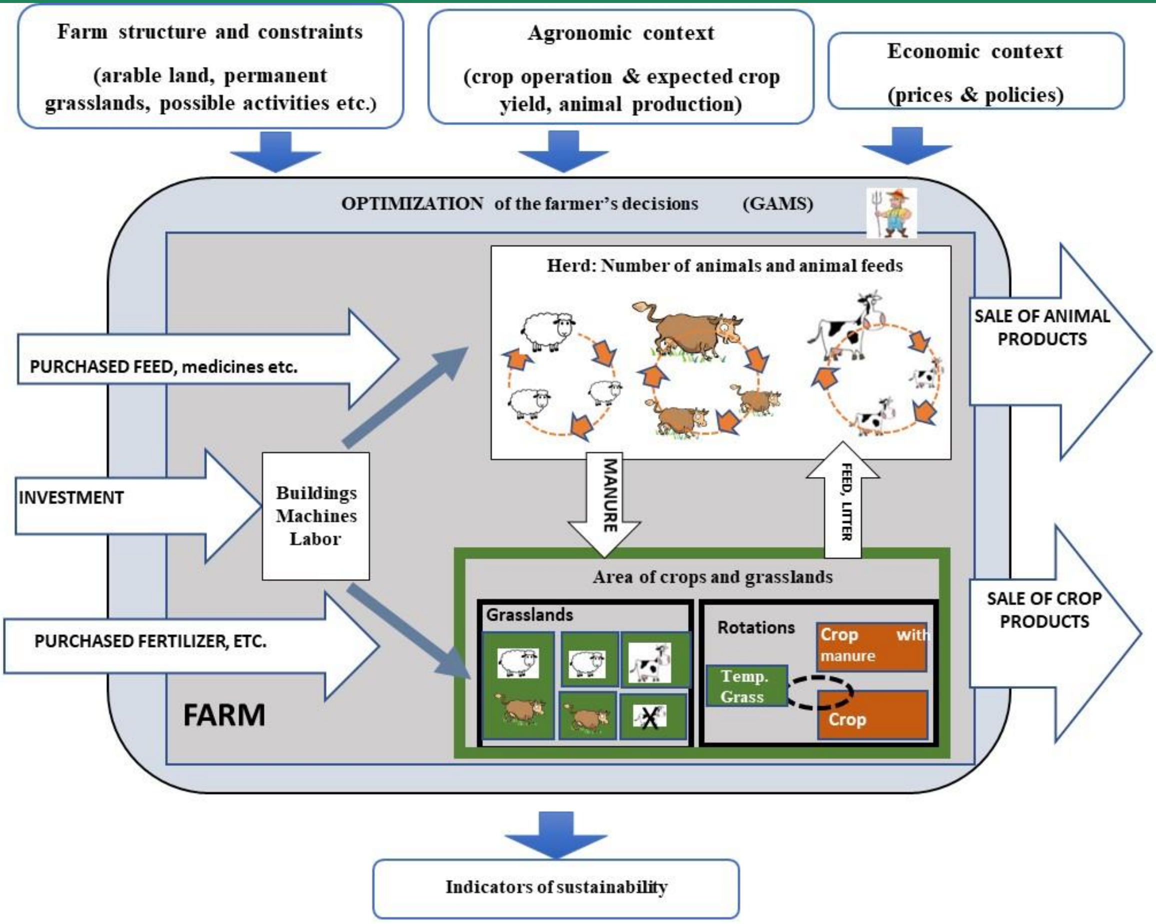

Figure 1: Representation of the Orfee Model (source: Mosnier et al., 2021)

The IAT(McDonald *et al.* 2019) is a whole farm model that captures the key economic and biophysical processes, and their interactions in smallholder farming systems. It integrates separate models: outputs from pre-existing farming system models (e.g. APSIM), and models for predicting cattle growth and simulating the economic performance of a typical smallholder farm-household (Fig. 2). A user-friendly interface forms the 'hub' of the IAT with links to other input forms." The IAT model was originally developed to assess Bali Cattle farming systems in Eastern Indonesia (Lisson et al. 2010), and has since been used in Vietnam (Parsons *et al.* 2011), China (Komarek *et al.* 2012), Pakistan (Shafiullah, 2012), west Africa (Rigolot *et al.* 2015), India (Shalander *et al.* 2017), and Ethiopia (Mayberry *et al.* 2017; Mayberry *et al.* 2018).

The IAT is no longer supported by the developers, and it has been incorporated into the CLEM model (https://www.apsim.info/clem/Content/Home.htm). The Crop Livestock Enterprise Model (CLEM) is a bio-economic model based on the IAT, but developed within the APSIM NextGen framework. As the model is recently released, there are no publications of CLEM or its results; however the model is well documented (https://www.apsim.info/clem/Content/UsingCLEM/UsingCLEM.htm).

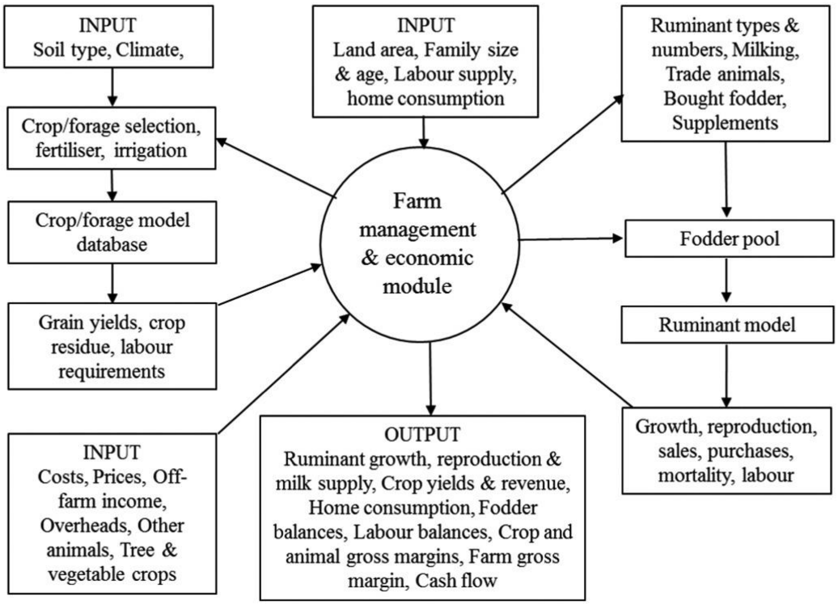

Figure 2. Structure of the Integrated analysis tool (IAT) (From: McDonald et al. 2019).

Table 1: Development and application of each model

	ORFEE	IAT
Origin of the model	France, Inrae	Australia, CSIRO
Previous model application context	-Prospective and GHG emissions for Beef and dairy cattle production in France (Mosnier *et al.* 2017b; Mosnier *et al.* 2020) -Simulation of the impact of a change of dairy breed in French dairy cattle farm (Balandraud *et al.* 2018) - Consequences of mixing beef and dairy cattle sheep (Diakité *et al.* 2019) and beef cattle, and, crop and beef cattle in Auvergne France (Mosnier *et al.* 2021)	Smallholder farming systems with Bali cattle in Eastern Indonesia (Lisson et al. 2010). Subsequent contexts and publications are listed at the CLEM website.
Platform & solver	GAMS with MIP solver CPLEX and Excel	Excel. IAT is not used for optimisation.

1.2 Agricultural activities considered

Each model gives the possibility to simulate farms with different agricultural activities. They are summarized in table 2.

Table 2: Activities

	Orfee	IAT
Cattle	Systems with or without cows (e.g. just calve fattening) Several beef and dairy breed possible at the same time and 6 periods of calving Suckler cow with optional fattening period Young Heifers renewal heifer that calve at 24, 30 or 36 m.o, Purchase/sale of pregnant heifers at 24, 30 or 36 m.o, Sale of fattened 33 m.o. heifer, or female calves at 3-week-old, 5 m.o., 8, 10 or 12 m.o. Young Males: sales of males of 3-week-old, 5 m.o., 8, 10, 11, 12, 18, 20, 22,33 m.o. Bulls for reproduction	Cattle of all age groups and types. Initial development for Bali Cattle. The model is largely based on published energy functions. The model has been adjusted to represent many tropical cattle breeds.
Sheep	3 periods of calving Ewes and replacement ewes kept for a first lambing at 12 m.o. Single and twin lambs could either be raised indoor and sold at 4 m.o. or outdoor and sold at 5.m.o. Ram	Sheep and goats are modelled in a similar manner to cattle.
Pigs	Systems with or without sows (e.g. just piglet fattening) Sows, Gilt, Piglet before/ after weaning and during the fattening	Pigs and poultry can be included as components of a smallholder farming system. IAT simulates the animal numbers, reproduction rates, and sales. Growth and reproduction are not limited by resources (i.e. growth is not simulated), however the cost of keeping them is accounted for.
Grasslands	Permanent & temporary grassland: grazed only, gr.+hay+gr, hay+gr., hay+hay+gr, hay+hay+hay, Wrap+gr, Wr.+wr+gr., Wr+hay+gr, silage+gr, sil.+sil.+gr, sil.+ hay+gr., green fodder Alfalfa: 3 or 4 years, hay or silage	All types of grassland are possible, but it is the responsibility of the user to provide the production and quality data.
Crops	winter barley, spring barley, winter soft wheat, durum wheat, triticale, grain maize, irrigated grain maize, sorghum grain, mix cereal/protein for grain, peas, soya, irrigated soya, sunflower, rapeseed, linen	All types of crop are possible, but it is the responsibility of the user to provide the production and quality data.
Forage crops	maize silage, irrigated maize silage, mix cereal/protein for silage intercrops	All types of forage are possible, but it is the responsibility of the user to provide the production and quality data.

1.3 Input/ output production

The simulation requires different information to be able to simulate each activity and the functioning of the farm. The following table 3 presents what the model needs and the results it can provide.

Table 3: Input and output of each model

	Orfee	IAT
Production decisions	Optimisation to maximise a function of profit under various constraints	The model is deterministic and not optimised
Crop production		
exogenous	for each grassland or cropping activity: -annual crop yields and monthly grassland production, -Monthly crop operations required, -N exported by crops, P&K needs, protection treatments, insurance, price of inputs and outputs	Land allocation to crop areas, Monthly production, crop, residue, and forage quality. Production costs.
endogenous	Crop and grassland acreage, grassland end-use, quantity and type of fertilizers, total production harvested, consumed and sold, labour and machines used, economic and environmental results	Fodder and residue pools. Sales of excess products.
Cattle and sheep production		
Exogenous	Monthly liveweight & milk production for each type of animal product, grazing period	Initial numbers, production coefficients.
Endogenous	Animal Diets, herd size and composition, animal sales and purchases, manure produced, feed purchase, economic and environmental results	Liveweight and milk production, sales and purchases, manure production, feed purchases, economic results, methane emissions.
Pig Production		
Exogenous	Age and weight of animal purchased and sold, reproduction and mortality parameters, quantity of feed consumed, share of feed produced on the farm, labour per animal, type of housing	Initial numbers, birth and death rates, consumed feed, economic results.
Endogenous	Total amount of feed consumed and animal produced, economic and environmental results	
Machines		
Exogenous	Investment and maintenance cost, fuel consumption, time required to do an operation for each type of machine	
Endogenous	Type of machines in ownership or hired, hours and costs	
Labour		
Endogenous	Max. number of family workers and employees; max working time per worker Time required per activity	Required labour, labour shortfalls.

Exogenous	Number of workers and working time required per month & year	Number of workers each month, their ability to do certain tasks.
Public policy		
Endogenous	Amount of subsidies and conditions for decoupled payments, organic payments, animal payments etc	
Exogenous	Amount of subsidies received according to production decisions	Many public policy options can be simulated if the exogenous effect on the farm household can be defined.

Notes: default data could be used for some exogenous data and some endogenous data could be fixed by the operator

1.4 Time and spatial representations

Orfee is a model that represents in each simulation the production result for one year. However, for a given production results, it can provide the economic results for different economic contexts. Some results are provided with a monthly disaggregation: cattle and sheep liveweight, production, diets and housing status, manure, grassland production and labour. Regarding crop rotation that spans over several years, Orfee defines activities that consider a succession of crops over two consecutive years so that the agronomic effect of the previous crops is considered on the current crop. In addition, constraints ensure that 1) the area of each combination of previous-current crops is consistent to be reproducible over several years, 2) the area of each crop doesn't exceed a maximum share of the total agricultural area that can enter in this rotation and that corresponds to the minimum rotation interval. Regarding investment, the cost of investment is split into the lifetime of the equipment which corresponds to a constant depreciation cost. The size of the building can be fixed by the operator to account for past investments.

Regarding space, Orfee doesn't take space explicitly into account. However, different categories of land can be defined: permanent pasture, maximum area that can be grazed by dairy cows, maximum area that can be irrigated.

By default, the IAT typically simulates a 10-year period, to enable the analysis of temporal trends. Thus, the model can be used to assess response to shocks or to assess different management options. The state of the system at the end of each month is the starting state for the following month. Labour and cash are tracked, however do not constrain management options or cause simulation scenarios to abort. Land is a resource that is fixed, and constrains simulations.

1.5 Risks and adaptation processes

Different sources of risks could modify production and economic results: climate condition, pest and disease, machine breakdown, worker disease etc. Farmers could consider these risks to take their decisions by choosing production systems less sensitive and less vulnerable to these risks. Vulnerability can be assessed as the probability for falling below a benchmark for consumption or income at an individual level (Hoddinott & Quisumbing 2010). It is the results of farm exposure to risks and farm sensitivity to risks. Sensitivity can be defined as the degree to which the system is modified or affected by an internal or external disturbance or set of disturbances (Gallopín 2006). It depends on farm risk management. Risk can be managed with both a proactive (ex-ante) and reactive process (ex-post). Various methods are used to model decision stages in time and space, and some methods can be combined to represent a sequential decision-making process (Mosnier *et al.* 2009; Robert *et al.* 2016).

Orfee can optimize proactive adaptation to economic risks by choosing a production system considering the probability of occurrence of different economic contexts. It will provide in outputs the optimal production systems and its performance for each economic context. However, it does not simulate sequential decisions making e.g. the simultaneous optimization of both ex ante and ex post production decisions. Nonetheless, it is possible to test alternative economic scenarios and to optimize only short-term decisions. Similarly, different levels of productivity or worker availability can be tested in different scenarios and the model could optimize short term decisions such as diet composition.

The principal function of IAT is to assess the potential effects of different intervention strategies, in response to hypothetical scenarios. It was designed to be used as a participatory tool with farmers, and therefore some of the model structure is simplified. IAT was not designed to optimise farming systems, but to simulate fixed scenarios and provide rapid feedback for the user. The model developers referred to this as "creep budgeting" which involves re-specifying various input and output variables in a systematic manner to explore the system response to these changes (Lisson et al. 2010).

1.6 Transferability, modularity and flexibility

In order to be reusable and transferable to other purposes or context, the model should be flexible and accessible (Janssen et al. 2010; Janssen et al. 2017; Jones et al. 2017). The flexibility is favoured by a modular (Louhichi *et al.* 2010) and generic structure.

Orfee proposes numerous options:

- Outdoor periods are specified by the user for each farm and herd
- A large range of animals (age/weight/ prices) is proposed, with possibilities to modify many default values
- Crop yield potential can be defined per region (countries) and adjusted farm by farm

Orfee is rather flexible as we can easily simulate (or not) some activities. The activities not selected will not be considered during the compilation and the optimisation. However, adding a new activity e.g. a different type of animal product or crops will require some modification of the code. The input data is generic so that the same excel sheets could be used to parameterize and store scenarios.

Transferability is the capacity of a model to be used by other people. Regarding Orfee, it is written mainly in French. The model is described in different scientific papers but not all the functionally and assumptions are explained in detail. Ideally the model inputs, outputs and code should include English translation and explanations. The model is complex and optimisation requires expertise to interpret results as a change in the input parameters can modify lots of dimensions (crop production, animal production, farm structure, economic results etc.). Claire Mosnier, who is the developer of this model participates in this project and could then provide support to overcome some difficulties

Early in the Mixenable project, development of the IAT model was discontinued, as the model owners focused on the development of the CLEM model. The CLEM model has many advantages over IAT: It is designed to be a flexible and modular tool, with many inbuilt functions that ensure that model assumptions are still valid when the structure of a farm is changed. However, CLEM is still under development, and requires further improvement and testing, particularly for European livestock and farming systems.

1.7 Conclusions and model selection justification

The project team decided early in the project to focus efforts on developing and applying the Orfee model, for the following reasons:

- Development of IAT/CLEM was in a period of transition.
- The new CLEM model was not currently designed for European farming systems.
- Both models required further development to add new livestock species, which would be a large undertaking if it were to be done for two models.
- The developer of the Orfee model is a project participant, so the lack of necessity to rely on outside project partners made it a safer choice.

2 Description of the main developments made for the Orfee model

2.1 Activity

The model was modified in order to be able to simulate the farm case studies selected.

Regarding beef cattle, we added the possibility to produce:

- Heifers sold at 6, 15, 18, 20, 30, 36 and 42 m.o.
- Lambs sold after birth, after weaning and at 7 m.o.

- To modify ewe productivity by adding a share of empty ewes

Regarding crop production we added low productive natural grassland that can be grazed only

2.2 Risks

In the Mixenable project, the aim was to assess the sensitivity and vulnerability of organic farm to risks, namely climate risks. It was accepted that it would be too complicated to introduce sequential decisions making within the core of the Orfee code. Instead, we decided to test different strategies by fixing long term decisions such as herd size, main crop allocation or maximum-security stocks and to optimize short term decisions such as feed purchases or sales, end-use of crop and animal production, storage or removal of security hay stock. Several simulations can be made to simulate various perturbations and to assess the overall sensitivity, vulnerability and sustainability of each farming strategies.

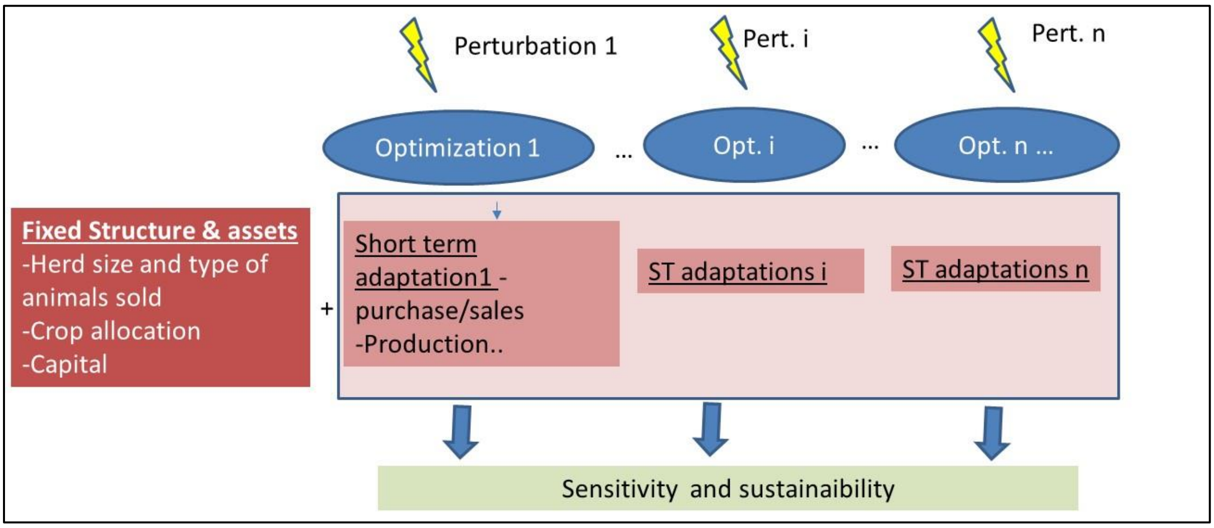

Figure 2: **Framework to simulate risk management and impacts of risks**

To do so, we added a parameter in the input files where the probability of the perturbation can be added and we also integrate in the gams code the possibility to have stock variation of cows and hay between the beginning and the end of the simulation years. This variation of stock was given an economic value.

2.3 Transferability

We improved the transferability of the model by translating the interface and of most model outputs in English (figures 3 and 4). We also provided training and support to the Swedish team and to the French master student. A first introductory session of training was organized in December 2019 by inviting Mukhtar Ahmed from the Swedish team in France. Unfortunately, he didn't stay on the project and was replaced by Leonardo Monteiro. Due to the covid, support was only provided by skype/teams which was less easy. No detailed documentation and user manuals are available yet.

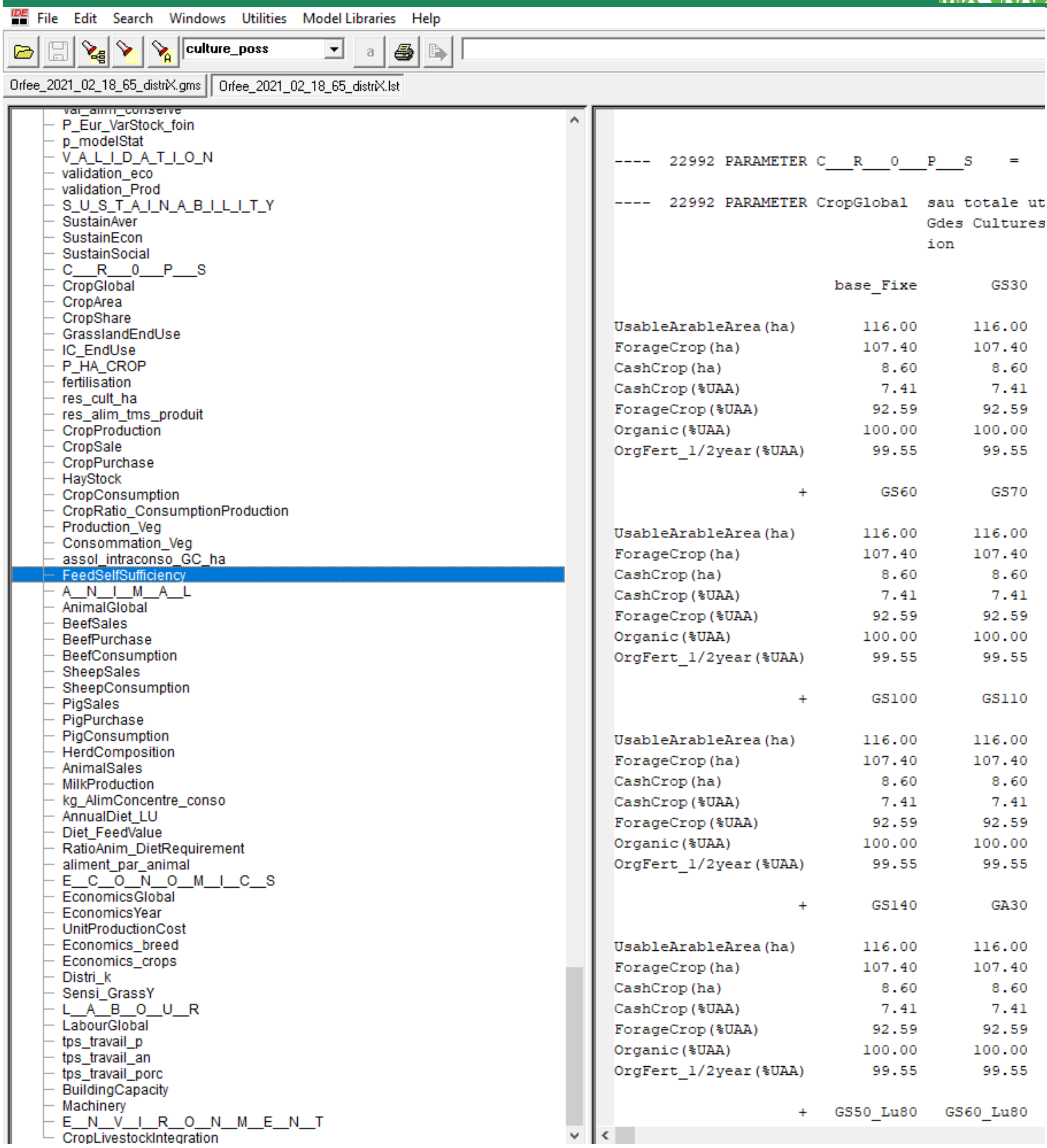

Figure 3: screenshot of a gams output file

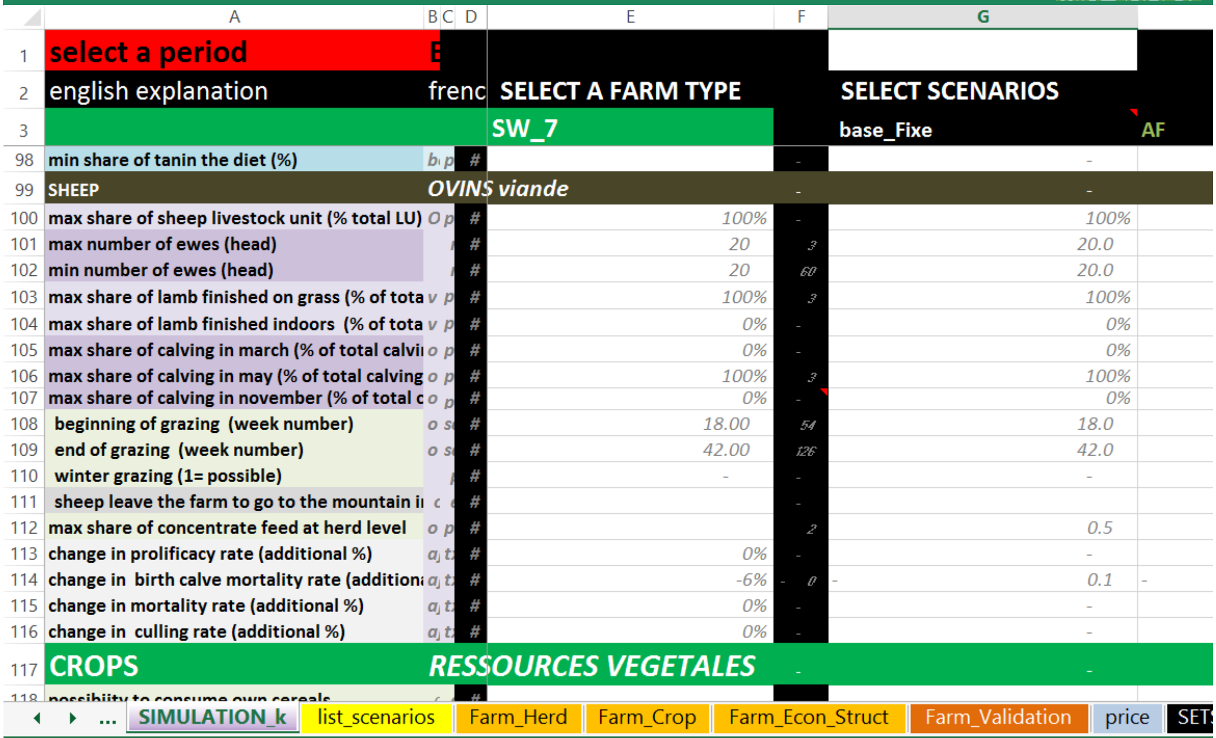

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Figure 4: screenshot of an excel input file

3 Indicators of Sustainability

Different indicators are calculated in Orfee to give information on the technical functioning of the farm and its detailed economic results (Figure 4). These indicators are important to understand the changes between the farming systems and scenarios. They have not been exclusively developed in the frame of the MixEnable project but efforts have been made to translate most of them in English.

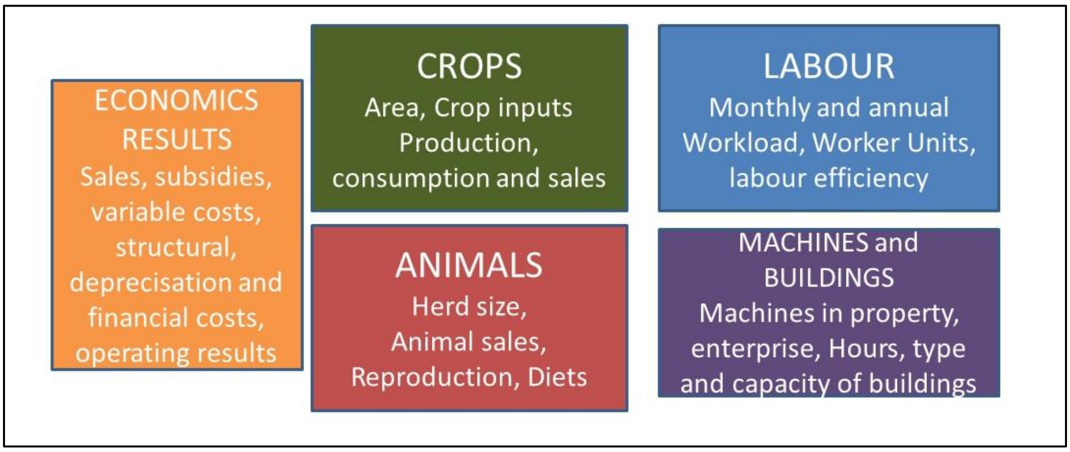

Figure 4: main type of technical and economic indicators

To assess farm sustainability several indicators are proposed for the different components of sustainability assessed (Table 4).

Table 4: Components which can be assessed for the different criteria

Economic pillar	**Environmental pillar**	**Social Pillar**
Average income for farm workers - Operating results *(net animal and crop sales + subsidies – variables and fixed costs)* - Operating result per associate worker unit - Hourly wage per worker	Global warming potential - GreenHouse Gas (GHG) emission on farm and during input production per ha, per kg of milk or meat, per kg of Human edible protein - Net GHG = *GHG – carbon storage*	Workload -average workload = *Hours/ worker unit/ week* - labour peak = *% month with more than 65 (or 55) hours/week*
Risk (indicator of variability of operating results) - Standard deviation - Coefficient of variation - Value at Risk (average income for the 20% lowest income)* - Probability of income below a threshold* - Subsidy dependency = *subsidies % Operating Result*	Biodiversity - Score derived from the High Environmental value methodology (Appendix) - Late mowing = *% of grassland with haymaking*	Employment -Spatial density of labour on the farm = *total hours spent on the farm/ UAA*
Efficiency of inputs - Technical efficiency including subsidies =*sales + subsidies / all costs except social taxes and wages* - French High Environmental Value	Fertilisation Score derived from the HVE methodology (appendix)	Food production - Production cost per unit of meat, milk, human edible protein or energy produced - Quantity of human edible protein or energy produced per ha - Feed food competition: ratio of human edible protein or energy in feed

indicators: Intermediate consumptions (€) / sales (€)		consumed by animals and in human edible animal product sold
Creation of economic value: Net added value per ha =*(sales – intermediate consumptions - machinery and building depreciation)/ usable arable area*		Animal welfare -animal grazing = *area grazed by LU in spring, or share of the quantity grazed grass (in tonnes of dry matter) in animal diet* -veterinary cost per LU

Conclusion

The model Orfee was chosen and used for the desktop simulations of the project Mixenable. This model was improved for this project by adding more activities to be able to simulate a larger range of farming systems, by proposing a framework to simulate ex-ante and ex-post adaptations to different type of perturbations and by translating a large number of model input and output. Applications will be presented in deliverable 5.2.

Appendix: details of indicators derived from the French certification High Environmental Value

A. Fertilization Score derived from the French certification High Environmental Value

The fertilization score is based on the criteria for the French certification High Environmental Value level 3A (https://certification.afnor.org/environnement/certification-haute-valeur-environnementale-niveau-3)

The composite HVE indicator "Fertilization management" is composed of 4 items: nitrogen balance, percentage of UAA not fertilized, percentage of the UAA covered by legumes alone and soil cover. HVE certification also considered the use of decision support tools which cannot be assessed from the Orfee model output

- **Nitrogen Balance**

The apparent balance considers the inputs and outputs of nitrogen on the "farm" system and is equivalent to a "nitrogen accounting balance".

Criteria	score
NB>80	0
80≥NB>60	5
NB≤60	10

Note: in Orfee we introduce intermediate scores for intermediate balances

- **Percentage of area not fertilized**

The share of unfertilized UAA includes:

- grassland that is not fertilized, except by grazing animals;
- areas under crops or covered by semi-natural vegetation, with no nitrogen input (neither mineral fertilizer, nor organic fertilizer, nor livestock effluent, nor composts or other), except by grazing animals

Criteria (% of UAA)	Score
[0 ;10]	1

[10 ;20]	2
[20 ;30]	3
[30 ;40]	4
[40 ;50]	5
[50 ;60]	6
[60 ;70]	7
[70 ;80]	8
[80 ;90]	9
[90 ;100]	10

- **Share of legume crops**

Legumes are plants of the Fabaceae family, which in the agricultural field refers to species cultivated for food purposes, both for human and animal consumption. The legumes taken into account for this item are the following:

- Protein crops" (including seeds): Protein peas, broad beans, faba beans,
- sweet lupin,...
- Pulses" (including seeds): Lentils, chickpeas, vetches, dry beans,
- Artificial grasslands with legumes (alfalfa, red clover, ...)
- crop mixtures containing legumes, protein crops or pulses,
- temporary grasslands (5 years and less) with a complex mixture of grasses and legumes.

The legumes that are not taken into account are the following:

- legumes whose seeds are harvested green (flageolet, pea) or harvested before maturity (green beans and mangetout peas)
- peas),
- legumes managed as intercrops,
- legumes grown mainly for oil extraction such as soybeans,
- permanent grasslands

Criteria	Score
Area of single legume crops ≥5%	2
Or	
Area of legume crops mixed with other crops ≥5%	1
Area of legume crops mixed with other crops ≥10%	2

- **Soil coverage in winter**

This item measures the percentage of the UAA covered in mid-November. Soils are considered covered if they have:

- A winter crop
- A vegetated system, grass or a perennial crop
- A nitrate trap intermediate crop (CIPAN)

Criteria	Score
Area covered ≥ 75%	1
Area covered ≥ 90%	2
Area covered = 100%	3

B. Biodiversity score derived from the French certification High Environmental Value

The biodiversity score is based on the criteria for the French certification High Environmental Value level 3A (https://certification.afnor.org/environnement/certification-haute-valeur-environnementale-niveau-3)

The "biodiversity" composite indicator in Orfee is the sum of the score of 3 items: Weight of the main crop, Number of plant species cultivated and Number of animal species reared. Three Items taken into account in the HEV certification are not accounted for in the Orfee indicators: “Presence of hives”, “Percentage of UAA in agro-ecological infrastructure” and “Number of varieties, breeds or endangered species”.

- **Weight of the main crop in the agricultural land (excepted from Permanent grassland)**

The weight of the main crop in the agricultural land is calculated as the ratio between the area covered by the main crop (excluding permanent grassland) and the UAA of the holding (excluding permanent grassland). The main crop covers the largest area. For grassland five years and under and crop mixes: each 10% of the UAA of grassland five years and under or of crop mixes counts as a crop consequently if they are the dominant crop their share couldn’t exceed 10% of the total UAA.

$$BiodivMainCrop(\%UAArot\ ) = MAX\left(\frac{CropArea(ha)_{crop \neq TempGrass\ or\ MixCrop}}{FarmArea(ha) - CropArea(ha)_{PermGrass}}; \frac{Min(0.1 \times (FarmArea(ha) - CropArea(ha)_{PermGrass}; CropArea(ha)_{(crop = TempGrass\ or\ MixCrop}}{FarmArea(ha) - CropArea(ha)_{PermGrass}}\right)$$

MainCrop (%UAA) Value	Score
≥ 70%	0
[60 ;70]	1
[50 ;60]	2
[40 ;50]	3
[30 ;40]	4
[20 ;30]	5
[0 ;20]	6

- **Number of plant species cultivated**

The aim is to identify the number of plant species cultivated on the holding: main crops, catch crops, mixtures of crops. The concept of species is used, so varieties are not counted. A species is counted regardless of the surface area on which it is grown. For mixtures of crops, the number of species sown is assessed and not the number of species actually present on the plot. For temporary grassland (5 years and less): one specie sown alone counts for 1 point, a "simple" grassland mixture (of grasses or legumes) counts for 2 points regardless of the number of species present in the mix, a complex mixture (grasses or legumes) counts for 3 points regardless of the number of species in the mixture. For permanent grassland each 10 % portion of UAA in permanent grassland counts as a different species.

$$BiodivVegSpecie(Nb) = \sum_{crop \neq grassland\ and\ crop\ mix} 1\ if\ CropArea_{crop} > 0 + \sum_{crop = Mix\ Cereal\ and\ protein\ or\ \ TempGrass} 3\ if\ CropArea_{crop} > 0 + \sum_{crop \neq PermGrass} \frac{CropArea_{PermGrass}}{FarmArea} \times 10$$

Note: winter and spring barley counts for the same crop, Alfalfa count for 1 specie, mix of cereal and protein crops account for 3

VegSpecie(Nb) Value	Score
<3	0
4	1
5	2
6	3
7	4
8	5
9	6
≥ 10	7

- **Number of animal species reared**

The aim is to identify the number of animal species reared on the farm. The concept of species is used for this indicator; therefore, it is not necessary to count the different breeds. To be considered, the species must be present on the holding for the purpose of breeding.

$$BiodivAnimSpecie(Nb) = 1\ if\ the\ number\ of\ cattle > 0 + 1 if\ the\ number\ of\ sheep > 0 + 1 if\ the\ number\ of\ pigs > 0$$

AnimSpecie(Nb) Value	Score
0	0
1	1
2	2
≥ 3	3

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