To manage livestock farming system, which tools for which goals and which users? Examples from France

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Examples from France

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Abstract. Farmers and their technical advisors use tools to manage livestock farming systems. Those tools are more or less complex and deal with decisions which can be either short term (tactical) or long term, having consequences on the system configuration (strategy). We present a sample of tools, used on the ground, particularly on sheep production, and based or not on a modeling process. They concern many domains, like feeding animals, managing the flock, work organization, range of animals to sell… We compare then those different tools, according to their goals, in relation with the users' involvement during the designing process. This involvement seems to be crucial, especially for long term decision tools.

Keywords. Model – Tools – Farming system.

Pour piloter les systèmes d'élevage, quels outils, pour quels objectifs et quels utilisateurs ?

Résumé. *Les éleveurs et leurs conseillers utilisent des outils pour piloter les systèmes d'élevage. Ces outils sont plus ou moins complexes et concernent des décisions qui peuvent être de court terme (tactiques) ou de plus long terme, concernant la configuration des systèmes (stratégie). Nous présentons un par un, un certain nombre d'outils, utilisés sur le terrain, en particulier en production ovine, et basés ou non sur une démarche de modélisation. Ils concernent des domaines très divers, comme l'alimentation, la gestion du troupeau (lots), l'organisation du travail, le choix des filières… Nous comparons ensuite ces outils, en terme d'objectifs, en relation avec le rôle qu'ont eu les utilisateurs dans le processus de conception, qui apparait déterminant, notamment pour ceux de ces outils qui portent sur des décisions stratégiques.*

Mots-clés. *Modèles – Outils – Système d'élevage.*

I – Introduction

Livestock farming systems (LFS) are complex, as it is not sufficient to analyse the functioning of every component to understand their global behaviour. Moreover, the evolution of the context in which are engaged many actors of agriculture (farmers, but also advisers, rural actors, etc.) is more and more complex and characterised by uncertainty. That's why researchers, with or without extensionists, have developed tools to be able to help decision making, to build frameworks representing systems functioning, including heterogeneous knowledge. As far as LFS are concerned, some of those tools are model-based, and are supposed to be useful either for extensionists or for farmers or for both.

Sheep-meat farming systems can be very different from each other, depending on aspects such as farm size, level of intensification, self-sufficiency, or even specialisation (possible mix with other livestock productions or cultures), the product types sold (weight, age), the seasons in which these products are sold, the economic indicators (level of investment, debt, gross margins), the degree of technical skills, the objectives of the breeders in terms of income, but also the workload. That means that tools must be able to capture all these dimensions, either individually or globally.

Farmers, at least in France and Europe, have access to a very large number of possibilities to be advised: technicians from chambers of agriculture and cooperatives, internet (technical, financial advice), advisers for accounts companies, veterinarians, consultants from banks, input suppliers, technical journals, etc. (Magne *et al.,* 2005). To complement the expertise of the people and to manage the interface with the farmers, tools have been developed, as a basis for advice, and also to mediate exchanges between advisors and farmers, or between advisors themselves on a side, and between farmers and another part.

Models are at the basis of many of the tools proposed; the scope of the use of modeling is very large, with a link between spatial and temporal aspects. According to the representation of Sauvant (2009) (Fig. 1), and under the approach dealing with this paper (breeding farms, extension services) we will present models starting at the level of technical issues until models operating at farming system level. The sub models (organs, cells) or above models (regional, national or even international) do not concern us here. We are positioning the examples of models and tools chosen on these two scales of space and time in Tables 1 and 2.

Fig. 1. Position of models studied according to a global representation of modelling with concordance of scales of space and time (from Sauvant (2009), *Modélisation systèmique*).

We will present some tools, either based on modelling processes or not. They differ also by their focus level: analytic or systemic. We chose them firstly because some users can be identified for each of them, which is not so frequent. Moreover, they all concern small ruminants, they all deal with the LFS level (flock or farm) and they are supposed to represent different categories of tools which are proposed, according to their goals.

In a first part, we will present each tool (type of modelling process, users and goals). In a second part, we will compare them within a discussion about actual needs for such tools. We will discuss about the issue of tools, model-based or not, largely used for sheep for meat production in France.

Table 1. Models and tools for farm management: which biotechnical scale?

Scale	Animal/Plant	Batch	Flock/Land	System
MODEL-BASED-TOOLS				
"Forage Rummy"		—	—	—
"Farm type"			—	—
"Ostral"		—	—	—
QuaeWork			—	—
INRAtion	—	—		
OTHER TOOLS				
"Choice lamb"	—			
"Batching diagrams"		—	—	
Flock Management	—	—	—	
Account software				—
Optimis. Crop production	—	—		
Pasture management		—	—	

Table 2. Models and tools for farm management: which time scale?

Scale	Day	Week	Month	Season	Year
MODEL-BASED-TOOLS					
"Forage Rummy"			—	—	—
"Farm type"			—	—	—
"Ostral"		—	—	—	—
QuaeWork				—	—
INRAtion	—			—	
OTHER TOOLS					
"Choice lamb"			—	—	
"Batching diagrams"		—	—	—	—
Flock Management	—	—	—	—	—
Account software	—	—	—	—	—
Pasture management	—	—			

II – Different kind of tools dealing with livestock farming systems management

Some of the tools proposed are traditional and simple farm management ones helping farmer's decisions under the condition "If ... Else". The solutions proposed are based on highly targeted parameters without giving an overview of the wide implications at the scale of the farming system. Other tools, model-based, have the ability to feed a reflection on the strategic choices of farmers, often through simulations. Note, however, that the boundary between models and management tools is not always so clear.

We choose tools to help decisions and strategies for several items: technical adjustments between feeding needs of the flock and local resources, adjustment of the type of products for better economic results, analysis of work organisation and level of workload, long term adaptation according to new goals taken into account.

1. Model based tools

A. The Forage Rummy (“Rami Fourrager”)

The Forage Rummy (Martin *et al*., 2012) was developed by Inra AGIR Research Unit in Toulouse. The players are farmers. The goal is to build a coherent forage system to feed a flock over a year initially defined by the players (numbers and lambing seasons). Players choose chopsticks representing the production of a given resource for one year (eg permanent pasture or corn). These rods were built on the basis of available scientific knowledge (yields depending on the area, the operating mode and time of year). The system built is considered consistent when food intake (including inventory and purchases made) can cover the needs of the animals throughout the year. The design goal of the game is to trigger discussions between farmers and analyse systems built on the basis of their knowledge (participatory process). An example of use of this game was for example to put breeders on a situation corresponding to a likely scenario from global warming (increase in average temperature and inter-annual variations) and see how they fit in the forage systems accordingly.

B. “Farm type”

The national device “breeding Networks‘ hosted by the Institute of Livestock (Institut de l’élevage) relies for sheep for meat production on monitoring of a sample of 380 farms spread in various French regions. These farms allow the development of regional typologies of farming systems based on the definition of farm types (IDELE, 2013). These are farms modelled, each illustrating a case of the typology (a farm with its structures, functioning and performances). The phase of “modelling” combines (1) observation and analysis of results of farms studied on many years, (2) the “alleviation“ of the impact of remarkable or specific years, (3) optimization and drawing up of the coherence of the structure and levels of technical and economic performances of the case presented by trying to position the performances a little above of the farms of the type concerned, and finally, (4) the expertise of the technical team.

The farm types can be used in different situations:

– For technical advice and training to farmers: the description of a farm type allows situating oneself (technical and economic benchmarks) at different phases of the life of the farm. It is also a training tool for the approach “farming system”.

– As an observatory of the economic situation and prospects: the technical and economic assessments of the farm types are updated annually. This allows, through an analysis of the evolution of a multi panel farm types, to analyse the effects of global economic situation on the economic performance of farms. In addition, the implementation of simulations enables to analyse –all things being equal, the impact of changes in macroeconomic parameters (selling price of products, cost of inputs, changes in support of the CAP).

C. Ostral

This software is a simulator that runs at the scale of farming system. It is based on the selection and consistency of a functioning of the reproduction cycle at the scale of the “campaign” (12 months) (Benoit, 1998). Then, the operator defines the resources used (types of forage and concentrates purchased or produced, depending on the batch and the seasons). Technical routes are pre-configured (to crop forages, to cultivate pastures and cereals) and generate an equipment fleet. Setting economic data (inputs and outputs prices, subsidies) allows the calculation of all the economic criteria (gross margins, income, cash etc.). Moreover, Ostral calculates the balance of GHG emissions (including carbon sequestration) and non-renewable energy consumption. Finally, a module can analyse the sensitivity of the results to the uncertainties on the economic situation (feed, energy, lambs) and on technical aspects (fertility, prolificacy, lamb mortality). It is planned to incorporate a “workload“ module (Dedieu *et al.*, 2000) in order to validate the consistency of the system on this criterion (peak of work). It is a research tool that could have an application for engineers and technicians through the simplification of the number of parameters and improving the user interface. This tool allows to analyse the technical, economic and environmental impacts of changing a better farming system in terms of seasonality of production, change of the type of product (age of lambs, fattening mode), degradation/improvement of technical parameters, extensification, adoption of specifications, improved feed self-sufficiency, changing conditions or agricultural policy, etc.

D. QuaeWork

QuaeWork (QUAlification and Evaluation of Work in livestock farms) is a tool to assess work productivity and flexibility on a farm, and it is used to identify how livestock management can contribute to work organization on dairy farms (Hostiou and Dedieu, 2012). The QuaeWork allows analysing work organization over the year through a systemic approach to the farm, integrating interactions between flock and land management, workforce composition, equipment facilities and combinations of activities through a characterization of “who does what, when and for how long”. The criteria for assessing work productivity are work duration (routine work, seasonal work) and work efficiency (per livestock unit or hectare of utilized agricultural area). The criteria for assessing work flexibility are room for manoeuvre and adjustments to internal and external events. The method suggests social sustainability criteria to assess work productivity and flexibility, which are important for making reasoned decisions on livestock farm changes, especially innovations. Researchers could usefully exploit the QuaeWork to integrate work objectives (productivity, flexibility) into technical and economic goals.

E. “INRAtion” – Diet calculation for ruminants

INRAtion – PrevAlim (INRAtion 2013) is a software package to calculate diets for ruminants. It includes the latest scientific discoveries tested by INRA. It is a multi-species tool: dairy and suckler cows, growing and finishing cattle, dairy and suckler ewes and dairy goats, which proposes theoretical diets validated by research. These diets can be analysed at the animal and flock level or even over time. This tool can be used for diagnosis, to establish a feeding plan for a particular animal, to illustrate the concepts, the principles or even the practical aspects of feeding and to prepare experimental protocols. The method of calculation is identical for all species. The results obtained can either, be similar for all production systems or, take into account the particularities of a species.

2. Other tools

In parallel to the types of models shown above, breeders get software tools that allow them at the same time to manage their farm, and/or to optimize the use of inputs and technical and economic performance, and/or to facilitate the management of their workshops.

These tools may concern for instance economic analysis, flock or surface management. It may also be accounting tools. Most of them are developed by private firms, instead of models above developed by research (Table 3).

A. “Choice of the type of lamb to sell”

This is a tool developed by researchers (INRA) under spreadsheet software and used for 15 years by the main regional cooperative for sheep production (Auvergne). It allows calculating the difference in gross margin from the sale of a lamb according to its type: heavy lamb (17-19 kg carcass) *vs* lightweight lamb (24 kg alive) exported to Spain or Italy. The economic interest is calculated taking into account: economic value of the lamb (in relation with the weight, the specific price per kg, the additional mortality) and cost (concentrate, hay, veterinary). The price of heavy lambs is based on their ranking on EUROPA grid, the daily growth gain and the amount of daily concentrates are to be set. The results are presented in a table showing the difference in gain between the two types of lambs, according to the price range expected for each.

Table 3. Models and other tools: who are the users (U) and who are the designers (D)?

	Farmers	Technicians and advisers	Research and Devlpt	Training	Private Company
MODEL-BASED-TOOLS					
"Forage Rummy"	U	U	UD		
"Farm type"		D	UD	U	
"Ostral"		U	D		
QuaeWork		U	UD	U	
INRAtion	U	U	UD	U	U
OTHER TOOLS					
"Choice lamb"	U	U	D		
"Batching diagrams"		U	UD	U	
Flock Management	U			U	D
Account software	U	U		U	D
Optimis. Crop production	U		D		D
Pasture management	U	U	UD	U	

B. Batching diagrams

These diagrams are graphical representations of the management of ruminants flocks in batches. On a diagram, each batch in the physical sense (in a parcel, in a stabulation compartment), is represented by a line under specific graphic conventions (Ingrand and Dedieu, 1994). On the basic frame based on the representation of all batch, the user can overlay all elements concerning the flock, such as feeding, reproduction (male taken in or out, periods of lambing and weaning periods...), health treatment, planning for pasture (the succession of paddocks used can be easily represented for each batch). The diagrams of animal allotment are used as a tool for gathering information on farming practices by students, but also by agricultural consultants and engineers in research and development in projects requiring collect information in private farms. Until now, the construction of the diagram was manual (paper, eraser, pencil). A computer tool has been developed and is currently being tested in two agricultural schools, in order to save the data and return by printing diagrams on a selected period. The objective is educational (farm visits by students or outsiders) and the project is to disseminate the tool, once tested in all agricultural schools getting suckler cattle.

C. Flock management

In the French context, the profitability of meat-sheep production is closely linked to the technical performance of the flock, itself based on the numerical productivity of each female. This one is based on ewe fertility, prolificacy and viability of the lambs. Also, it is essential for a breeder to identify within its flock females with "problems" (fertility in particular) to be culled.

With the expansion of the flocks, software tools then prove very useful, and can also be coupled to electronic identification of animals.

Many software packages are available in France. Some are linked to genetic monitoring of the flock through breeding programs: the data recorded in farms are directly "lift" in the collective data bases and in particular allow the selection of the best ewe lambs, via genetic indexing females.

Usually, the software used to flock to manage the flock allows registering transfers of animals and interventions: matting of ewes, lambing, mortality of animals, veterinary treatments. The coupling of electronic identification allows automatic sorting of animals according to the chosen criteria, in connection for example with specifications (Age lambs, number of veterinary treatments, natural milking, etc.). This type of tool allows farmers to sort their animals, to make inventories at key dates, to get flock performance at flock or batch levels (fertility, ewe productivity etc.). It is used daily.

D. Accounting software

This type of tool is used to manage the farm from an economic point of view: follow up of expenses and products, debts and account receivable, cash situation, level of investment and annual economic report. It allows monitoring these aspects and making the necessary tax returns. It also allows performing simple simulations for investments. In general, these tools are made available by accounts services, data entry is sometimes made by farmers, and the analysis carried out in the presence of a management consultant.

Other economic tools are now available for farmers. Thus, the web is an important source of economic information, particularly with regard to the quotations of agricultural products.

E. Work optimisation for crop production

Some tools combine recent technologies for geographic positioning to adjust the use of inputs relative to expected yields. During the grain harvest, a device recording the immediate yield is coupled to the GPS positioning of the machine. The database that is created is later used for spreading fertilisers, adjusting the dose to the observed performance in connection with the local agricultural potential of the soil. The geographical positioning is now very accurate and can even made an inter row weeding with high accuracy. This kind of tool can be used in the mixt farming systems, when the part of the cultures is consistent.

F. Pasture production

In the current context of increasing input prices, it is necessary for farmers to maximize forage self-sufficiency of their flocks (part of the flock needs supplied by forages). This involves, in particular, a significant contribution of pasture, both from qualitative and quantitative point of view. Planning of the use of paddocks to be pastured in the time and the provision of quality grass to animals can be made using a measurement tool of standing biomass and calculation of days before grazing. There is for example in France the Herbomètre® tool that allows this (Arvalis, 2013). This tool can easily be used by breeders.

All these tools are complementary to models-based tools: they are limited to optimize / facilitate technical behaviors that are elements building a production system.

III – Discussion

1. Users are not obviously decision makers

We have seen that both the model-based tools and the other tools can be used by farmers or by external persons involved in the farm. These are numerous, belong to different organizations, and can have financial interests to intervene in the firm. We can include: bank representatives, technicians from cooperatives (for inputs or output), veterinarians, extension services, agricultural equipment sellers and various private companies.

These people can be valuable sources of advice for farmers because they are often highly specialized in their field. However, they very often have commercial interests that guide their advices; in particular, only few of them can advocate the development of autonomous systems restricting the use of inputs. Rare are those who have a global vision of the production system and a fine view of all technical components of the farm.

As such, the development and use of simulation models with “systemic” approach (as Ostral for example) can be valuable because they provide most often a multi-vision of the farming system (economic approaches, environmental, social, sensitivity to hazards, etc.). In particular, advisers from the chambers of agriculture can use tools of that type, but this requires from them a significant flexibility and a good level of training.

Similarly, it is necessary now that farmers have a good level of training to build their own analysis by the synthesis of all the information provided to these people and these tools.

Livestock farming systems can be defined with different boundaries (Landais, 1987), from productive workshops within the farm (Coléno, 2002) to communities of farmers valorising a common pool of resources on a given territory (Badini *et al*., 2007). Every model or tool built within a modelling approach which we presented previously have a common property: they are simple to use and to understand. Some of them are very specific and are supposed to solve one problem, eg “which kind of lambs to sell?”. Others are more complex as they deal with the whole management of the flock (Ostral, flock management tools). Some models are useful to assess some performances, such as breeding or genetics (Ostral, tool for flock management) and other ones to evaluate different configurations at the system level (farm type, batching schemes, Rummy Forage). Most of the time, they have also been elaborated together with final users who are not farmers themselves, but rather extensionists and people aiming to advise farmers. This is the case even for the “Rummy Forage”, as the games are performed with researchers or experts of the tool. Paradoxically, in this case, the results are mostly useful for researchers than for farmers, as the objective is to assess farmers’ knowledge and strategies, instead of helping to make a decision for a specific and real situation.

2. Involving the users in the design process can be useful

Improving the usefulness of a model intended to be used as a development tool can be seen as a functional motive of implementing stakeholders’ participation in modelling processes. In the domain of crop systems, successful experiences do exist in participatory design so as to obtain tools that are better adapted to their users’ needs: for instance a tool aiming at supporting breeders, growers and food suppliers in assessing soft wheat cultivars performance (Prost, 2007), or a wider participative research project, FARMSCAPE, involving the Australian farming community that aimed at exploring whether farmers could value simulation as a decision support tool for managing their farming system, and if so how to deliver it cost-effectively (Carberry *et al*., 2002).

Livestock modelling can concern systems defined by different boundaries, from an animal to a productive workshop or even the whole farm. That system can be analysed from different disciplinary points of view, which results in different ways of analysing and accompanying the changes. The targeted users may differ between models, and there can be different ways of conceiving an intervention aiming at accompanying actors, so that it is possible to formalise different typologies of models according to the way they operate as accompanying tools (Girard and Hubert, 1999; Keating and Mc Cown, 2001). Last, the place given to the targeted users in the design process of the model can vary between the models although there is an increasing concern about the users’ participation so as to make the models more appropriable (Newman *et al*., 2000; Mc Cown, 2002;

Woodward *et al*., 2008; Cerf *et al*., 2008). We assume that tools can be prescriptive, i.e. giving "the" best solution according to one situation, if the decision is short-termed and deals "only" economic or technical aspects (ie selling one or another category of animal). But for global issues, we believed that to be non-prescriptive is a great advantage and a decisive reason for models and tools to be well accepted by users. We can also see that the tools designed to help livestock management, including these supposed not to directly help to take decisions, are fairly widespread in farms or in breeders advisors "toolboxes" (flock management, allotment schemes, farm type).

Regarding models at the scale of the farm, they are numerous but we can consider that only a small minority may be useful to farmers in a vision of "redesigning" their farming system. Gouttenoire *et al.* (2011) Identified 79 modeling tools of livestock systems for the period 2000-2009 in journals listed, at the farm level or below (forage system, flock management...). She identified three types of models: (i) simulation based on decision rules (39 models). These models address different disciplinary levels, but farmers are not involved in their design which greatly limits the interest they may have (inadequate consideration of their questions); (ii) economic optimization (15 models). These models (net income maximization) cannot afford to assist the transition to a new farming system; moreover, the "black box" aspect does not give the keys to adapting the system, which interested farmers; (iii) dynamic simulation (12 models). These models operate in a dynamic simulation based on a management guided by the overall objectives of the breeder. However, these models have difficulty articulating time scales, different disciplinary perspectives and different subsystems. Their interest is limited as a tool to support farming system redesign.

Overall, it appears that complex modeling tools (simulation, dynamic operating) are often developed as research tools but are rarely used directly in the field as tool for discussion and decision at the farm level, with an active role of the farmer. Tools such as those discussed in section II.2., more thematic and often based on the farm data itself, does not make it possible to drive a profound reflection on the redesign of a farming system but they make real service to farmers on their scope (management of the flock and land, investment etc.).

3. Are these tools usable for other production than sheep for meat?

We can focus on ruminants (sheep, cattle, goats) for the production of meat and milk. All tools presented before can directly be used in dairy sheep production, except Ostral for which a work of adaptation is necessary (in particular the characterization of milk production in terms of seasonal volume and value).

The great majority of these tools are also usable in beef and dairy cattle productions. The tool "choice lamb" could be easily re-developed to choose the type of fattening cattle (weight, type of feeding).

There are other softwares such as Ostral, operating at the scale of the farming system, developed for dairy or beef cattle production, albeit with different objectives and concepts (Gouttenoire *et al.,* 2011). For example, Opt'INRA is a software for suckler cattle production that is looking for the farming system that gives the higher economic result under a panel of constraints (agronomic, price or aid) (Veysset *et al.,* 2005).

At the scale of the farming system, there is currently no generic multi-species model. It seems difficult to consider as mono-specific models can already be extremely complex. Their complexity is usually linked to the sharpness of the biological characteristics in relation with the specificity of the local context. The use of such models in new situations requires large soil and climatic parameters. These sophisticated models cannot be used outside of research activities.

IV – Conclusion

The tools to help farmers in their activity are now very numerous and of various kinds. They have different objectives from the daily control of the activities of the farm (to optimize the flock or land management for example) to the redesigning of the farming system.

Regarding the models at the scale of the farming system, they are mainly research tools that cannot be used by farmers themselves, especially the must encompassing ones which seek to identify the impact of changes or reorganization of production at farm scale, through several evaluation criteria. These tools come up against the complexity of their implementation and the difficulty of taking into account specific factors of the farm as pedoclimatic or socioeconomic conditions. The advantage of these tools is mainly to be used as basis for discussion in discussion groups. The latest versions of these tools allow an overall rating of performance of livestock production systems, which appears essential towards the new features that are expected of livestock and its environmental and social consequences

Farmers can benefit greatly from the development of all these tools to adapt to the changing socio-economic or climatic contexts. However, many of them have to be implemented at a collective level, and anyway by persons trained in their use (technician). In addition, maintenance is usually essential to their sustainability. Other tools, more sector-specific, can be used directly by producers in everyday life.

In all cases, the training of farmers in the different disciplines needed to manage a farming system is essential (animal science, agronomy, economics and management, computer) to take advantage of these tools, individually or in collectively.

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