Adaptability through spatial management: a case study of livestock farms in the Massif Central (France)

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Abstract: *Over the last 15 years livestock farms in Europe have faced considerable changes in their socio-economic environment. Furthermore, many of these farms are situated in areas with heavy environmental and agronomic constraints. Adapting spatial management to socio-economic changes is a real challenge for these farming areas. This research work analyzes and compares the forms of assignment and management of farm territories in mountain areas of French Massif Central. It also describes various forms of farm adaptability with regard to spatial management. The studied area covers two agricultural regions where permanent grassland and cattle farming predominate. We investigated the spatial management of thirty three livestock farms and its links with cattle management and the farming system. The analysis confirms the role of known factors influencing land use (relief, distance, agronomic potential, etc.). Other less known factors have also been identified: collective mountain land management, location of buildings assigned to animals, environmental or production specifications, collective family farm organization. All of these factors are combined in different ways, revealing distinct spatial management in livestock farms, particularly in terms of fodder securing systems. Moreover, we highlighted that the spatial management is a good clue to analyse the adaptation possibilities of livestock farms. It results from a combination of several constraints, concerning the agro-climatic conditions, the farm-land lay-out, the conditions of implementation of the fodder system, and at last, it seems to be particularly adapted to each farm, according to its current farming system. In the regions investigated, the adaptations of livestock farm may be difficult in the future, because the three kinds of the conditions and constraints present simultaneously important uncertainties or changes.*

Keywords: *forage system, cattle, land management, farming system, adaptability.*

Background and issues

Livestock farming uses a large part of the world agricultural area (30 % of the ice-free territorial area, 20% of the EU-27 area, Steinfeld et al., 2006) and concerns an important part of less favoured areas. Over the last fifteen years these livestock farms have faced considerable changes in their socio-economic environment: variations on meat product markets due to sanitary crisis, emerging countries production and monetary fluctuation; revision of production support mechanisms linked to WTO and CAP (Common Agricultural Policy); rising and diversifying demands; environmental and sanitary laws and codes, etc. Thus, the evolution of livestock farming system's land use becomes a considerable stake for the future, particularly in less populated mountains areas. Moreover, many livestock farms suffer agronomic constraints (dry or humid mountains) which limit the adaptation of such farming systems.

The present analysis is part of an ongoing research project on changes in livestock farming and the dynamics of rural areas (TRANS project : «Transformations de l'élevage et dynamiques des espaces» of the French ANR program « Agriculture et Développement Durable » - ANR-05-PADD-003). The project involves research and professionnal institutes, and universities working on French mountainous regions (Alps, Massif Central, Pyrénées) and on southern livestock regions with contrasted features (Sahel, Pampas, Vietnam).

Recently, many studies have focused on the links between livestock activities and land use management with different approaches in term of study scales, time periods, and impacts (Brossier and Dent, 1998; Gibon *et al.,* 1999; Monestiez *et al.,* 2004). Some methods used imply some limits, e.g.:

- in some studies, the consequences of changes in livestock activities on land use are only addressed at a regional scale (e.g., Verburg et al., 2006), and do not include internal factors of the farms;

- in other studies, the analysis of farms functioning and their adaptation to background changes, does not include links with changes in land-use and the landscape in which these farms are located;
- in other studies, the analysis is addressing only selected farm types, key factors and comparisons of spatial distribution of practices on different farms (e.g., Zander and Kachele, 1999).

Overall, few studies have linked the different scales relations, the different farms links, the different land-uses and farm-constraints ties. One of the aims of the TRANS project is to associate research teams and studies concerned by these different points. The project also aims to provide information on potential land use change as a consequence of major changes in cattle breeding context, based on the comparison of land use management at farm level and territory level in very different socio-economic and agro-climatic context in the world. The analysis reported in this paper focuses on one study region (a mountainous area in the French Massif Central) to show first investigations and results on current spatial functioning and adaptations in livestock farming systems.

In this work, we consider the land use practices as defined by Girard *et al.* (2001), with the aim to identify the factors involved in the choices in land use management at the farm level. Further, we want to identify their hierarchy through a set of decisions rules (Murray-Prior, 1998; McGregor et al., 2001).

Research materials and method

The aim of our research is to compare the spatial management on livestock farms, and their potential adaptation to changes in areas with heavy agricultural constraints. To do this, we focused on two adjoining mountainous regions (see Fig. 1) which suffer important agro-climatic limits in the French Massif Central. The first one, the "*Monts du Cantal,"* is a region of crests and valleys with very different altitudes of farming areas (800-1800 m) and a humid climate (>1200mm/year). The second one, the "*Planèze de St Flour"* is a high basaltic plateau, protected from the west by the *Monts du Cantal* reliefs and where summer drought occurs regularly.

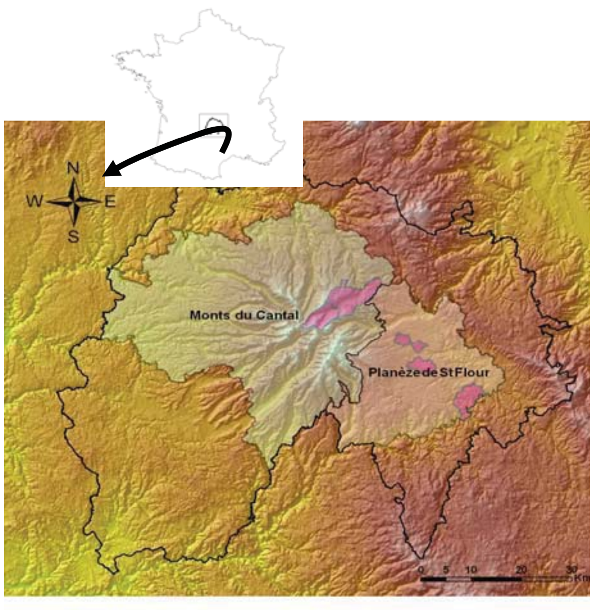


Figure 1. Location and topography of the study areas

These two regions present characteristics that make them very sensitive to changes of the CAP and thus a good object to analyse future prospects of livestock farming in European mountain areas:

- Cattle farming predominate, with three main systems: i) specialised in dairy production with added-value of Protected Designation of Origin (PDO) cheeses; ii) with suckler cows and grass calves production, iii) a typical dual herd system combining the two previous systems within the same farm unit.

- The fodder systems are based on permanent grassland, with an important need of stored fodder because of a long winter housing (≅ 180 days) in the *Monts du Cantal*, or because of a strong summer drought in the *Planèze de St Flour*;
- For these regions, the last agricultural census in 2000 revealed frequent abandonments, enlargements, and conversions from dairy to meat farming;
- These regions will be concerned by some changes in production specifications linked to reinforcements of the cheeses Protected Designation of Origin (PDO), the sanitary demand on animals, and the quality of alimentary products.

Inside those regions, we focused on five little areas (corresponding to 5 French *Communes*) typical of the geographic diversity of the two regions. To capture the effect of the diversity and interactions between farms, we chose to survey all the farms in the five communes. It corresponds to a total of 85 farms, and currently 35 have been surveyed. The survey consists of four parts: i) a "classical" one of discussion on history, structures, orientation of the farm; ii) the current farm territory characteristics (components, location, management, uses) by drawing and explaining a schematic map of the farm, iii) the fodder system components (areas and periods intended to each type of stock and animal pasture); iv) the farmer's explanations on his choice of pattern for animal grazing.

The first analysis showed an important diversity of fodder system components inside and between farms in terms of land-uses, practices, spatial arrangement and time positions, even in similar types of farms (orientation, size). Deepening and comparing the characteristics and determinants of that diversity, it is possible to show the place and limits of the spatial organisation and functioning in farms adaptation to a set of constraints. To illustrate these points, we compare in this paper two pairs of similar farms which illustrate well the diversity in feeding systems:

- one pair of small dairy farms (35-40 ha; 20-30 dairy cows) which harvest 2/3 of their area to stock as hay and wrapped bales, located in the *Planèze de St Flour;*
- one pair of large mixed dairy and suckler farms (102 ha; a total of 50-60 dairy and suckler cows) which harvest only 1/3 of their area to stock as hay and wrapped bales, located in the same valley of the *Monts du Cantal*.

We compare each pair and point out the similarities and differences in fodder management and in field-uses pattern (see Tab. 1 and 2). We then identify the determinants of these differences, based on the characteristics and trajectory of the farming system. Comparing the two pairs, we show the important role of the spatial management in farming system adaptation under the multiple constraints farmers face in these mountain areas.

Initial research findings

With the four farm-cases selected for this paper, the objective is to illustrate a finding standing out the first analyses of the 35 farm surveys: the livestock farms have some capacities to adapt their spatial management in reply to their fodder system and their other specific farm constraints. Further more, our objective is to show the interest of spatial management analysis to evaluate and to understand the potential adaptations of farming systems facing the new and important changes of the agricultural context.

Different spatial management for similar farm types

For the two dairy farms selected, production, land uses and part of area for stocks are quite the same. But looking at their fodder system schedules and their field-uses patterns, we note important differences in the type of harvests calendar and location (see Tab. 1). On the first farm (called D1) we can see many different combinations of harvesting techniques and periods (first spring cut and second summer cut, hay and wrapped bales). This is partly justified by the division of the land and by the agronomic diversity of the plots. On the other farm (D2), the harvesting shape is opposite: the fodder harvests concern a large area and a tight period at the end of spring and only for hay. This makes possible an added-value for the milk, produced with no fermented fodder and used for a cheese sold in a specific quality line. It also enables some simplifications in harvest work of the farmer, required by his dual activity.

This contrast between the two fodder systems goes with differences in grazing management constraints and practices. The important land division of the D1 farm makes a major constraint for dairy cows grazing. The farmer bypasses it by yearly integrating the largest fields, after a first mowing, into the grazing turn. The sequence of different harvesting periods and forms enables a spreading of re-growths to progressively open the fields for grazing. Moreover, at the end of the harvests period, the farmer comes to an arrangement with a neighbour for a seasonal exchange of plots for autumn grazing. This makes the farm spatial functioning more complicated.

Others elements differentiate the spatial functioning and the management of these two farms. Whereas the first farmer partly adapts his work to the fields and the year, the second has more systematic and repetitive practices to simplify his planning and tasks according to his “hay-only” system and his areas location. The order in which he mows his fields is the same every year, and governed by their distance to the caw housing and the possibility to include them in the grazing rotation system.

The two examples of "dual herd" system selected (DH1 and DH2) also have similar characteristics: labour force, size and geographical location of their areas, large and high-altitude farm-fields rented by the village community who owns the land and periodically decides of its allocation. Nevertheless, as for the dairy farms examples, their spatial management is different (see Tab. 2). In the first case (DH1), the area located at the bottom of the valley is limited to the quarter of the total farm area, is highly fragmented and concerns mainly mowable land. Due to this constraint and to the late start of vegetation in high-altitude pastures, the turnout to pasture of the cows must be on fields which will be mowed later. This contributes to delay the mowing dates, and certain years it may compromise the hay harvest.

On this farm, the traditional livestock system based on a hardy, local and dual-purpose breed (Salers cattle) also contributes to the original spatial management: each cow is a dairy cow and milked one part of the year, and a suckling cow the other part. So, after turning out to pasture as a single dairy herd, the farmer split his herd in several groups for summer grazing. The size and composition of the groups depends on the plot structure, the cow lactation, the calf age and sex, and the land ownership status.

In the second "dual-herd" farm-case (DH2), both productions are managed more independently. On one hand, the livestock farming system is based on two separated herds, one dairy and the other suckling. On the other hand, land structure imposes fewer constraints than on the farm DH1 and enables more possibilities and ease for milking, grazing and harvesting. In particular, an eleven-hectare grazing field, with a building fitted with a second milking place, enables rotating grazing for dairy cows like in specialised dairy systems. These conditions allow relieving the pressure of topping on plots adjoining the main building.

As in the first case (DH1) the suckler cows mainly graze on the high-altitude pasture rented from the village community, but the farmer has a greater land-use security due to an eight-year agreement. So he fertilises this pasture and he increases the summer grazing livestock by boarding cows from others farms. Moreover, he also has a 40-hectares farm, 20 km from his farmstead. To avoid transport of animals and to limit visits in winter, this unit is only used for heifers, with an adequate work organisation, and a partly independent spatial management: most of the fodder harvested is hay and as the volumes exceed heifer demand, part of the forage is returned to the main farm.

Key factors influencing spatial management

These four examples illustrate the complexity and diversity of the spatial management on farms in a region and within livestock production systems. Beyond these examples, the review of the characteristics, the fodder systems and the land use modes, for the 35 farms surveyed, highlights the main factors which interact with their organisation and spatial management. Some are well known, e.g. the type of farming or the field pattern, even if their interactions process is not well understood. But other factors, less well known, also emerge from our analysis: the "pattern of buildings", particularly the relative location of the buildings assigned to each batch of animals, the land ownership status, and the farm commitments to environmental or quality production specifications.

The type of livestock production

Linked to differences in grazing practices and winter rations, the crop management sequence differs between dairy and suckling farms. We also noticed more differences between milk producers than between meat producers, and a wider range of practices in terms of harvesting and grazing methods in the case of dual herd systems.

Looking at changes of practices during the last 10 years, the strategy and adaptation pattern implemented by farmers appears to be different between the two production systems. Among dairy producers, there is a tendency to replace early spring silage by middle-spring wrapped bales, a more flexible solution in terms of work organisation and supply management. At the same time, meat producers have enlarged their area and volume of wrapped bales harvest. So, even if the proportion of wrapped bales out of the total harvested remains lower than in dairy farms, these two tendencies suggest that progressively, animal feed, harvest practices and land-uses, are less and less specific between dairy and suckling farms.

The field pattern

Distance between different plots, as well as their distance from the farmstead, is frequently cited as a driver of livestock and land management practices (Brunschwig *et al.*, 2006; Andrieu *et al.*, 2007). It affects the choice between mowing or grazing, the gang organisation, or the grazing management (turnout to grass, batching, grazing circuit…). For dairy farms, the field pattern becomes a major constraint: In the farms investigated we observed different ways to remove this constraint, which have effects on grazing practices and management:

- Using an itinerant milking shed, moved between once a week and once a month. This practice is widespread on the *Planèze de St Flour*. The shed is preferably installed in the largest and/or central plot of a group of grazed fields and the animals are moved to it. The shed is then transferred to the next group of parcels. This alternative is also considered as a way to temporarily alleviate the lack of comfortable equipments for milking in buildings.
- Outdoor milking, in a pen and using a small milking machine on the tractor. The pen in moved each three or four days in a whole "mountain" range. This practice may be observed in the *Monts du Cantal* and is a continuation of local traditional system but with an adjustment. The "mountain" range is now divided in two large paddocks and it corresponds to an intermediate system between extensive free grazing and rotation grazing (see farm DH2);
- Installation of a second milking machine in a building located near a group of grazed fields that are distant from the farmstead (see farm DH1);
- Arrangement with neighbours and seasonal exchanges of plots for back-end grazing after mowing in distant or enclosed plots (see farm D1).

The housing pattern

Because of the progressive enlargement and consolidation, some farms have several animal housings. Their location, capacity and equipments may introduce important constraints which influence the spatial management. Depending on the location of each building, on its accommodation capacity and on its standard of fittings and fixtures, the land use and management (fodder harvest and grazing priorities in the time and on the space) are locally adapted to the animals (type and number) grazing in summer or housed in winter (see farm DH2).

The status of land ownership

One feature of the investigated areas is the presence of collective land properties of village communities inherited from the French revolution and the traditional agrarian systems. Locally, these properties can cover the major part of the district territory (over 65% in certain cases) and consequently of the farms areas. Depending on the villages, the availability of the land guarantees farmers a more or less perennial land-use and affects their level of intensification and input use. In accordance with the renting land status defined by the village, the farmer considers or not the rented hectares in his farm area for his aids or taxes demands, with important economic and technical consequences.

The commitments for environmental or quality of products specifications

More and more, livestock farms have to integrate environmental and/or quality production specifications, with commitments on practices relative to harvest, fertilisation, fodder system, etc. and which concern the all farm or part of it. The example of the farm D2 illustrates this point: the commitment to a quality line relying on a “hay-only” fodder system largely governs the farm’s spatial management. In other regards, the commitments associated with eco-friendly agricultural measures are also drivers of changes that farms have implemented in their land management (maintaining land under grass, adaptation of fertilisation, cutting date, etc.).

But for an easy overall coherence of the fodder system to these commitments, farmers also frequently leave a part of their areas, animals or production out of the agreements. In this way, they keep some adaptability in grassland management and fodder balance. Some fields are left out the commitments, and are particularly intensified because of restriction on others fields. In term of spatial management, these combined and increased spatial differences in the land use on a farm.

Spatial management and farmers' choices

The spatial management of the farm results from the combination of different factors considered altogether, and according to the possibilities and the choices of the farmer. The explanations of these choices reveal that the farmers organise the overall coherence of the farm land-uses with regard to different functioning levels. They primarily consider the balance of fodder system, seeking to ensure the winter and summer needs of their herd by some few standard itineraries and production on the largest part of their farmland. They then introduce space and/or time adaptations which change these itineraries more or less, and affect a larger or smaller part of their farm.

On the farms surveyed, level and type of fertilisation and/or field maintenance practices is not highly varied on each farm (3 or 4 standard itineraries).The set of standard itineraries deployed on each farm primarily depend on the main methods of fodder production (silage, wrapped bales, hay, grazing). The diversity of itineraries encountered on a farm, on one field and between fields, is mainly based on a more or less complex and varied combination of fodder productions methods. Spatial adaptations to these itineraries are often introduced in response to specific agronomic conditions related to plots and field pattern (bearing capacity, production potential, earliness harvesting, accessibility), to production features (types of livestock, destination of animal production, etc.), or to breeder's technical options.

Two different terms can distinguish time adaptations, which can be observed on farms:

- the first one concerns seasonal adaptations which modify the sequence defined at the beginning of the crop year. Adjustments are decided at certain key moments as turn out to pasture, end of first cut or start of autumn regrowth. Mainly they concern the production method according to the stock level, the bearing capacity of the fields, or the weather conditions;
- the second one, which has been less studied, covers several years and permit to distinguish farmers who adapt their work organisation depending on the year from farmers keep the same organisation from year to year (grazed field order of rotation, mowed field order of production, animal grouping strategy, etc.). In such a case (see e.g., farm D2), the changes result from a major shift in the farming system: land acquisition, change in the labour force, system realignment, etc.

All these combination patterns between the different factors and adaptations reveal distinct land management strategies, in particular to increase the security of the fodder system. Farmers who prioritise fodder self-sufficiency pay more attention to their land management, and closely differentiate their itineraries and operations on their plots according to the features of each field and to the current forage year. They also adapt the size of their winter-housed herd to the volume of fodder stored for winter with an impact on the heifer count or early sale of cull calves. They may even reduce the size of their cows herd. At the opposite, farmers who prioritise the production target (milk quota, number of cows, etc.) purchase more frequently fodder from outside the farm. In some cases, this purchase has become a regular practice and part of the farming system.

The fodder system organisations and spatial management modalities that we have reviewed suggest that different farmer profiles exist in a small region varying between "breeders" who first target their interventions based on the condition of their livestock and "grass growers" who generally modulate and fine-tune their land management according to the vegetation on their plots and land divisions.

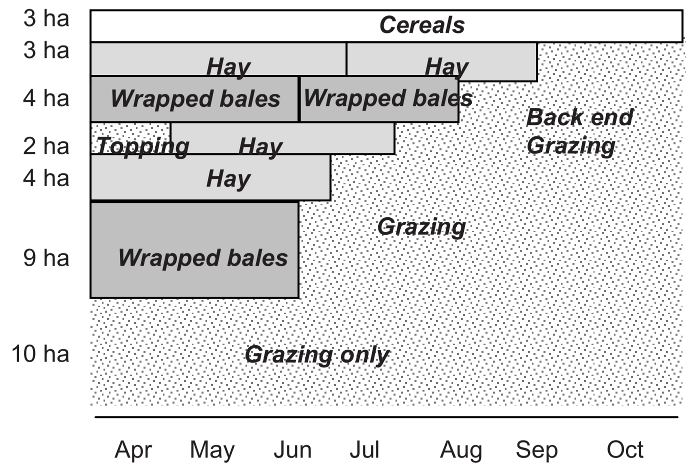
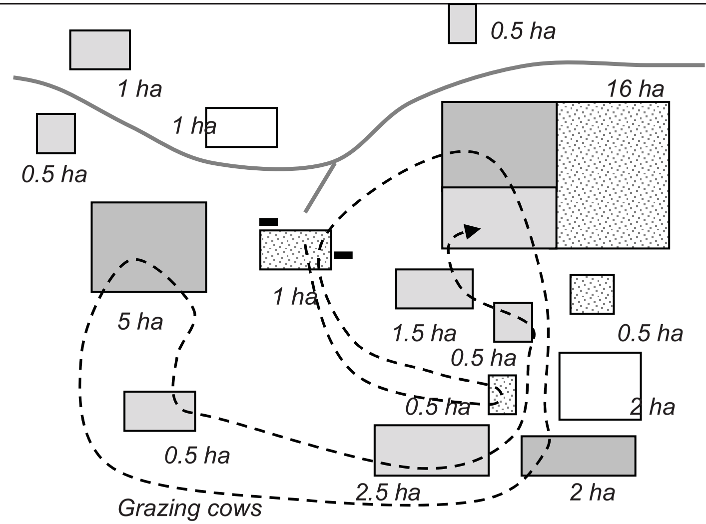
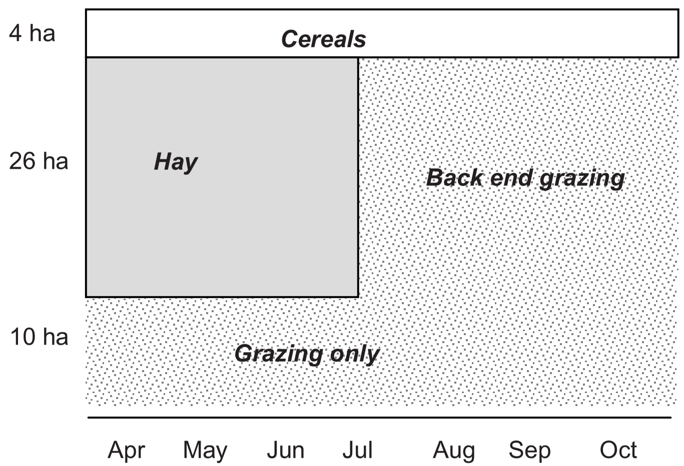
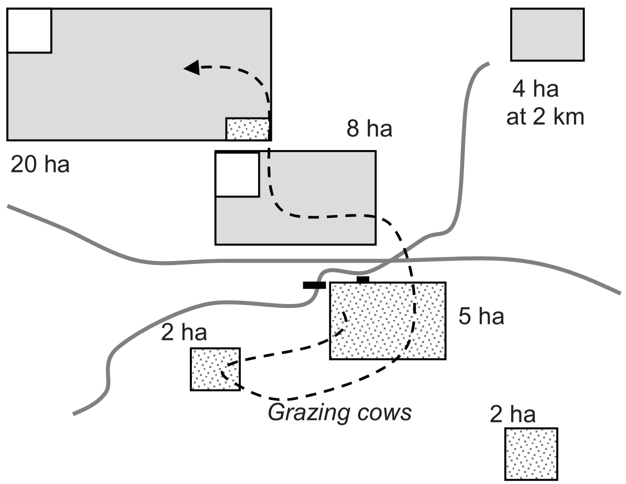
Basic farm description	Fodder system schedule	Field-uses pattern (→ represent movement pattern of dairy herd)
Example D1 Dairy farm 35 ha 20 Dairy cows “Montbéliardes” Milk quota: 105,000 L		
Example D2 Dairy farm 40 ha 30 “Montbéliardes” and “Abondances” dairy cows Milk quota: 135,000 L		

Table 1. Main characteristics, fodder system, and spatial functioning of two contrasted dairy farms

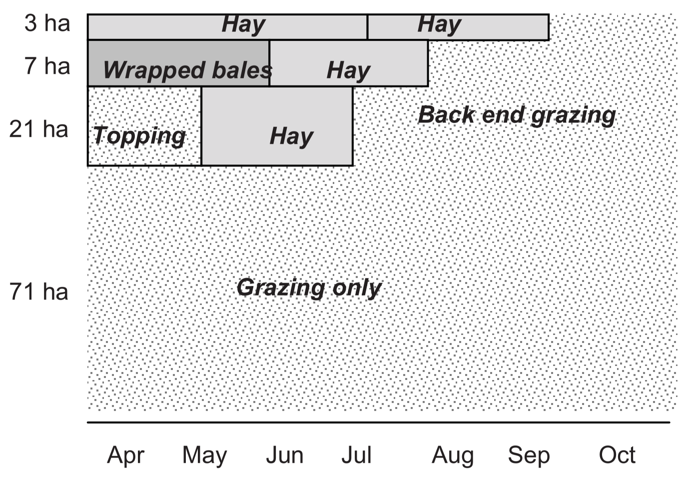
<table>
<tr><th>Basic farm description</th><th>Fodder system schedule</th><th>Field-uses pattern (→ represent movement patterns of cows)</th></tr>
<tr>
<td>Example DH1

Father-and-son GAEC

102 ha

Dual herd system

65 “Salers” cows:
- 20 Dairy cows
- 45 Suckler cows

Milk quota : 62 000 L</td>
<td>
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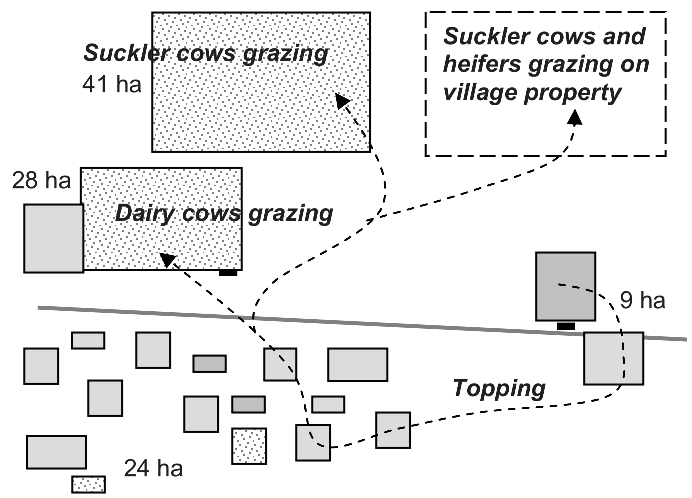
<td>
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<tr>
<td>Example DH2

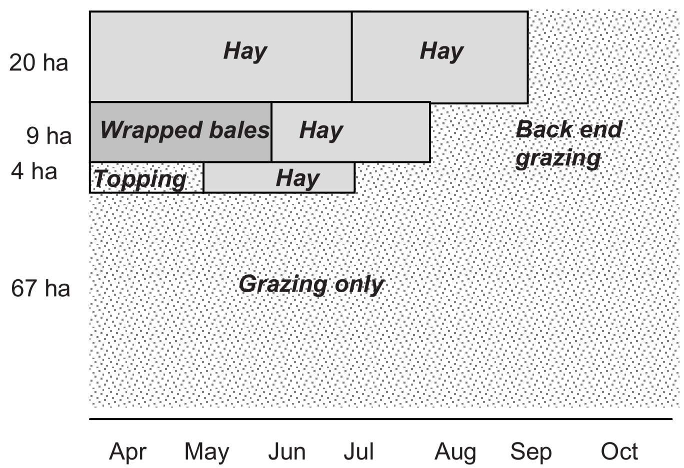
Father-and-son GAEC

102 ha

Dual herd system

30 “Montbéliardes” dairy cows

Milk Quota 195 000 L

18 “Salers” suckler cows</td>
<td>
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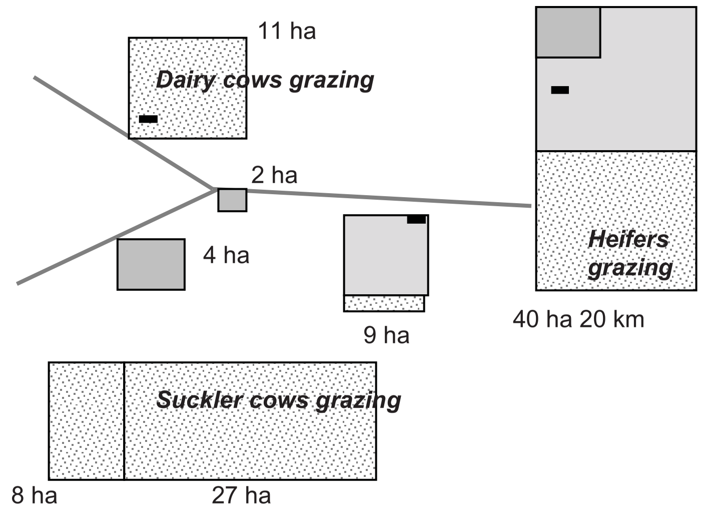
<td>
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Table 2. Main characteristics, fodder system, and spatial functioning of two farms with dual herd system

Discussion: spatial management as a key to analyse livestock farms adaptabilities

As mentioned previously, the surveys and analysis within this research program are still ongoing. So our conclusions and comments have yet to be confirmed. Nevertheless, after analysing the four farm-cases, and looking at all the 35 farms currently surveyed in the *Monts du Cantal* and the *Planèze de St Flour*, we may conclude that livestock farms have a large capacity to differentiate their spatial management in accordance to their fodder system and to others farm constraints, even given a common regional context.

Each spatial management form reveals, through a specific set of fields-uses linked to space and time characteristics of a farm, a combination of several constraints. Three drivers of the spatial management stand out from our analysis:

- the agro-climatic conditions influencing the grass production period and dynamic, the grass harvesting possibilities and the animal housing period;
- the layout of the farm-land, influencing the land-uses and the maintenances priorities of the farmer;
- the conditions of implementation of the fodder system (possibilities of labour organisation, storage conditions, environment or PDO specifications, etc.) influencing the type and place of the grass harvesting and the animal feeding decided by the farmer.

But, these drivers are also partly linked to one another. For example agro-climatic conditions influence the maintenance priorities of the farmer, farm-land layout influences possibilities of labour organisation. In consequence, synoptic regard on this package of conditions is necessary to understand and describe the spatial management of a farm (Fig. 2), and to analyse its changes abilities.

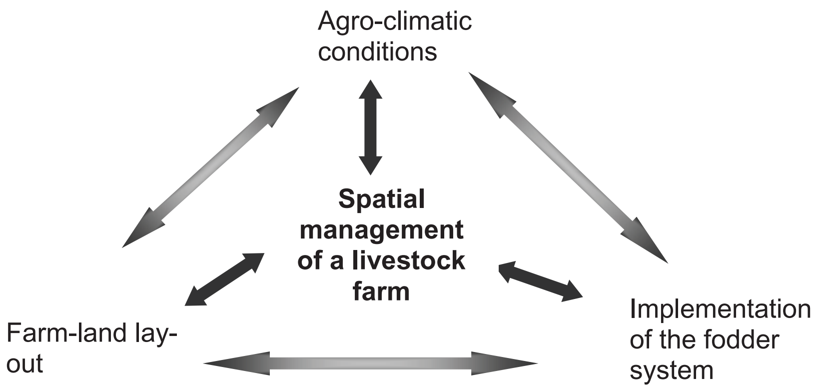

Figure 2. Key links involved in the spatial management of a livestock farm

Finally, the spatial management seems to be adapted to each farm, according to its current farming system. Because of reciprocal links between conditions at the farm level, adaptations exist but, at the same time, are limited and progressive.

Looking to the future and the changes in livestock production context (policies, consumer demands, active farm population…), the adaptations of spatial management in these two regions may become difficult. Indeed, the three kinds of conditions and constraints which currently support the spatial management, simultaneously involve important uncertainties or changes:

- the agro-climatic conditions: due to the global climate change and the more frequent summer droughts in the region, and the newness of such changes to farmers,
- the spatial arrangement: due to farming abandonment partly linked to farm population age and renewal,

- the implementation of the fodder system and the storage conditions: due to the revision of the specifications for PDO cheeses. Indeed, to become more consistent with the PDO concept and increase returns on milk, farmers will have to gradually phase out wet fodder storage (silage and wrapped bales) and will have to limit purchases from outside the PDO zone. For many farms this will require a new organisation of their fodder system and spatial management.

Although farmers may be able to find tactical solutions for each point, it may be more difficult to reconcile them, due to contradictions between each point adaptation. This context would probably drive farmers to drastic choices on farm orientation, farm technology, farm support, or farm maintenance. Some first signs are already observable with farmers who plan to stop the production of PDO cheese, declining financial aid, or investing in second activity. A better consideration of the spatial management and its drivers could help to anticipate the impact of such changes.

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