
Pastoralism, agroecology and work: frugal agro-pastoral systems of the Limousine Mountain

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Abstract: This publication deals with the analysis of frugal agropastoral systems which base the feeding of their flocks on grazing, including both of grasslands and pastoral areas. These systems are set up by small groups of farmers in middle mountain areas marked by agricultural decline. Based on a case study carried out in the Limousine Mountain, analysis reveals that this strategy allows reduction in the use of inputs and fixed capital. It leads to extensive modification of the work schedule and the nature of tasks and requires the development of very specific skills, in order to manage grazing on varied ecosystems. An economic comparison of agropastoral systems called frugal of the Limousine Mountain with other systems from the same area practising limited use of pastoral resources shows that frugals create more wealth and added value and maintain jobs in disadvantaged regions while being less dependent on agricultural subsidies and changes in the price of agricultural inputs and products.

Keywords. agropastoral, agroecology, productivity of work, farming system, comparative agriculture.

Introduction

For the last 70 years, increasing the physical productivity of human work has been the aim of French agricultural development. This technical model centres on the increasing use of inputs and farm equipment (Mazoyer and Roudart, 1997). These transformations have led to the erosion of agricultural added value (Devienne, 2019) and to shrinking landscapes (Meuret *et al.*, 2010). Though it allows for a decrease in heavy work, it has also led to a strong decline in the number of agricultural workers over the same period. The introduction of new agricultural techniques, the evolution of farm labour structure and the socio-economic context have together induced massive changes in work organisation (Dedieu and Servièrè, 2012).

Over the past two decades, small groups of farmers have chosen another development pathway by gradually implementing low-input production systems called *frugal*, among them frugal agro-pastoral systems (Garambois *et al.*, 2020). Over the past few years, small groups of farmers have settled in middle mountain and foothill areas, strongly hit by the rural exodus. They try to base the feeding of their flocks on grazing as much as possible, including grasslands but also pastoral areas.

The establishment of systems based on grazing involves many modifications in the work organisation (Hostiou *et al.*, 2015; Coquil *et al.*, 2018; Servièrè *et al.*, 2019). Indeed, routine work duration and seasonal work vary from one system to another according to flock herding, equipment power and management of the work force (including work in farm machinery cooperatives (CUMA) or services of agricultural contract work) (Dedieu, 1995; Dedieu and Servièrè, 2001). In addition, the transition to agroecological systems leads to the emergence of new tasks, involving new know-how (Hostiou *et al.*, 2015; Malanski *et al.*, 2015; Petit, 2015). Furthermore, in the case of frugal agropastoral systems, several tasks such as shepherding the flocks involve additional routine work duration, which can be considered as a brake to their development on a larger scale. Consequently, there is a special need to study the link between the functioning and economic efficiency of these agro-ecological systems and their work organisation.

This article aims at analysing the effects of the development of agroecological systems in agro-pastoral areas in terms of work, through various dimensions: agricultural employment, labour schedule and amount of work, skills and know-how required. It is based on a case-study conducted in the Limousine Mountain, a small agro-pastoral area of the Massif Central, where over the past few years several farmers have regrouped themselves around the same objective: pastoral area grazing. This case study aims to evaluate the viability of agro-pastoral frugal systems by comparing them with systems remaining in the predominant agricultural dynamics, and to determine whether these systems could be a potential path leading to agricultural development in agro-pastoral areas. As part of a doctoral thesis,¹ this research is based on a comparative agriculture approach (Cochet *et al.*, 2007; Cochet, 2015), that focuses on the study of agricultural dynamics of small regions in order to get a better understanding of the processes leading to a diversity of production systems due to differentiated access to resources, and of the close links between technical functioning and economic results.

This research is based on 50's surveys of former farms in the Limousine Mountain, in order to identify the past agricultural dynamics and to draw up a typology of current production systems² in this region, and on 50's techno-economic surveys of farmers (including those in frugal systems). These latter enable modelling the functioning and economic results, closely linked together, of the different current production systems of the study area (frugal or not), which allows comparing both their techno-economic results and their calendar work schedule. This approach crossing functioning, economic efficiency and work organization also allows identifying factors leading to the emergence of frugal agro-pastoral systems and the brakes and levers for their development on a larger scale.

Seventy years of agricultural development in the Limousine Mountain leading to the decline of agricultural employment and pastoralism

Agrarian system of the 50s: a middle mountain crop-livestock farming system with limited physical productivity

An agriculture based on agropastoral management of grazing through the shepherding of flocks, polycropping and animal traction

The Limousine Mountain is a small granitic middle mountain area occupied by a large diversity of ecosystems: moors, bogs, wet pasture, hayfields irrigated with upstream drained water and a few crop fields on flat areas where the villages are located. In the 1950s, the agriculture consisted of production systems integrating mixed cropping and diversified livestock farming (sheep, cattle, pigs) and focused on self-consumption. Shepherds took their flocks to the pasture year-round. The sheep grazed moors during winter (always with a bit of hay), herbaceous wasteland during spring, bogs during summer and the hay regrowth during autumn. The lambs were born at the end of winter: they followed their mother to the pasture and were sold at the end of summer at livestock fairs. The cows stayed in the barn during winter, where they were fed with hay and fodder vegetables, and were taken by a cowherd to the wet pasture and bogs during the rest of the year. Calving dates were spread out throughout the year and calves were sold at three months as suckled calves. The pigs were fed with cereals and fodder vegetables and sold at 10 months. The farmers produced cereals (rye, oat and buckwheat) and fodder vegetables. Most tasks were manual or involved towed traction and there were few farm buildings, as the barns mixed sheep and cows.

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² A production system is characterized by a specific combination of cropping systems and livestock systems, set up by farmers with the same access to resources (land, workforce, capital/equipment) (Reboul, 1976 ; Cochet and Devienne, 2006).

A calendar work schedule adapted to abundant workforce and limited productivity of work

At that time, production systems were characterized by important annual routine work duration: the flocks had to be taken to the pasture throughout the year. As there was calving year-round, the farmers had a routine work duration of three sucklings a day. The combination of three breedings (sheep, cows, pigs) allowed spreading out work peaks throughout the year.

The diversity of ecosystems led to a varied number of seasonal tasks requiring an abundant workforce: maintenance of the irrigation channels of hayfields during winter, soil preparation and sowing of the crops, hay making (spread out because of the rainy summers), mowing the moors and bogs (for the litter) all summer long, reaping spread out from July (rye and oats) to the end of autumn (buckwheat and fodder vegetables) and peat exploitation (harvesting and drying during summer, storage in autumn).

The physical productivity of work was limited. There were often 4 to 5 family workers (three generations on farms) dealing with 50-60 ha (of which 4-5 ha were crops and 10 ha were hayfields), 8-10 cows, 50-60 ewes, a few pigs. The number of animals was linked to the limited area of hayfields that each family was able to maintain and mow, conditioning the size of flocks that farmers were able to feed during winter.

The first capital intensification, systems' simplification and physical productivity of work increase phase (60s-80s)

The 20th century agricultural revolution brought about the generalisation of motorised farm equipment, input purchases and the intensification of agricultural practices. It led to the specialisation of regions according to their agronomic potential. In the study region, it led to the decline of pig production and a mixed sheep and cattle specialisation. Since this period, the number of farmers has kept decreasing and it requires deep modifications of the production systems to adapt itself to the new economic context.

Livestock systems transformations and cropping systems simplification in a moto-mechanization development context

Farmers started fattening lambs in sheepfold with purchased concentrated feed and hay. In order to produce fattened lambs at the proper period (when the prices are higher), mainly Easter, the lambing from now on took place during winter. Lactation period of the ewes was covered by stored fodder (hay and cereals). Higher nutrient density of fodders and genetic selection allowed a higher prolificacy (ewes) and body weight gain (lambs). Not adapted to the higher needs of ewes, the grazing of moors and bogs diminished throughout these years. The first modern farm buildings to be built were mainly sheepfolds to facilitate the management of fattening lambs.

With the concurrence of the milk powder-fed calves from dairy farms, the production of suckling calves was gradually replaced by grazer calves, or "broutards", sold at the age of 8-11 months to be fattened in regions with soils of higher agronomic potential, and closely linked to the increasing demand for Italian bull calves. Calvings began to be grouped together in spring, in order to synchronize peak grass growth with the lactation period of cows and calf growth, which have nevertheless always had access to concentrated feed. As most of the calves were sold before winter, cattle herds spent winter outside, feeding with hay. As the Limousine cow breed had been genetically selected for meat production from the 60s, its average size kept increasing, making the grazing of bogs harder, because of animals' weight and footprint.

In parallel, the beginnings of moto-mechanization in the 60s modified the cropping systems. With the first tractors (20-60 horsepower), it was not possible anymore to mow the irrigated hayfields, because of the slope and the fact that the irrigation channels obstructed passage of tractors. The former hayfields were converted into pastures and the moors were progressively cleared to be sowed in temporary grasslands, fertilized with manure and increasing quantities of artificial fertilizers and limestone. The moors with too much slope were planted with conifers. As the fattening of pigs and the production of suckling calves diminished, farmers decreased the cereal and fodder vegetable areas. Most of the crops were not adapted to the new farm equipment: for example, it was not possible to harvest buckwheat with a combine. Since the 80s triticale has replaced rye, because it is more productive (but is also more sensitive to pathogenic agents).

As tractors allowed faster mowing of temporary grasslands, whose yields were also higher thanks to artificial fertilizer use, one worker has since been able to breed an increasing number of animals.

Physical productivity gain and heavy work decline, but new work peaks and deep landscapes transformations

As farmers began fencing all the pastures, both sheep and cow flocks were no longer taken to the pasture by shepherds. The routine work duration of shepherding disappeared but was partially replaced by maintaining fences year-round.

As the number of ewes per worker and the output per ewe increased, the lambing work peak became heavier. The same trend was observed in cattle breeding, as births were from now on grouped together in spring. But with the end of the suckling calf breeding, there was a strong decrease in the duration of cattle breeding work, as there were no longer three sucklings a day. To spare the workload, grazer calf breeding was the production mainly chosen on farms with only one worker.

Many tasks, not motorized, were abandoned: maintaining irrigation channels, fodder vegetable cultivation, peat exploitation, bogs and moors mowing. The extension of hayfields over moors and the massive use of selected grasslands species, synthetic fertilizers and limestone allowed hugely increased hay supplies, that had been the restricting factor to the size of flocks. Consequently in two decades, there was a huge step-up of physical productivity growth: at the end of the 70s, one worker was able to breed mixed flocks of 75-100 ewes and 15 cows, or specialized flocks of 200-250 ewes and 30-40 cows.

Animal husbandry radical simplification, physical productivity increase and massive decline of agricultural employment (80s-present period)

Decline of sheep breeding to the benefit of cattle breeding, simplified grazing management and increasing power of farm equipment

Following the entry of the United Kingdom into the ECC, the prices for sheep meat kept declining from the beginning of the 80s. In the study region, this led to a decline of sheep which disappeared from the majority of farms, which then specialised in cattle breeding. When sheep remained bred on farms, this was always associated with cattle breeding. In order to enhance the potentiality of lambs, most farmers crossed a part of their Limousine ewes with meat breed rams. Some farmers changed completely their breed, turning towards Suffolk ewes. The use of this less hardy breed accentuated the decline of grazing of pastoral areas including moors and bogs. Quality labels (Country Lamb of Oc Red Label and Lamb of Limousin (Protected Geographic Appellation)) were created during this period in order to try to redress lamb prices.

In most specialized bovine farms, farmers stopped cultivating cereals to put land into grasslands, in order to maximize their hay supplies. As the size of flocks increased, grazing management was simplified, with a limited number of fenced paddocks. When farmers had access to bogs, most of the time they used them only during drought summers. But without proper management, bogs deteriorated and did not offer proper resources for grazing anymore.

Large size cattle breeding was possible only thanks to the increasing power of farm equipment, allowing hay making on bigger areas: the power of tractors reached 100 horsepower during the 90s and today is frequently over 150. The round baler appeared in the 90s in replacement of the small square balers and permitted the development of wrapped hay, making farmers less dependent on the weather, as wrapping allows hay-collecting even if it is not completely dry. As the size of flocks grew, farmers spread out the calvings (peak at spring) and built free stalls to winter some of the cows.

Extreme simplification of agricultural tasks and calendar work schedules

With the decline of crops and sheep breeding and the generalization of cattle breeding, the simplification of the calendar schedule reached its peak: routine work duration was limited to grazer calf breeding, which allows an increase in the number of cows one worker is able to manage. As there were no cereals anymore there was no soil preparation, no sowing and no harvesting. The principal activities now included maintenance of grasslands (manure, fertilizers and limestone spreading) and fences, and hay making. Work remains spread out, as farmers can mow early and/or mow autumn regrowth, in order to have high-density energy fodder thanks to wrapping.

By contrast, the last farms with sheep still have a high activity peak during lambings. With the new labels, which restrict the age of lambs and require specific weight, conformation and fat cover (the best would be 18 kg carcass weight with R2 classification), and the high prices only at specific periods (Christmas and Easter), the farmers have no other choice than to regroup all lambings out-of-season, making this period extremely intense in working time: all lambings at the same time with high prolificacy.

Thanks to new farm equipment, the physical productivity of work keeps increasing: one worker can handle mixed flocks of 125-150 ewes and 40-60 cows or specialized flocks of 300-500 ewes or 80-100 cows. Over the past seventy years, the increasing use of inputs and farm equipment has created a huge growth in the physical productivity of work: on the biggest farms, physical productivity has increased more than ten-fold.

These massive transformations have led to the predominance of large grazer calves breeding systems with low added value, encouraged by the unfavourable evolution of agricultural prices in relation to the input prices. Increasing support from the Common Agricultural Policy (compensatory allowance for permanent natural handicaps, premium for maintaining suckler cows, compensatory ewe premium...) has not been enough to compensate for the erosion of agricultural employment (number of agricultural work units was divided by 4 between 1970 and 2010 (RGA 1970, 2010) and large areas of agricultural landscapes have been abandoned.

But all farmers couldn't keep increasing physical productivity of work growth. The farmers at the top of the Limousine Mountain are those placed in the best conditions: the former moors had light slope and were easily cleared, the soils had less rocks and the majority of communes benefited from a reparcelling. In peripheral areas of the Mountain, the slope is much more limiting and the afforestation rate of moors is higher than on the top. As there was almost no reparcelling, the agricultural parcels are dispersed which limits the enlargement of farms.

On peripheral areas of the Mountain, for almost a decade, several farmers, generally those set up on farms outside the familial context, have developed alternative systems. Their objective is to maximize the grazing part in the alimentation of their flocks, in order to limit inputs and farm equipment purchases. Generally faced with restricted mowable grassland areas, they progressively settled systems based on limited hay supplies, by giving priority to flocks grazing over mowing. As the access to grasslands is limited, farmers included pastoral areas in their livestock's grazing, areas largely abandoned over the past decades. This dynamic was and is still facilitated by several institutional actors. The combined work of the Regional Natural Park, the Conservatory of Natural Areas and the Selection Organism of the Limousine ewe allowed hiring shepherds in 2007 who led flocks from local farms to abandoned areas during summer. Since this period, and also because of the multiplication of droughts, four Pastoral Groups were created. It also permitted new installations (including several former shepherds), as the summer pastures are the key to fodder autonomy. For several years, the farmers have been also supported by the Federation of the CIVAM (Centres d'Initiatives de Valorisation de l'Agriculture et du Milieu Rural), which organises technical exchanges between farmers, focused on the grazing of pastoral areas. Indeed, these "frugal" production systems require a complete transformation of the technical functioning and of the calendar work schedule.

Frugal agropastoral systems of the Limousine Mountain: pastoralism and high added value products to the benefit of other productivity and agricultural employment

Frugal systems more pastoral and looking for better valorisation of production

In order to limit input purchases and use of farm equipment, frugal systems base their functioning on maximizing the grazing in the alimentation of ruminants. The farmers must take into account the diversity and the seasonality of all fodder resources of the ecosystems they have access to. They progressively build grazing chains which allow feeding of flocks year-round.

In order to synchronize grass growth and animal needs' peaks, the lambings are mostly in spring, from March to May. Throughout this period, flocks are fed by rotational grazing, allowing optimisation of grass growth. In order that ewes can feed their lambs without any supplementation, farmers in frugal systems voluntarily limit the prolificacy. As the access to grasslands is limited, these areas are reserved during summer for the growth and the fattening of lambs. Consequently, most of the flock go to pastoral areas on the top of the Mountain, where the bogs are concentrated, under the watch of a salaried shepherd (or a farmer-shepherd). From the end of May to October, the flocks will be fed only on bogs, underwoods, moors and forest clearing. After having grazed grassland regrowth during autumn, flocks go to pastoral areas close to the farms, mostly moors and forest clearing. When the resources on farm are limited, those who are farmer-shepherds are able to look for supplementary resources in the surroundings. Shepherd know-how is in this case essential to limit the use of stored fodder and concentrates.

Most lambs are fattened on pasture but not all lambs are ready for slaughter in early winter. Some farmers finish the fattening during winter with a mix of alfalfa, grassland hay and barley; others prefer to maintain their state only with grassland hay, in order to finish the fattening on grass during the next spring and summer. The farmers are not looking to speed up the production cycle and prefer to adapt their husbandry practices to local resources, which has led them to produce older lambs than in sheepfold systems. As they don't need huge fodder and concentrated supplies, farmers invest very little in farm equipment and buy only small quantities of inputs.

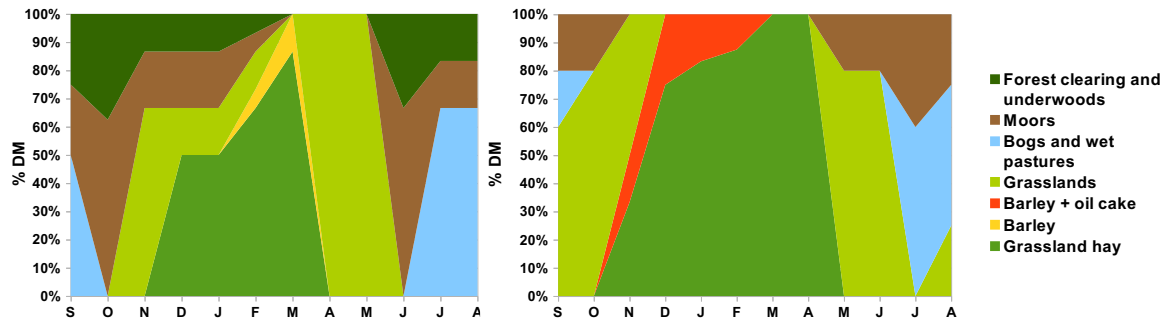


Figure 1. Compared grazing calendar of ewes led in frugal system with spring lambing (left) and current system with winter lambing (right). Source: surveys, realisation: authors.

The products from frugal agro-pastoral systems do not respond to agricultural cooperatives demand: lambs are expected to be under five months and fully fattened in sheepfold (Country Lamb of Oc Red Label) or under ten months (Lamb of Limousin PGA), in both cases with a conformation and fat cover close to R2. These weight, age and classification objectives can be reached only with a very concentrated alimentation, mostly purchased, and is facilitated by crossbreeding with meat bred rams. Grass-fed lambs of frugal systems are at age-equivalent lighter and leaner than sheepfold lambs and would be underpaid in the long chain. In addition, lambs are better paid at Christmas and Easter thanks to out-season premiums, whereas lambs from frugal systems are born in spring and ready for slaughter most of the time from July to November. Consequently, farmers in frugal systems sell their production through short channels, directly to consumers or through local butchers. Most of the time, the cull ewes and wool are also processed locally, which permits a better valorisation of these products, underpaid in long channels.

A deep shift in work organisation: shepherding the flocks on pasture and transformation of products take the place of large sized flock management and moto-mechanized tasks

As there is no need to regroup the lambings, they can be more spread out in frugal systems, in order to sell lambs at the proper periods. The limitation of prolificacy also allows diminishing the on-call during lambings. Indeed ewes with two lambs require a higher monitoring time.

During winter, routine work duration linked to fodder distribution is more limited, as there are less ewes per worker. It can be counteracted by the shepherding of the flock on pasture that lasts 4 to 5 hours per day during winter (versus 6 to 8 hours during summer), as the flocks eat hay in a fixed park or in sheepfold to equilibrate their ration. But the shepherding time also allows a closer monitoring of the health of the flock. When the farmers maximize the grazing part in the alimentation of their flocks, the fodder distribution routine work duration is shorter than in the other systems: 4 months in frugal systems versus 6 in the others. When flocks are not shepherded, they are most of the time in pasture with mobile fences. The fences are moved every 3 to 6 days, taking into account that it takes 1 to 2 hours to settle the next park. On the other hand, most farmers manage the grazing with fixed parks, requiring every year the replacement of some barbed wire fences and fence posts, and the brush clearing of fences.

In frugal systems, farmers limit their investment in farm equipment to a strict minimum. The few moto-mechanized tasks are done by a farm work firm; in particular clearing the sheepfold (once a year versus three times a year in the other systems), spreading manure and hay making steps (sometimes the only task done by farmers is the tedding in order to control the fodder quality). Consequently, in frugal systems, the hay making period isn't the huge work peak as in all other production systems. When farmers have a tractor, that is only used to store the hay balls and distribute them during winter. Summer is the period with the shortest routine work duration for farmers who can let a part of their flock to a shepherd: no hay making (or only a part of the operations), and a simplified grazing management as there are only lambs and a few ewes remaining on farms.

However, the transformation and sales of the meat and wool products are workloads year-round: these involve regular roundtrips to take the animals to slaughterhouse and come back to pick up the meat, and also home delivery services. But farmers in frugal systems try to sell meat through diversified channels, as it is less time consuming. It could pass through local butchers, reseller stores or distribution systems like Chronofresh.

Frugal agropastoral systems give priority to economic productivity over physical productivity of work, in favour of agriculture employment

The following economic comparison is based on the modelling of production systems. As mentioned, a production system is characterized by a specific combination of crop systems and livestock systems, set up by farmers with the same access to resources. Most of the time, the data of 3-4 farms allow modelling a production system. In the case of frugal systems, the sample is more reduced because these particular systems are emergent. Furthermore, grazing management is closely linked to the nature and the distribution of pastoral areas: if the logic of functioning is common to all frugal farms, their detailed functioning can be specific to each one. Consequently, frugal agro-pastoral system modelling is often based on only one or two farms.

Among the production systems identified and characterized thanks to field surveys, four of them are presented here to offer pertinent comparison between frugal systems and systems that remain in predominant development pathways.

We can see in Figure 2 that the frugal system (PS1), despite its limited access to higher agronomic potential areas, is the one creating the most added value³ per ha. Increasing the percentage of grazing in animal feedings allows decreasing the fodder and concentrated supply needs, and consequently the need for concentrated alimentation purchases (IC Alimentation) which appear to be one of the main expense items of the three other systems. Concentrated alimentation and litter purchases represent less than 7% of the Gross Products in PS1, whereas they constitute 20% in PS3, 30% in PS4 and 50% in PS2. In the case of PS3, which produces cereals and silage and so needs less litter and concentrated alimentation, this partial autonomy is offset by additional costs (fuel, seeds, fertilizers, lime purchases, agricultural contract work, equipment and its maintenance). IC farms, IC Seeds, fertilizers, lime and IC Agricultural work represent 44% of the Gross Product in PS3, versus less than 25% in PS1.

³ The added value corresponds to the gross products (sales of agricultural productions) minus the Intermediate Consumption (IC: products and services consumed during the agricultural activity like fertilizers, fodder purchases, agricultural contract work...) and the Depreciation of Fixed Capital (DK: equipment value used each year).

	PS1 Sheep + Direct Selling (frugal system)	PS2 Sheep	PS3 Sheep + Cattle (weaner)	PS4 Cattle (weaner)
Agricultural surface (ha)	110 + 50 (summer pasture)	90	300	400
Number of workers	2	1	3	2
Mowed grasslands / Cereal lands (ha)	35 / 0	20 / 0	100 / 30 (silage maize, wrapped meslin, triticale)	100 / 0
Size of flocks	300-350 ewes	300-350 ewes	450-550 ewes and 100-120 cows	120-160 cows
Products	Grass fed lambs, breeding ewe lambs, cull ewes transformed and wool products	Concentrate fed lambs, breeding ewe lambs, cull ewes, raw wool	Concentrate fed lambs, breeding ewe lambs, cull ewes and cows, raw wool, 10 months grazers calves	Cull cows, 10 months grazers calves
Channel of commercialisation	Direct selling, local butchers and reseller stores	Agricultural cooperative		

Table 1. Main characteristics of modelled production systems of the Limousine Mountain. Source: surveys.

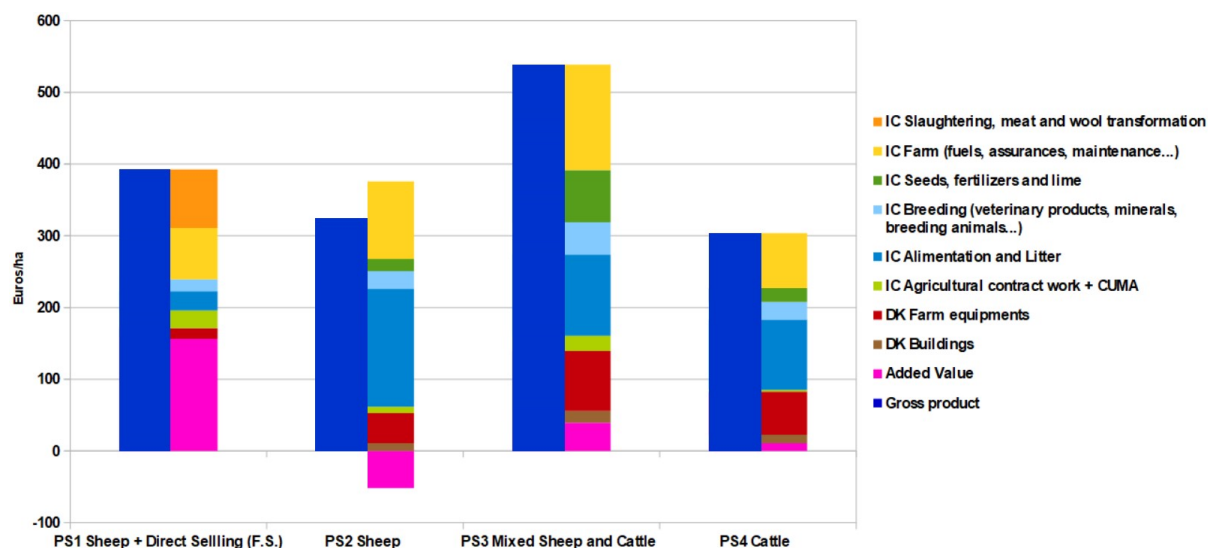


Figure 2. Gross product per ha and net added formation per ha in different production systems of the Limousine Mountain. Source: surveys, realisation: authors.

As farmers in frugal systems don't need high hay yields and develop a more efficient use of grassland thanks to rotational grazing, they make no fertilizer and lime purchases. Finally, they limit to a strict minimum the moto-mechanized tasks (decrease in IC Farm and DK Farm equipment), available, for the few ones remaining, through agricultural contract work. Because of their very limited need for buildings, they prefer to rent them rather than investing and paying interest on the loan.

Simultaneously, frugal farmers are looking to increase their Gross Product per ewe (and ha) by a better valorisation of their production, that may involve some new charges (slaughtering, transformation....). By basing their system on process and functionalities of ecosystems rather than on inputs and fixed capital, and by introducing transformation and selling activities into their production system, farmers in frugal systems create more added value per hectare than the others, despite access to areas judged of lower agronomic potential.

Thanks to the high added value per ha and in spite of the lower area mobilised per worker in frugal systems, the added value per worker remains much higher than in all other systems (Figure 3). This explains why the frugal system is the only one which permits generating an income, before agricultural subsidies payment.⁴ These results illustrate that the main objective in frugal systems is the maximization of the net added value, not of the gross product or of the number of animals per worker. Farmers in frugal agropastoral systems look towards *economic* productivity of work rather than *physical* productivity of work. Thanks to this alternative logic, frugal production systems reach equivalent or even higher levels of agricultural income than other systems of the Limousine Mountain, while being less dependent on subsidies (70% of the income versus more than 100% in the three other cases), meanwhile mobilising less area per worker and contributing value to abandoned areas.

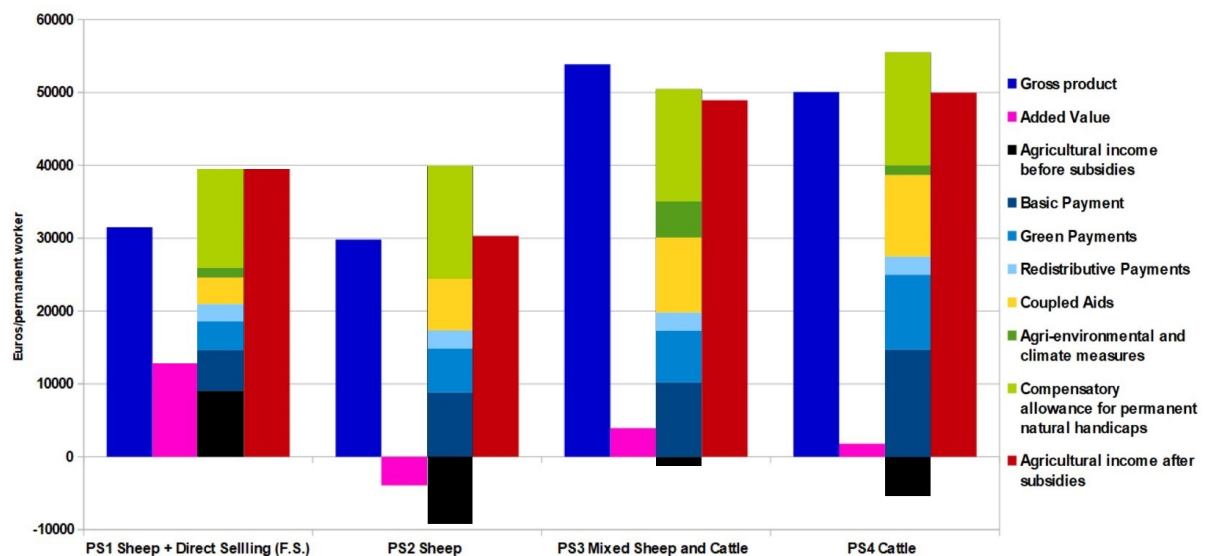


Figure 3. From the gross product to the agricultural income after subsidies per worker before MSA.
Source: surveys, realisation: authors.

Thanks to this frugal approach closely linked to agroecology and associated with a better valorisation of production, these agro-pastoral systems contribute more largely to agricultural job creation in the Limousine Mountain than the others. Taking into account the deep technical changes required in order

⁴ The agricultural income before agricultural subsidies payment corresponds to the Added Value minus the cost of access to lands (rent and/ or property taxes), the interest on borrowed capital) and wages and salary charges.

to set up this type of production system, there is a special need to study their viability, in particular in terms of workload.

Frugal agropastoral systems more resilient and sustainable

Techno-economic surveys also permit us to collect data about the organisation of work on farms. The estimations of duration of tasks can be in hours/day/task, days/task, and hours/hectare/task with one or several permanent workers. In order to permit comparison, all data are combined to obtain an amount of working hours per month and per production system, divided by the number of workers. When the farmers indicate data in days/task, the duration is about 8 hours except during hay making (about 10 hours per day). The calculation only takes into account the working time at normal speed (as for the techno-economic results): major repairs or difficult calvings are susceptible to increase the working time for example.

When additional farmers are present on farms (mostly during shearing and silage of maize), their working time is recorded, as this time will be returned by doing the same task on their farms.

According to the figures 4 and 5 showing the detailed composition of daily work month by month in PS1 (frugal) and PS3 (non-frugal), the frugal system allows smoothing off the work peaks and offers a more regular work calendar. In fact, as the animals graze most of the time, routine work duration linked to fodder is strongly diminished. During winter, most animals in PS1 are grazing and there is no need to bring fodder every day. By contrast, in PS3, all animals depend on stored forages and as there are more animals per permanent worker, the whole morning is necessary to feed the flocks. Even during spring and summer, animals are always being fattened in buildings in PS3, whereas those in PS1 are outside with the rest of the flock.

The same observations apply to fodder harvesting : in the frugal production system (PS1), this operation lasts 30 hours per year (teddering and hayball storing) done by only one worker, while hay fodder harvesting needs 2 to 3 workers for 4 weeks (one for the meslin wrapping and three for the hay) in the non-frugal system. In addition to hay making, farmers in PS3 also have to handle the culture of triticale, meslin and maize (soil preparation, sowings, phytosanitary treatments, rock pick-up, harvest), grasslands renewing and fertilization of all crops and mowing grasslands. It explains why farmers in PS3 spend much more time on a tractor than in PS1: more than 500 hours per worker per year against less than 125 hours.

The shepherding time, the sales and round trips between slaughterhouse and clients involve additional working time in frugal systems, in comparison with non-frugal systems, but the feeding mainly based on grazing permits large reductions in the time spent on many other tasks. As the animals are often shepherded throughout the year, and grasslands are managed by rotational grazing with mobile fences, farmers in frugal systems spend less time maintaining fixed fences. By contrast, in PS3, maintaining fixed fences keeps one or two permanent workers busy for more than a month per year, with an activity peak in late winter. We can also notice that shepherding the flocks and getting them used to eating fibrous resources allows reducing the working time dedicated to controlling bushes (scotch brooms, brambles...) and refuse in bogs and grasslands, which occupied one permanent worker during the end of summer in non-frugal systems.

A comparison of the total amount of working time hours of each system shows that farmers in frugal systems work a bit less than in non-frugal systems (2100 hours/worker/year against 2350).

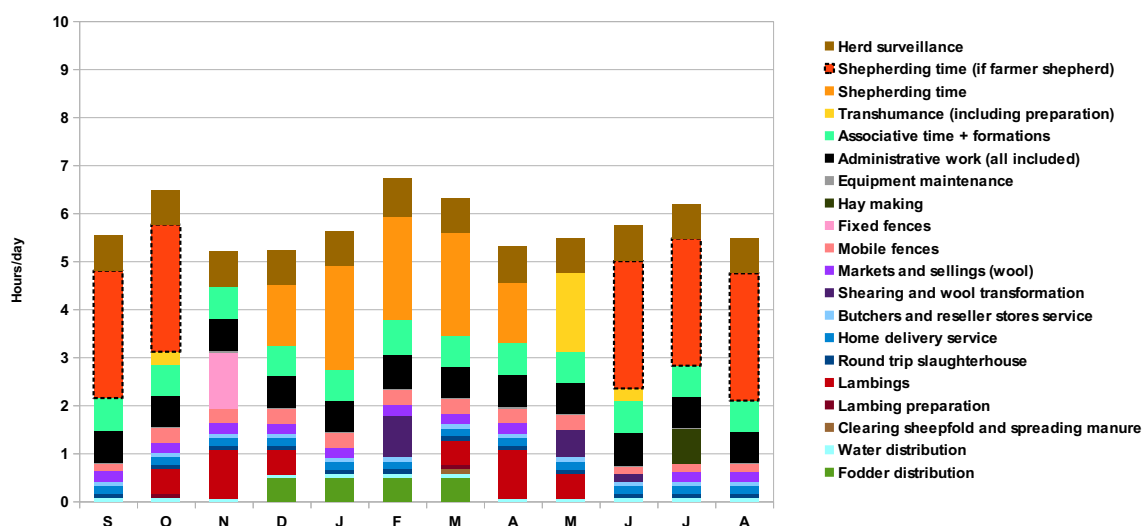


Figure 4. Decomposition of daily working time in PS1 (frugal systems) by permanent worker. Source: surveys, realisation: authors.

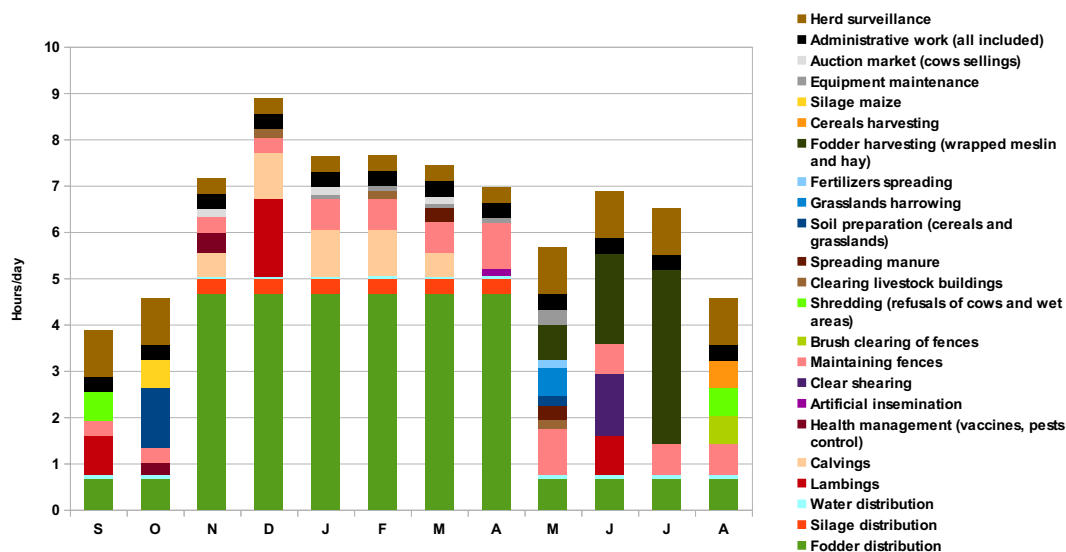


Figure 4. Decomposition of daily working time in PS3 (non frugal system) by permanent worker. Source: surveys, realisation: authors.

Finally, over the past few years, the Limousine Mountain has been hit by summer droughts, requiring most farmers to distribute fodder from the end of summer and bring water in to an increasing number of pastures where it wasn't necessary a few years ago. Because of droughts, a lot of farmers have diminished grazing time on mowable grasslands in early spring, or just stopped it. Those placed in better conditions regarding land access and potential, chose to increase their fodder supplies by cultivating silage maize and wrapped meslin. This leads to new economic charges: supplementary input purchases (seeds and fungicides), CUMA investments or agricultural contract work for the maize cultivation requiring specific material and new farm equipment for the distribution. It also leads to an

increase in workload: soil preparation for sowing, fast clearing of stalls and sheepfolds in spring to spread manure on maize, silage packing and supplementary fodder distribution routine work duration during winter. Farmers in frugal systems are relatively unaffected by droughts and don't distribute fodder during summer. On the contrary, shepherding flocks on bogs and under-woods during summer contributes to limit the effect of droughts in frugal systems, without implying additional work.

Conclusion

For more than sixty years, the agricultural development of the Limousine Mountain has been focussed on a development pathway aiming to increase the physical productivity of work thanks to the increasing use of inputs and farm equipment. It has led to the erosion of job employment and the abandonment of the majority of the pastoral areas of the Mountain, of the moors and of the bogs.

However, over the past ten years, several farmers have progressively implemented alternative production systems, based on the maximization of grazing for flock feeding, in order to limit the use of inputs and farm equipment. It is achieved through the use of diversified ecosystems that allows a more pastoral functioning year-round. Economic results of the frugal agro-pastoral systems of the Limousine Mountain show that through this agro-ecological approach (Altieri, 1986) using more intensively the processes and functionalities of the agro-ecosystems, farmers increase their added value instead of their gross product which confirms results recorded for frugal cattle systems in other regions (Garambois, 2011; Devienne *et al.*, 2016; Garambois *et al.*, 2020). Agro-pastoral frugal systems involve new tasks, in particular shepherding flocks and those related to the transformation and commercialization of products. Nevertheless, their alternative functioning and different calendar work schedule organisation contribute to a better spreading of working time, by cutting work peaks such as hay making and fodder distribution during winter.

These results show, both from economic and work organization aspects, that frugal systems can provide an alternative agricultural development strategy for middle mountain areas which are under the threat of depopulation and abandonment of large parts of agricultural landscapes. Besides, as such farms need less area and less fixed capital to be profitable, their creation and transmission would be facilitated. Nevertheless, today only a small number of farmers have established such systems in the study region, which raises the question of the obstacles to their development on a larger scale. Even more than in the plains, the implementation of frugal systems in agro-pastoral regions requires acquiring new knowledge: grazing management of diversified ecosystems, education of breeding females in order to accustom them to graze diversified vegetation, know-how of shepherds, etc. As each farmer has different access to pastoral grasslands areas, each one of them has to build his/her own grazing management, which can take years to be fully mastered. But some farmers' associations and rural activists provide frames of work in order to set up peer-to-peer exchanges which facilitate the acquisition of these new techniques and knowledge.

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