

Livestock grazing systems and sustainable development in the Mediterranean and Tropical areas

Recent knowledge on their strenghts and weaknesses

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Adaptation trajectories of livestock in the territories: where does grazing fit in? What are the key factors?

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This section examines the adaptation trajectories of livestock farms in contrasting territories located on three continents, over a long time span of several decades. The research outlined here aims to: (i) reconstruct these adaptation trajectories, with specific emphasis on the evolution of the role of grazing; (ii) understand the determinants of these trajectories, whether local or global; (iii) assess the extent to which these trajectories are consistent with sustainable development.

I The Causses and Cévennes: mechanised fodder production, farmers on the verge of extinction

Since the 1950s, farms in the Causses and Cévennes, like elsewhere in France, have experienced a period of specialisation and a continuous increase in size. The environmental conditions, less favourable than in the plains to an increase in physical labour productivity in crop production, have favoured a specialisation in livestock: dairy or suckling ewes in the Causses, dairy goats or suckling ewes in the Cévennes. The expansion of farms has also been based on a continuous increase in their investment in equipment, which currently amounts to several hundred thousand euros per farm. In places where it was possible to use them, increasingly powerful motorised mowing equipment, sometimes combined with motorised fodder distribution systems, enabled a significant increase in the volume of milk produced per farm (up to twenty times more milk than in 1950 in caussenard dairy sheep farming), with a low contribution of grazing to the ration (Aubron *et al.*, 2016; 2019).

Our research based on the comparative agriculture analysis framework shows that these developments, which are problematic both in terms of employment and maintaining an open environment, correspond to adaptations of farms to global socio-economic changes. European and French policies to support investment, the downward trend in agricultural prices in real terms, and the allocation of subsidies per hectare or per livestock capita with no strict capping mechanism following the abandonment of price policies from the 1980s onwards, all encourage farm enlargement and leave few alternative choices. As a result, the most modest farms or those with no easily mechanised land were not able to make these adaptations and disappeared massively, leaving the landscape to scrub. The larger and better situated farms (deeper soils on the Causses, wider valleys in the Cévennes) were equipped for mechanised fodder crops and turned to dairy farming under a quality label (PDO Roquefort and Pélardon). Those with less labour force and less mechanised land have often opted for suckling livestock, which grazes more but creates fewer jobs.

A different type of trajectory focused on product processing and marketing in short distribution channels completes this picture: initially taken by neo-rural farmers who set up

goat farms in areas abandoned in the 1970s, this path is now also being explored by ewes (Causses) or goats (Cévennes) farmers who until now have delivered their milk and struggled to expand or maintain their access to milk collection channels. For similar reasons, suckler ewes or cows farmers are developing direct meat sales for all or part of their production (Nozières-Petit, 2019). Apart from a few so-called frugal farms, this evolution towards short distribution channels and processing is not systematically associated with an increased use of grazing in the animal's diet (Garambois *et al.*, 2020). It is nonetheless of interest as it reflects adaptations to local conditions that can counterbalance national and European determinants.

■ The Brazilian Amazon: restructuring the relationship between livestock and forests

Bovine rearing has long been emblematic of these “Open Veins of Latin America” where E. Galeano (1971) condemned the plundering of natural resources, notably at the expense of small rural producers. The short history of beef in the Amazon began in this way. In 1960, the federal government launched the “colonization by cattle ranching”, which established cattle ranching as a tool for occupying the territory, and consequently deforestation and land conflicts.

This is a land of cattle ranching born out of the ashes of the forest: fifty years later, four times as many cattle as people live in the Brazilian Amazon. 86 million zebus graze on pastures twice the size of Germany, forming the world's largest livestock basin on the “Arc of Deforestation. Livestock farming, conducted in extensive systems, proved to be extremely well adapted to the conquest of territories in a pioneer front situation. Even if exotic, the *Brachiaria* grasses and the Nelore zebu breed adapted very well to the Amazonian ecology, and the migrants were able, with very little workforce, to open and expand cattle farms with fire as their main tool. As appropriating land was the primary objective of the migrants, livestock production was quickly democratized, stepping out of the traditional framework of large farms and spreading to family farms, some of which began to produce milk (Poccard-Chapuis, 2004). However, oversimplified animal husbandry practices, favouring expansion rather than grazing management, resulted in significant waste of natural resources, including organic matter accumulated in soils by forest ecosystems. Since 2005, the government introduced an arsenal of repressive measures to prevent further deforestation. The land logic that had previously governed livestock systems was halted, with the exception of the pioneer fronts where deforestation continued illegally.

A new period of adaptation then began, starting with limited land, degraded soils, and technical baggage that had become unsuitable for most farmers. Grazing is at the heart of the transition: it is no longer simply a matter of suppressing the seeds of woody species to prevent the return of the forest, but of ensuring an optimized forage supply, making the most of rainfall and sunlight in the equatorial climate. Livestock production must

provide income, rather than the heritage function. This implies managing soil fertility: rotational grazing is the most accessible technique, as the integration of an annual crop of maize or sorghum in rotation with the grassland is not possible in all regions, nor for all farmers due to the high cost of machinery and fertilizers (Burlamaqui, 2015).

But behind this technical change, the whole landscape is changing, and the whole territory must be mobilised to lead this transition. By investing more resources, work and know-how in their grazing lands, herders tend to concentrate on their best lands, leaving the least suitable to revert to the forest. A new forest system is established that is better able to produce services because it occupies the slopes and wetlands, forming corridors that connect the forest blocks (Pinillos, 2021a). In conditions that have become drier due to the reduction in forest cover, accidental fire or fire used by individuals for land or cultivation purposes threatens the investments undertaken, and the territorial stakeholders must organise themselves to control it. To accelerate and control these large-scale processes, landscape restoration plans based on soil suitability are being developed by city councils, such as along the Belém-Brasília road, where the first Amazonian pioneer front began. Systems for monitoring environmental performance are being created, so that producer groups and value chains can attest to their progress, and in this way organise value chains or attract sustainable investments.

After providing a land tenure function, environmentally disastrous due to its impact on the forest and soils, an intensification of Amazonian livestock is underway. Whether this intensification is agroecological (rotational grazing, legumes, fodder trees) or part of the green revolution (fertilizers, herbicides, mechanization), it is implemented by young farmers and represents a generational shift. The resulting increase in land value may, as has been the case elsewhere in South America, benefit the highest bidders, and see grazing land replaced by soyabean, eucalyptus or oil palm plantations, where the soil and transport infrastructure favour these crops (Osis, 2019).

■ Maghreb: less and less pastoral breeding, reinvented mobility

Grazing in North Africa was adapted to the biophysical constraints. It has fluctuated since Roman times. This extensive livestock farming was practiced by families with small ruminants grazing on modest vegetation, but adequate to provide milk, meat, skins and wool. The grazing ecosystem was maintained thanks to the mobility of families living in tents (the *khaima*, the *guitoune*).

From the 1950/60s, several factors have impacted this grazing: population growth (32 million inhabitants in 1960 and 93 million in 2020), the development of crops on former rangelands, changes in access to resources (land laws, customary uses of the *Arch* (Bessaoud, 2013)) and multi-year droughts (OSS, 2008). During severe droughts (1970/1980), states began to provide partially imported and subsidised grain barley for animal feed. Once this practice was under control, livestock numbers increased. As a result, the ovine livestock population increased from 10 million in 1960 to 57 million

in 2018 (FAOSTAT) for 62 million hectares of rangeland ($\frac{3}{4}$ between isohyets 100 to 400 mm/year). Grazing productivity, under the combined effects of droughts and intense farming, has fallen by 60% (Mahyou *et al.*, 2018), as predicted by Le Houérou in 1995.

Barley cultivation is central to the livestock producer's strategies. They sow it every year. If rainfall is satisfactory, the grain is used for animals. It also allows for early spring grazing. After the harvest, the stems are valued grazing land (which can be rented at a high price) and in the fall, regrowth is grazed. In years with high rainfall deficits, barley crops are used as grazing land (damaged barley). In these livestock systems, the feed cover of animals by natural grazing is less than 35%, even 10% in central Tunisia (Jemaa *et al.*, 2016). The various pastures provided by barley and hay represent 25% of the requirements, while the remaining 40% is met by concentrates (Hadbaoui *et al.*, 2020). Even if its contribution to the feed is low, transhumance is still practiced by farmers who can use trucks, shelter areas (most often at a cost) and shepherds (family members or employees). As a result, farmers have at least two hundred ewes in their herds. Smaller farmers have access to grazing land adjacent to the homestead (stubble, damaged barley, fallow) and must maintain a constant supply of concentrate. These grazed lands are either rented or free for the shepherds who look after animals belonging to one or several owners working outside agriculture. Transhumance routes are rain dependent and are managed by telephones and trucks. Livestock owners take more varied paths than in the past and change from year to year depending on the rainfall in the regions and the price of land rental for grazing (Gaci *et al.*, 2021). Summer transhumance grazing (stubble, natural rangeland) saves farmers kilograms of grain (concentrate intake is reduced from an average of 600 to 300 grams per day and per head).

Sustained by high demand, notably during religious festivals, and with limited competition from imports, which are heavily taxed (200 to 300 percent depending on the country), the price of ovine meat is high. On the condition of having a certain number of animals and having access to enough grazing land and barley to cope with the variations in climatic conditions, livestock farming ensures an income. Livestock farmers have become agro-pastoralists, or even farmer-herders. This adaptation ultimately makes livestock farming vulnerable, as cultivation on fragile land and overgrazing of rangelands encourage desertification. Since 1980, 11 million hectares of rangelands have been cultivated, threatening neighbouring lands with desertification through silting, and 14 million hectares of the steppe zone are affected by desertification (Bencherif, 2018; Snaibi and Mezrhah, 2021; Abaab *et al.*, 2020).

■ Cross-sectional analysis

The cases presented in this section illustrate the continuous and significant adaptations of livestock farms in the territories. Over the last few decades, livestock farms in the regions studied have changed in *size* (enlargement in France), in *form* (family farms vs. large livestock estates in Brazil, recruitment of paid shepherds in North Africa), in

production (shift from suckler farming to dairy farming in Brazil, opposite movement in France), but also in *practices*. In France and in North Africa, the contribution of grazing to the feeding of the herds has decreased significantly, replaced by fodder grown on the farm and by purchased feed concentrates. In Brazil, on family farms where livestock production has developed, grazing is managed more intensively: it has become rotational and is sometimes rotated with an annual crop of maize or sorghum. In response to predation by wolves, farmers and shepherds in France have sought to adapt their practices, in particular on mountain grazing lands (Box 2.1). Moreover, the territories and operators in the sector - in this case, mini-dairies - are also adapting, developing their local collection from a core group of farmers, contributing to the settlement of these groups and encouraging them to intensify their practices (Box 2.2).

The determinants of these adaptations are diverse and operate at varying scales. Public policies, and their impact on the price of products and inputs, have played a major role in France (credit, pricing policies, subsidies that replaced them), but also in the Maghreb via the price of concentrates, which in some cases have been subsidised, and the price of ovine meat, whose imports are taxed. The mandatory nature of a minimum local collection in order to operate in the country imposed in West Africa is another example of the influence of national or supranational political choices. In two of the regions under review, *land use regulations* have also played a role, whether by controlling deforestation from 2005 onwards in Brazil or enabling the private appropriation of cultivated areas and hence transforming the pastoral space into an agropastoral space in the Maghreb. At a more local scale, ecosystem transformations have also been at the origin of certain adaptations, whether it is the closing of landscapes (France), the rapid development of weeds on grasslands reclaimed from the forest (Brazil), climate change reducing the productivity of pastures (Maghreb) or the return of a predator like the wolf in France. *Human demographics*, the balance between generations among the local population, and their more or less extensive investment in local or more remote non-agricultural activities have also led to adaptations (e.g., neo-rural farmers in the Cévennes, management from cities of certain large grazing herds by prominent people in North Africa, and the pioneering migratory flow and different aspirations of their descendants in Amazonia). Finally, changes in the *demand for animal products*, whether expressed locally or nationally, have also played a role, encouraging family farms to produce milk in the Amazon, promoting the development of processing and short supply sales channels in France and stimulating the collection of local milk in West Africa.

It must be noted that these adaptation trajectories, which have now been explained, do not systematically lead to sustainable development in the territories.

Accordingly, the reduction in the contribution of grazing to animal feed observed in France and North Africa is contrary to the principles of agro-ecology: it limits the energy and feed autonomy of farms and contributes to the overgrowth and closure of the landscape in France. In addition, not all farms are always able to adapt and therefore these trends exclude some livestock farms: In the Causses and Cévennes, farms with limited

Box 2.1. When adaptation is no longer enough: farmers dealing with wolves in France.

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For reasons of safety to humans and damage to livestock, wolves had been eradicated in France in the late 19th and early 20th centuries. There were no wolves left when the country made a commitment in 1992, within the framework of the EU Habitats Directive, to contribute to the restoration of the species under protected status.

The arrival of wolves in France from Italy was only made public in 1993. As the arrival was not anticipated, farmers were in no way prepared to deal with it. This is in contrast to other regions of the world, such as north-western United States, where all parties likely to be affected by the wolf restoration programme, starting with farmers and hunters, had been invited to negotiate for 10 years before the first release (Meuret and Osty, 2015).

In nearly 30 years, farmers in French regions where wolves are present have tried to adapt to this new constraint, as soon as contracts and financial aid have allowed them to adopt the recommended protection measures: reinforced human presence, guard dogs, secure fences, systematic return to night pens or sheepfolds. Currently, in the Alps and in Provence, the adoption of these measures is widespread, embodying the adaptation effort of the farmers, with the number of protection contracts for farmers closely corresponding to the number of grazing units, in particular on the alpine meadows (Meuret *et al.*, 2017). However, the effects are sometimes harmful: difficult co-existence with a shepherd's assistant in cramped alpine huts; conflicts with hikers due to guard dogs; conflicts with hunters related to the erection and electrification of fences; twice-daily movements to and from the pen at night that disrupt the routes of the shepherds and also generate soil erosion and damage to the grasslands.

While farmers and shepherds have gradually adapted, most are experiencing considerable work-related discomfort due to the direct and indirect consequences of the attacks. In addition to the dead animals, there are also losses in physical condition, sometimes mass abortions, as well as drops in production linked to the stress generated (Meuret *et al.*, 2017). The constant and linear progression of the annual number of wolf victims: + 1,000 animals killed or mortally wounded per year between 2009 and 2019 in France (Meuret *et al.*, 2020), with a total in 2019 of around 15,000 victims (all animal species, those found but also those missing as a result of the attacks) demonstrates the limited results of the efforts to implement herd protection.

The adaptive capacities of wolves, highly intelligent and opportunistic carnivores, have not been anticipated or have been insufficiently anticipated. Wolves learn to bypass the obstacles erected by farmers, especially when there are no serious consequences for them and their offspring. This is a dynamic of co-adaptation between humans and predators, a constantly evolving process and one that it would have been much wiser to consider (Meuret *et al.*, 2020).

Box 2.2. The adaptation of industrial dairies to small-scale producers in West Africa.

Christian Corniaux, Guillaume Duteurtre

Collecting milk in West Africa is expensive. The fragmentation and low productivity of rural livestock farms have resulted in an increase in price of around 100 CFA francs per litre of milk collected, which is one-third of the price paid to the dairy. Competition with imported milk powder, notably from Europe, is intensified in a market dominated by urban consumers with low purchasing power. Dairy manufacturers, located in the capital cities, prefer this cheap powder. Out of a hundred companies, only twenty or so collect milk. Sometimes constrained by national enforcement measures (compulsory quota), they also see in this collection of local milk a focus for their corporate social responsibility (CSR) actions and a means to enhance the value of their products on a few profitable niche markets.

As a result, these companies adapt to the conditions of the farmers to encourage them to produce and sell their milk (Corniaux, 2019). The main lever is the price, which is kept relatively high throughout the year. The second is the provision of feed for milk. A major effort is also invested by the dairies to increase the size of the logistical resources. Furthermore, often with the support of development projects, they support the progressive setting-up of intensified mini-dairy farms to complement the established dairy farms. The cost of collection is then significantly reduced, making the processing of local milk more profitable.

land resources that are easy to mechanize were at a disadvantage in mobilising these new means and tended to disappear; in North Africa, farms equipped with trucks and able to employ hired labour can explore more distant grazing areas and thereby feed larger herds with greater security in the face of hazards; In West Africa, livestock with a strong pastoral component, highly mobile, have difficulty accessing the milk collection circuits of the mini-dairies and must therefore find alternative outlets for their milk. Finally, the adaptation to predators in France generates an intense stress for farmers.

Studying adaptation trajectories and their determinants appears to be essential in identifying the levers that can lead to the evolution of livestock activities in the direction of sustainable development. Rendered possible through the mobilisation (or even the construction) of adapted analytical frameworks and research devices, comparisons between nearby territories (the Causses and Cévennes, for example) or more remote ones (France and North America on predation) often prove profitable. This research makes it possible to highlight and reason various levers, such as the subsidy allocation rules of the Common Agricultural Policy (CAP) and the collective choices made within the Roquefort or Pélardon quality approaches in the Causses and Cévennes, on corporate social responsibility and dairy policies in West Africa, or on land tenure regulations in Brazil and North Africa.