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Controversies of the French Academy of Agriculture 2024

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How can producers, citizens and consumers be reconciled?

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Summary

Executive summary

Since domestication began in the Neolithic period, livestock farming has intensified, leading to a considerable increase in production per animal, per unit of land and per worker. It has contributed to the development and flourishing of human societies. However, limitations have gradually emerged in the three pillars of sustainability (economy, environment and society) for economically efficient, socially equitable and environmentally sustainable development, particularly in the case of so-called "intensive" livestock farming systems.

The presentation of definitions and discussion of terms used to describe livestock farming is a prerequisite for any further reflection. Thus, the term 'intensive' can cover several definitions depending on the quantity of inputs, or capital and labour mobilised for production. However, the term 'intensive' is often used to describe livestock farming in buildings and, more often than not, in confinement. The "size of farms" is a criterion that reflects the agricultural area or the number of animals used, but the concept of "large" or "industrial" is highly dependent on the countries in which they are located. The term "family farm", which is also highly dependent on the country, is not necessarily related to the two previous definitions. The term "concentration" refers mainly to the territory. It is also associated with the term "specialisation", which can refer both to the farm itself and to the territory in which it is located alongside other structures of the same type.

Several observations are then made. Firstly, there is a growing divergence between production and consumption of animal products in France. Although there are significant differences between sectors in the ratio between the two, for several types of animal products, particularly meat, domestic production no longer covers consumption. For almost all sectors, production has been declining for several years. Consumption of animal products, on the other hand, has only declined slightly but has evolved differently depending on the type of meat: consumption of beef and sheep meat is falling significantly, while consumption of pork, and above all poultry and fish, has risen sharply. In all sectors, the increase in out-of-home catering has been accompanied by a shift towards lower-quality meats and cheaper products. Regardless of changes in consumption, consumers, through their actions, are one of the key drivers of medium- and long-term developments in livestock farming systems.

Secondly, it is important to remember the significant contribution of livestock farming to human nutrition. Animal products are nutritionally rich foods. Nutritional recommendations currently aim to reduce meat consumption, especially among heavy eaters, in order to reduce the associated risks, while taking advantage of their interesting and important contributions in micronutrients. In this area, it is reported that the nutritional, technological and organoleptic qualities of products from intensive farming may be inferior to those from more extensive farming.

Thirdly, the image of livestock farming and, to a lesser extent, livestock farmers has deteriorated in society, and questions are being asked about the relevance and necessity of maintaining intensive livestock farming in the future. This questioning of livestock farming affects the profession of livestock farmer, which has become public under the constant scrutiny of society. While farmers want to thrive in their work, earn a decent living and have a successor, they are subject to criticism because their profession uses a lot of space and natural resources, which are considered common goods. Farmers' sensitivity to criticism about the sustainability of their farms, combined with the economic difficulties they face, is jeopardising the renewal of generations.

Finally, and more broadly than just France, it seems that "intensive" livestock farming is essential to meet global demand, which is expected to continue to rise, but that it must evolve, in France as elsewhere, to respond to criticism of its unsustainability. Numerous studies have been carried out over more than a decade to design scenarios for change that would enable food production and consumption to coincide without exceeding planetary limits. All of them propose reducing the consumption of animal products to limit the impact on the planet, especially in countries that consume them in large quantities in varying proportions, with two opposing options: fewer ruminants to reduce greenhouse gas emissions, or fewer monogastric animals to reduce competition with humans for land use. In all cases, maintaining technically efficient livestock farming must enable sustainable production in France and Europe so as not to import unsustainable products from elsewhere.

The diagnosis made for each pillar of sustainability, production by production, shows first of all that intensive livestock farming has advantages and provides services. It enables the production of affordable food, contributes significantly to the vitality of territories and, in environmental terms, has a lower footprint per kilogram of product. However, this assessment also shows that the economic situation of these systems is heterogeneous and often uncertain, both in the medium and long term, despite the promises of "moving upmarket" and the search for "non-price competitiveness". This situation is due in particular to increased competition with other countries, distorted by unequal rules for the production of animal products. Still on the economic and societal pillar, the high degree of specialisation in production, which uses genetic selection based on a small number of traits, is a medium-term risk, particularly in view of growing demands regarding animal welfare and the place of farmers and livestock farming in the agri-food systems and society in general. The relationship between animal health and human health is also a subject of debate in the context of intensive farming. While intensive farming allows for better control of environmental conditions and medication use, it also promotes the transmission of diseases between animals by bringing large numbers of them together in the same place.

Finally, intensive livestock farming has a significant impact on the environment due to nitrogen emissions into the air and water, greenhouse gases and chemical compounds, and the indirect effects of animal feed production on biodiversity, health and resource consumption. These environmental issues are currently very much in the public debate and focus heavily on the importance of enteric fermentation and emissions of methane, a powerful greenhouse gas. In this environmental pillar, it should be noted that intensive farming has largely lost its ecological role as a recycler due to its high degree of specialisation, and that much of the criticism it faces stems from this development. Finally, there are "hidden costs" for the environment and human health that are not taken into account in the price of the food we consume.

The above considerations show that livestock farming must undergo significant change compared to what we know today in order to continue producing nutritious food while undergoing a profound transformation towards greater sustainability. Several paths for progress have been identified to improve the sustainability of these intensive systems across the three pillars of sustainability.

With regard to the economic pillar, it is necessary to protect against low-cost imports, whose products are mainly found in ultra-processed foods and out-of-home catering, and to create value for products, in particular by establishing and/or consolidating new exchanges of trust between consumers and producers. The design and financing of buildings that break with the existing model for the well-being of animals and farmers is an essential path to follow. Regarding the environmental pillar, reducing methane emissions from ruminants is a priority, without neglecting the search for progress in other areas. Better management of livestock effluents would make it possible to move towards closing the nitrogen and phosphorus cycles.

However, a more comprehensive, systemic approach at the level of farms, sectors and territories, taking into account the entire agri-food system, will enable real progress to be made in terms of sustainability. It must involve consumers and citizens in order to define a kind of societal pact. Proposals for changes towards livestock farming better integrated into the region, combining de-intensification and a certain degree of de-specialisation in certain regions within an agroecological approach, would maximise biomass recycling at farm level and link livestock farming and crop production more closely within regions. The challenge, therefore, in the medium and long term, is to rethink the agricultural model in order to achieve greater sustainability in intensive livestock farming.

This involves finding consensual paths for the evolution of intensive livestock farming in France. French livestock farming is suffering. Production is declining, as is the number of farmers or candidates for setting up farms, and imports are increasing, even though we have one of the highest production potentials in Europe.

The document outlines a number of avenues and tools that are available for these changes, some of which can be implemented in the short term within the current systems or are already being implemented in the field. Others will be available in the medium term. Accelerating and generalising their deployment would quickly lead to a reduction in the environmental footprint of livestock farming, as well as improving animal welfare and working conditions for farmers. At the same time, farmers and industries will continue to strive for competitiveness. These transitions cannot be achieved at the expense of the competitiveness of livestock farms. Ambitious public policies geared towards these objectives are essential to achieve this.

These developments should be steps towards a more ambitious transition in order to truly achieve livestock farming that closely combines, at the farm level, groups of farms or a small region, diversified animal and plant production, conducted according to the principles of agroecology within the framework of nourishing agroecosystems, sequestering carbon, protecting or restoring biodiversity and leading to good water and air quality.

Acronyms and abbreviations used

ADEME: French Environment and Energy Management Agency, a French public institution

FA: fatty acids

PUFA: polyunsaturated fatty acids

Agreste: statistical service of the Ministry of Agriculture

Anvol: National Interprofessional Poultry Association

BEA: animal welfare

IARC: International Agency for Research on Cancer

CNPO: National Committee for the Promotion of Eggs, Interprofessional Egg Association

FAO: Food and Agriculture Organisation of the United Nations.

FranceAgriMer: National Agency for Agricultural and Marine Products, agricultural policy management body

GHG: greenhouse gases

ICPE: Classified Installations for the Environment

Idele: the Livestock Institute is a qualified agricultural technical institute

IDDRI: Institute for Sustainable Development and International Relations

IED: European Union directive on industrial emissions

INRAE: National Research Institute for Agriculture, Food and the Environment

INSEE: National Institute of Statistics and Economic Studies

IPBES: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

IPCC: Intergovernmental Panel on Climate Change

OECD: Organisation for Economic Co-operation and Development, an intergovernmental organisation for economic studies with 38 members that consider themselves to be "democratic" and "market-based"

CAP: Common Agricultural Policy (of the European Union)

PAT: Territorial Food Project

PNNS: National Nutrition and Health Plan (French public policy)

SNBC: National Low Carbon Strategy (French public policy)

Solagro: French association active in engineering, research and training, "serving energy, climate, agroecological and food transitions"

tec: tonne carcass equivalent or, more generally, carcass equivalent weight.

EU: European Union

Introduction

Invented in the Neolithic period simultaneously in different parts of the world, the breeding of a limited number of domesticated and then improved animal species spread across the globe (Cucchi et al. 2021). It provides high-quality animal-based foods such as proteins with a good balance of amino acids, minerals and micronutrients (vitamins and trace elements), various co-products, and ecosystem and societal services. However, it is criticised for its environmental footprint, its significant use of resources, its impact on the climate, inadequate animal welfare and the health impacts of consuming animal products. Ultimately, the very consumption of animal products can be controversial (Delanoue and Roguet, 2015). These debates on livestock farming really gained momentum after the publication of the FAO report "*Livestock's Long Shadow*" (Steinfeld et al., 2006), although other warnings had already been issued, particularly with regard to the increase in nitrate levels in water intended for human consumption (Henin, 1980).

This criticism is mainly directed at what is commonly referred to as intensive or industrial farming, which prioritises productivity from a technical and economic point of view, as opposed to small family farms, which are widely believed to be more sustainable, to the extent that several NGOs and politicians are suggesting nothing less than the abolition of intensive farming[1] . Can we objectify this debate by analysing the criticisms and assessing the level of sustainability, species by species, and propose ways of improving new systems that better meet the multiple and sometimes contradictory expectations of the industry and society?

The question raised in our 'controversy' concerns 'sustainability'. Several concepts of sustainability exist in the literature (Ekins et al., 2003; Johnston et al., 2007): especially that of "strong" sustainability, which aims to maintain human activities within planetary limits (Rockstrom et al., 2009) and which considers a logic of redesigning systems where natural capital is essential by prioritising the environment over the economy, and "weak"

[1] https://www.20minutes.fr/planete/3245251-20220309-presidentielle-2022-sortir-elevage-intensif-idee-fait-chemin-campagne
https://reporterre.net/L-elevage-intensif-n-engendre-que-souffrances-pollutions-et-dangers

sustainability, which aims to seek socially acceptable compromises in the short term by assuming a certain interchangeability between natural, technical and human capital. Our approach was based on three pillars: environmental, economic and societal (Figure 1; Purvis et al. 2019), and on the analysis of the services and impacts produced by the intensification process, which vary according to its degree. The objective to make livestock farming more sustainable[2] requires systemic transformation efforts.

Numerous studies have been conducted on livestock farming worldwide, based on strong sustainability approaches (e.g. EAT Lancet: Springman et al., 2018). They all conclude that there is a need for a drastic reduction in animal production in order to move towards more sustainable food systems, but they ignore the services that livestock farming can provide to natural environments and societies, as well as the technical advances that can be made to reduce its impacts. They also ignore the economic and social dimensions. For example, Hirvonen et al (2020) estimated that the cost of an EAT-Lancet diet exceeded the per capita household income of at least 1.58 billion people.

In this work, we favour a pragmatic approach to intensive farming in France, taking into account the sociological and agronomic diversity of our territories. This does not mean ignoring the long-term challenges highlighted by global approaches, which clearly require action, but rather incorporating into our reasoning the economic and regulatory constraints associated with open markets and the needs of society and consumers as reflected in their consumption patterns. By "sustainability of intensive farming", we mean maintaining a level of food production consistent with consumer "demand" while reducing the net environmental impact associated with this production, improving the quality of life of animals and the people who work with them, and increasing the sector's capacity to produce ecosystem services and withstand climatic and economic shocks.

[2] They would simply "borrow" inputs from the natural environment before returning them "in good condition" so that they could be reused by future generations, preserving biodiversity and contributing positively to climate change mitigation.

Some definitions to clarify the subject of the debate

Several terms are used to describe livestock farming systems and operations, but they are not always clearly defined in debates and can cover different concepts. Without necessarily seeking consensus on definitions, it is worth recalling a few basic concepts.

"Intensive": in its primary sense, the term refers to the production system and reflects the importance of inputs from outside the farm (synthetic fertilisers, animal feed and additives, plant protection products), or the capital and labour mobilised for production. Intensive systems are therefore more dependent on external factors than on local agronomic potential. In this respect, they contrast with so-called "extensive" systems, whose productivity is closely linked to the agronomic potential of the land farmed (the prototype being organic farming) and which are much more self-sufficient. Intensification could be defined on the basis of the proportion of production factors covered by external purchases or the levels of effluent produced per unit of agricultural area. Livestock farms producing more than 170 kg of organic nitrogen (N) per hectare before any effluent treatment under the Nitrates Directive would be considered "intensive". However, this concept is fundamentally relative, especially since within the same farm, some production factors may be exploited intensively and others extensively. Michel Griffon (2013) also defined the concept of ecologically intensive agriculture, which seeks to maximise the use of biological processes to meet the dual challenge of the environment and production while limiting the use of synthetic inputs.

Historically, the intensification of systems has been driven in two directions: producing more per animal and per unit of area by increasing the density of animals per unit of area, leading to the rearing of animals in confinement. Thus, the term "intensive" is often used to describe livestock farming in buildings and, more often than not, in confinement; but in doing so, it loses its original meaning of significant use of exogenous inputs. Some grassland systems can be very extensive in terms of surface area, with animals grazing and producing little milk per cow (e.g. dairy systems in New Zealand or Ireland), but remain highly intensive under the Nitrates Directive. Confinement systems aim to produce animal products for food at the lowest cost, whereas increasingly, input-efficient "extensive" farming (as opposed to intensive farming) also aims to produce environmental services that are often recognised by society and are in fact closely linked to grassland and the ruminants that graze on it. It should also be

remembered that farm animals are selected for their ability to adapt to a particular farming system (Lauvie et al., 2023).

"Farm size": This is an economic criterion that reflects the size of the farm, the number of animals, or the number of people employed. Larger farms benefit from economies of scale. Size is a precise criterion, but the notion of "large" remains subjective. It varies according to region and country. European farms are therefore nothing like American beef feedlots or mega dairy farms in the USA or China, which have several thousand (or even tens of thousands) of cows, or Chinese pig farms, where tens of thousands of animals are stacked on several floors. Even on a national scale, a farm with 300 sows, which is quite common in Brittany, is considered very large elsewhere in France.

"Large herds" are often the subject of social debate, much more so in France than in other European countries, as they are believed to be associated with environmental nuisances and animal welfare issues, and any expansion is questioned. However, France is characterised by herds that remain moderate in size in Europe. In dairy farming, the average herd size is 80 cows (as in the Netherlands and Ireland), and French herds of several hundred cows are virtually non-existent, whereas they are the norm in many European regions (15% of cows are in herds of more than 500 cows in Europe, and as many as 20% in Germany, Italy, Sweden, 45% in Denmark, 70% in the Czech Republic, Hungary, Estonia and Slovakia)[3] . The number of farms with more than 1,000 cows is increasing in Spain, the United Kingdom and Germany, while farms with 1,000 cows have met with strong opposition in France. Similarly, the average size of broiler poultry farms is 20,800 in France, but 61,000 in Germany, 70,000 in the Netherlands and 93,000 in the United Kingdom[4].

According to the French classification system for environmentally classified facilities (ICPE), the smallest farms are required to submit a "declaration", farms with 150 to 400 dairy cows, 400 to 800 calves, 500 to 2,000 pigs and 30 to 40,000 poultry are subject to "registration". Beyond that, herds must follow the "authorisation" procedure with more thorough monitoring of their environmental impact. For the purposes of legislation, these are therefore considered "large herds" with potentially negative impacts on the environment that

[3] Weekly session of the Academy of Agriculture on 5 June 2024: Development of very large dairy herds in different countries around the world: driving forces, challenges and impacts.
[4] Source: Anvol (interprofessional organisation for poultry meat) and FranceAgriMer.

need to be controlled. At European level, the IED Directive (No. 2010/75/EU of 24 November 2010, revised in 2024) on industrial emissions applies to livestock farms with more than 40,000 poultry places, more than 2,000 places for pigs weighing more than 30 kg or more than 750 places for sows, and does not apply to dairy barns. Around 3,000 farms are affected by this directive in France. These large herds are sometimes referred to in France as "industrial" or "factory farms" (Greenpeace France, 2020), even though they are far from being on the scale of the aforementioned mega-farms and even other European herds.

The number of people employed in livestock farming is less commonly used to describe the size of farms. The values observed in France would mostly classify farms as small-scale rather than industrial. In 2020, farms with more than 150 sows (82% of the sow population) had an average of 350 sows and employed 3.7 people, including 1.7 salaried employees. In standard chicken farming, a 40,000-place farm (approximately 2,000 m²) can be run by one person working part-time or three-quarters time.

"Family farm": capital and labour are mainly provided by the farm manager and his or her family, which often, but not always, limits the size of the farm due to the available workforce. However, corporate farming, particularly in the form of GAECs (agricultural economic interest groups), makes it possible to partially overcome this limitation. The increase in farm size tends to separate capital providers from labour providers, increasing the proportion of salaried labour and giving rise to the category of "agri-managers". With expansion, the high capital requirements may necessitate external intervention by financial or industrial agri-food companies, or even cooperatives. However, it is worth noting the case of large American herds, which remain the property of a single farmer[5] . The sign of equivalence between family farms and farms that remain of a reasonable size cannot therefore be generalised on a global scale. Furthermore, expansion is accompanied by a reduction in the number of farms, which can have social and economic effects on local areas. Size also impacts the competitiveness of a system and its ability to amortise investments needed to integrate new technologies and automate the most thankless tasks. The debate on size is therefore linked to political choices regarding agricultural models.

[5] Session of the French Academy of Agriculture on 5 June 2024: Development of very large dairy herds in different countries around the world: driving forces, challenges and impacts (already cited)

"Specialisation" can be defined at the farm level but also at the regional level. A farm is specialised when its activity is primarily or exclusively devoted to a single type of production. Farms have become highly specialised over the last 40 years, to the detriment of mixed farming and livestock farming, which has declined sharply and now accounts for only 10% of farms in France. At the regional level, specialisation refers to the presence in a given region of very dominant types of production, often carried out by farms that are themselves specialised, as well as upstream and downstream industries linked to production. The expansion and specialisation of farms have been encouraged by the faster growth in the price of labour compared to other factors of production (Dupraz, 1997). In addition, each region has capitalised on its competitive advantages. For example, Brittany is a region specialising in pig, poultry and dairy production, the Massif Central is specialising in extensive cattle farming, and Beauce is a region of plains used for arable farming, mainly cereals.

"Concentration" primarily refers to the territory and expresses the density of farms and animals located there. A territory can be specialised and concentrated (e.g. pig farming in certain areas of Brittany) or, conversely, specialised and less concentrated (suckler farming in mountainous areas). The dual process of geographical concentration and specialisation at regional level makes it possible to benefit from agglomeration economies (Larue et al., 2010). The existence of gains derived from the geographical concentration of production has been a central element in the specialisation of regions.

All these terms, which are often used interchangeably to describe livestock farms, may overlap, but this is not systematic. For example, the term "family farm" says nothing about its level of intensification. A family farm can be intensive, like many pig farms in Brittany, or extensive, like many farms with suckler cows in mountainous areas. Size does not predict the production system and is not in itself an indicator of intensification, even if large farms are often intensive. Many organic farms in Denmark have more than 200 or 300 cows and would be classified as large farms or industrial livestock farms in France. Nor is there a direct link between specialisation and the intensive nature of production, whether at farm or regional level, or in terms of size. Cattle farms in mountainous areas are specialised but not intensive. While the term "intensive" can be objectified using data to classify farms as more or less intensive, the word "industrial" is more subjective and depends on the desired agricultural model.

The controversy therefore centres on the sustainability of specialised (or specialised workshops within a farm practising multiple types of production) and intensive farms with significant use of external inputs to feed herds, which often exceed the capacity of their territory to produce and recycle the nutrients (N and P) contained in animal manure. These specialised farms are relatively large, are subject to ICPE regulations and either remain family-owned or take on a more entrepreneurial nature. The animals are often kept in buildings. These farms are most often concentrated in areas that are themselves specialised.

Divergent trends in production and consumption

The overall balance of the sectors is different for each type of meat in France, with quite diverse pictures (Table 1). For several types of meat, national production no longer covers consumption.

Production is declining for almost all sectors in France

Beef production from suckler herds increased significantly in France, particularly after the introduction of milk quotas, but is now in sharp decline, with the suckler cow population falling from 4.1 million in 2010 to 3.5 million today. Foreign trade still shows a surplus due to exports of weaned calves, but at the same time, 21% of the beef consumed is imported, mainly in the form of minced meat from culled dairy cows (Institut de l'élevage, 2024). In sheep and goat meat production, the decline in production has been continuous since the 1980s and very marked. Sixty-nine per cent of the sheep meat consumed is imported, and the external deficit has widened.

As for pork, although production has increased significantly over the long term, it has remained stable in recent years and has been declining for the past three years. The import-export balance in terms of volume has been maintained, but if production continues to decline at the current rate and assuming that current consumption remains stable, France will no longer be self-sufficient by 2025-26 (FranceAgriMer, 2023). Thirty per cent of the pork consumed in France is imported from the European Union, primarily from Spain, and the external deficit in value terms is widening due to exports being priced lower than imports, which include more value-added products (processed fresh meat and charcuterie).

The case of poultry is different again. After a period of strong growth, production has been declining for twenty-five years, while consumption has exploded. Under these conditions, just over 40% of poultry and 50% of chicken meat (94% of which comes from Europe) consumed is imported (FranceAgriMer, 2023); the sector, which had a surplus in 2000 (€1.2 billion trade surplus and a net surplus of 725,000 tonnes), is now running a deficit that is growing every year (trade deficit of €1 billion and 500,000 tonnes in 2023).

Cow's milk production has remained stable (23 million tonnes) since the introduction of milk quotas, with the decline in the number of cows being offset by an increase in individual production. However, milk production has been declining for the past three years, and some forecasts suggest that France will no longer be self-sufficient in milk and dairy products by 2027, despite having a trade surplus of more than €3 billion in 2020.

Fish farming, mainly of salmonids such as trout and salmon, has declined slightly between 1998 and recent years.

Consumption of animal products has evolved differently across sectors, but overall demand has not decreased significantly.

[6]Over the last few decades, eating habits have changed, with differences in behaviour between consumers. In France, average per capita meat consumption has increased sharply since the early 1960s, reaching 88.4 kg of carcass equivalent in 1980 and even 93.6 kg in 1998, then falling to 85.8 kg in 2010 and remaining fairly stable since then at 85.0 kg in 2022. These overall trends mask contrasts between different types of meat (Agreste, 2020). Individual consumption of beef has fallen by 26% since 1980, while that of sheep and goat meat has fallen by 13%. Pork consumption rose for a long time before falling only recently. Poultry consumption has more than doubled. Poultry even became the most consumed meat in France in 2024 (31.6 kg, including 24.9 kg of chicken). Pork benefits from the diversity of its offering (meat + charcuterie), while poultry, particularly chicken, benefits from its price, ease of use (prepared specialities, ease of cooking thanks to the range of cuts available), strong growth in fast food, the absence of religious prohibitions and the tarnished image of other

[6] Carcass weight equivalent: to calculate the flow of products containing variable proportions of raw materials, the weight of raw or processed products is converted, using a set of coefficients, into the equivalent weight of the carcass from which they originate. The carcass is the body of the animal after slaughter, including the bones. The finished products consumed have approximately half the carcass weight equivalent on average.

meats (health, environment, etc.). At the same time, consumption of eggs (a cheap source of protein, used in the food industry, etc.) and processed dairy products (yoghurts, desserts, cheeses) has increased, while consumption of liquid milk has decreased. While consumption of milk and dairy products has plateaued, egg consumption continues to grow, with each French person consuming 224 eggs per year in 2024, compared to 200 in 2013[7] . Consumption of farmed fish has risen sharply over the last 25 years to reach almost 5 kg per capita, leading to a massive increase in imports, mainly of salmon, which has become one of the French people's favourite products in this sector. This situation creates a very significant imbalance in the external balance for this type of product.

In addition to per capita consumption, the evolution of overall demand also takes into account population growth, which has risen from 45 million in the early 1960s to 66 million today (Agreste, 2020). Since 1980, national poultry consumption has increased 2.2-fold, pork consumption has increased by 14% while stabilising recently, beef consumption has decreased by 15% and sheep meat consumption by 20%. To meet demand and compete, livestock farming systems have greatly increased their productivity and become more intensive.

Out-of-home consumption is growing very rapidly and is driving demand for lower-end products.

Out-of-home consumption is growing rapidly and the phenomenon is accelerating. Fast food has increased by 30% since 2019 and *snack* products by 18% in 2023 alone. Out-of-home consumption now accounts for a quarter of food expenditure and is shifting towards industrially processed products (minced meat, etc.) and even so-called "ultra-processed" foods (nuggets, etc.). This consumption is the main driver of imports, as out-of-home catering often prioritises price constraints, with the purchaser of raw materials not being the end consumer. The origin of meat is rarely traced and is not readily apparent to consumers. As a result, more than 70% of chicken consumed outside the home is imported (FranceAgriMer, 2023) and 75% of imported beef is used in catering outside the home (Institut de l' Élevage, 2024) and in prepared meals.

[7] Source: CNPO (interprofessional egg organisation)

Through their actions, consumers are one of the key drivers of medium- and long-term changes in livestock farming systems.

Current changes in consumption patterns, with out-of-home catering, the search for convenience and the development of *snacking*, run counter to the calls for French industries to move upmarket, especially as, at the same time, inflation has prompted many consumers to buy less and cheaper, and this trend is continuing (a 3.2% drop in consumption value in 2023 and 2.9% in 2022 according to l'Insee). To date, only home consumption of minimally processed and locally cooked products can promote the consumption of regional/local products with quality labels, but this share of home consumption is tending to decline.

In addition to nutrition and purchasing power issues, environmental considerations, those related to animal welfare and, independently of food, the reconsideration of the relationship between humans and animals, and between humans and biodiversity as a whole, by society and in particular by younger generations, could also contribute to a decline in the consumption of animal products in the future. Generational shifts may also occur. A recent survey (Statistica, 2024) indicates that the proportion of French people following pescatarian, vegetarian and vegan diets is much higher among millennials (born between 1980 and 1994), where they represent 13%, and even higher among Generation Z (born between 1995 and 2012, 17%) compared to previous generations (3% among those aged 40 and over). Dairy consumption is also lower among younger generations (81% of Baby Boomers are regular consumers, compared to only 48% of Generation Z). The development of plant-based or mycelium-based alternatives could also contribute to a decrease in the consumption of animal products, even though the market share of these new products is currently very low.

What conclusions can be drawn? The growing gap between domestic production and consumption calls into question our food self-sufficiency, particularly in the poultry sector, where consumption is rising sharply, and in the beef sector, where decapitalisation is increasing and the export of weaned calves runs counter to this self-sufficiency. France is, in fact, the country that has increased its imports the most in Europe. In the future, the decline in national consumption of animal products could continue and accelerate under the influence of purchasing power, which remains a major determinant of consumption trends, nutritional recommendations (see below), considerations about the sustainability of systems, and choices of eating habits between generations.

Nevertheless, consumer purchases and the nature of their out-of-home consumption are two key drivers of demand for domestic production and imports. Currently, this demand is steering consumers towards more or less sustainable livestock farming. The issue of consumer information in all forms of consumption, at home or outside the home, is crucial. Having reliable information on the sustainability of the livestock farming from which the animal product they are about to buy or consume originates should help to restore their confidence and move national systems or imports towards greater sustainability. In the short and medium term, regardless of how consumption evolves, it is crucial to curb the increase in imports by developing competitive production that meets market needs. This will require changes in livestock farming. However, in order to adapt as effectively as possible, it would be useful to develop quantified scenarios for the evolution of needs. Efforts to provide information, training and promotion of the supply would be useful in shifting current trends towards quality consumption.

Nutritious foods, but not to be consumed in excess

For several years, animal products have been at the centre of several controversies regarding their nutritional value, with no real distinction between production methods.

Nutritional recommendations aim to reduce meat consumption.

National nutrition and health programmes (PNNS) aim to promote balanced eating habits in order to combat chronic diseases, overweight and obesity in France, with positive results compared to other countries around the world (NCD Risk Factor, 2024). National consumption recommendations have been revised downwards for animal products (PNNS 2018): the maximum amounts not to be exceeded are now 500 g per week of red meat (ruminants, pork, lamb, offal, horse) and 150 g of charcuterie, which is higher than the recommendations of other European countries (for example, the Belgian Superior Health Council recommends not exceeding 300 g of red meat per week). Among French adults, the average consumption is 430 g of red meat, 220 g of poultry and the same amount of processed meat (Darmon et al. 2024). It is estimated that 70% of the French population consumes less than the recommended amount of red meat[8], but 63% of adults consumed what was

[8] Survey on Food Behaviours and Attitudes in France (CAF), CRÉDOC, May 2021

considered to be too much processed meat in 2014-16[9] . Messages encouraging moderation in consumption (particularly in the case of processed meat) are therefore primarily aimed at populations who are heavy consumers and exceed the maximum recommendations. Today, nutritionists agree on recommending diets in which animal proteins account for around 50% of total protein intake (Pérignon et al., 2019; Vieux et al., 2022), although there are no official national or international recommendations on this ratio. Animal protein currently accounts for an average of 65% of the French diet, with total protein consumption exceeding recommendations by at least 20%. To maintain essential nutrient intake, the reduction in consumption of animal products should focus mainly on meat and less on dairy products (particularly fresh products) and eggs. According to linear optimisation studies of the composition of "ideal" diets, this would lead to a 50% reduction (Vieux et al. 2022; Darmon et al. 2024) in meat consumption, and more specifically in beef consumption, which is considered too fatty, while poultry meat is encouraged alongside increased consumption of legumes, vegetables and fruit and reduced sugar consumption.

Avoiding excessive consumption of animal products, but taking advantage of their benefits

The International Agency for Research on Cancer (IARC; Bouvard et al. 2005) has classified red meat consumption as "probably carcinogenic to humans " and the consumption of processed meat as "carcinogenic to humans" because it increases the risk of colorectal cancer for each additional daily consumption, by 17% for 100 g of red meat and 18% for 50 g of processed meat. These findings have been the subject of much debate, but in the case of red meat, the risk is zero for consumption below 490 g/week and insignificant for consumption below 700 g/week, provided the meat is not grilled. Only very heavy consumers are likely to be affected. However, the risk thresholds seem to be exceeded more quickly in the case of processed meat. Furthermore, while high consumption of animal products increases the risk of metabolic diseases (obesity, metabolic syndrome, diabetes) and cardiovascular disease, there is no clear effect of consumption close to nutritional recommendations (Lecerf, 2014; Sanders et al., 2024), even in the case of butter (Guo et al. 2017).

[9] Compliance with new dietary recommendations for adults aged 18 to 54 living in France: Esteban Study 2014-2016. Nutrition section - Epidemiological surveillance. Available here

Foods of animal origin are also important or even unique sources of several micronutrients (vitamins A, B12, B3, B6 and D, zinc, selenium, calcium, phosphorus and heme iron). The frequency of intake deficiencies is higher among low consumers of red meat than among high consumers, in terms of iron (78% *vs.* 45%), zinc (90% *vs.* 35%) and vitamin B12 (70% *vs.* 18%)[10] . The consumption of animal products also provides various bioactive components (taurine, creatine, carnosine, conjugated linoleic acids) that have nutritional benefits, particularly for the development of cognitive functions (Leroy et al. 2019). Nutritionists and paediatricians warn of the risks of excessive reduction in meat consumption, which can lead to deficiencies in essential nutrients in at-risk individuals (children and adolescents, women of childbearing age, the elderly) (Bourre, 2011).

The nutritional, technological and organoleptic qualities of products from intensive farming may be inferior to those from more extensive farming methods.

Animal feed and age at slaughter are the major factors influencing variation, whereas animal density does not appear to have a significant effect (Prache et al., 2020). Protein composition, mineral content and most vitamins differ little between farming methods. However, farming methods can have a significant effect on fatty acid (FA) profiles. Feeding cows grass leads to dairy products that are richer in polyunsaturated fatty acids (PUFA n-3) as well as antioxidants (particularly vitamin E) and pigments. These benefits are absent in more intensive systems where maize is the staple feed. Milk from intensive systems is also much richer in saturated fatty acids (Legarto et al., 2014) and the butter produced from it is whiter and less spreadable. In more intensive farming across all animal sectors, the use of extruded linseed increases the omega-3 fatty acid content of animal products (e.g. the Bleu-Blanc-Cœur sector), but does not alter the antioxidant content. It is estimated that 9% of pigs are supplemented with flaxseed. The high n-3 PUFA content of fish meat makes it a product of great interest, especially as it provides long chains (eicosapentaenoic acid, EPA, and docosahexaenoic acid, DHA), but these levels are decreasing with the change in feed for farmed fish, which uses less fish meal and more vegetable oil (Médale et al., 2013). The consumption of animal products enriched with omega-3 n-3 PUFAs is accompanied by a concomitant improvement in the metabolic profile of consumers of these products, as our diet

[10] Survey on Food Behaviours and Attitudes in France (CAF), CRÉDOC, May 2021

is very deficient in n-3 PUFAs (Weill et al., 2001) and protective health effects, particularly on the cardiovascular system and the prevention of insulin dependence (Schmitt et al., 2006).

In poultry, but also in pigs to a lesser extent, genetic selection focused on growth rate and heavier carcasses, but perhaps also stress in intensive farming and slaughter conditions has led to significant defects in muscle tissue structure over the past fifteen years. Defects are also observed in fish. They are not found in animals raised in extensive systems with slow growth and access to pasture.

Feeding behaviours have changed little to date.

Recommendations for a healthier and more sustainable diet (eating less red meat, ultra-processed foods, foods high in fat, salt and sugar, and increasing the proportion of plant-based foods, particularly legumes), which are regularly communicated by numerous prescribers (authorities, the medical community, consumer associations, the media, etc.), are not always easy to adopt on a daily basis and follow through on, at least until now. In fact, while nearly three-quarters of French consumers say they are omnivores and do not plan to reduce their meat consumption, just under a quarter say they are "flexitarians[11] ", and the rest (2%) follow a vegetarian diet without meat (but with milk, eggs and sometimes fish). Vegans, who exclude all animal products, represent 0.1%. Rebalancing diets should mainly involve reducing meat and processed products among the heaviest consumers.

The image of livestock farming and farmers

The sustainability of intensive livestock farming is also closely linked to the image of livestock farming and livestock farmers and the place they currently occupy in society.

Intensive livestock farming under scrutiny in the public arena

Today's citizens are largely uninformed about the reality of livestock farming. The countryside is often idealised by increasingly urban citizens, but this view is far removed from the realities and constraints of agriculture and livestock farming (Hervieu, 2002). With changing public opinion and new knowledge about ethology and animal consciousness, intensive farming systems are now facing major image challenges due to animal welfare issues,

[11] Who voluntarily limit their meat consumption

which are becoming increasingly important to a growing section of society (Delanoue et al., 2018). Intensive systems, whether confined or not, are particularly challenged for their proven impact on the environment and climate. Other issues have given rise to controversies surrounding livestock farming, concerning health risks and territorial concentration (Delanoue and Roguet, 2015).

Criticism is widespread in the media and on social networks. Sometimes radical solutions, or those that run counter to market trends, are put forward as the only way forward, such as the outright abolition of intensive farming. Criticism is not limited to the most intensive systems. The Comté cheese industry, for example, has been working on the issue of acceptability for a long time. Each farm is taken over when it ceases trading, and the Doubs is the department with the youngest farmers (Observatoire Prospectif de l'Agriculture de Franche Comté, 2022). The specifications for this PDO (protected designation of origin) exceptionally include environmental obligations, such as limiting productivity per hectare to control water pollution. Despite these efforts, this industry and its farmers are accused locally of polluting. This successful model could also reach its limits with high cheese prices[12] .

The farmer, a profession in the public eye

Farmers want to thrive in their work (working conditions, work-life balance, etc.), have a job that reflects their values, earn a living, have a successor, and be recognised and integrated into local life. In short, they want a job that has meaning, a meaning that is above all individual, multidimensional, and evolving (Sidot et al., 2005; Gernet and Dejours, 2009; Servière et al., 2019). Today's livestock farmer is a business leader who is proud of their profession ("feeding people") and is committed to continuous improvement, but because they use space and its resources, they are, in fact, exposed to the scrutiny of society. Opinions may vary, but opinion polls generally show a positive image and sympathy for farmers, but mistrust of agriculture and its effects, with "industrial" farming being particularly criticised (Delanoue et al., 2018). While public opinion seems to like livestock farmers, it is in fact mainly the images of cows grazing on grass and, more generally, very low-intensity and/or alternative systems

[12] https://www.estrepublicain.fr/economie/2024/05/04/pourquoi-la-production-de-comte-va-diminuer-cette-annee

with outdoor animal that it likes, even if this implies a certain lack of realism about the current conditions of the profession.

The profession has become public. The feeling of being constantly under society's scrutiny and often accused creates intense pressure and stress, and can discourage many from entering the profession. As a result, 42% of farmers believe that society has a negative view of farming (Coty et al., 2017). Farmers' sensitivity to criticism about the sustainability of their farms is causing an identity crisis (ibid.). Farmers feel trapped with no way out. Reactions vary, ranging from indifference (17% of farmers) to anger (33%), sadness (26%) and demotivation (12%) (ibid.). Ultimately, with the added burden of heavy workloads, administrative constraints and sometimes low incomes, some farmers are switching to other professions or ceasing their activities prematurely, with no young farmers taking over. Paradoxically, this situation may reinforce entrepreneurial models, where responsibility is diluted, to the detriment of family models, where responsibility is individual. Thus, in the dairy sector, 69% of new farms are set up as GAECs (agricultural economic interest groups) and only 12% as individual farms[13] . It could also contribute to the transfer of production to continents where the image of livestock farming is not tarnished and where industrial models are a source of employment and accepted by society. The development of mega dairy farms around the world is an illustration of this[14] . Conversely, the implementation of practices in response to societal expectations can contribute to the well-being of farmers. 11% of farmers say they are motivated to change their practices by criticism from society (Coty et al., 2017).

Intensive livestock farming is essential, but it must evolve

Global demand is still anticipated to rise

It is essential to have a debate on the very existence of certain types of intensive livestock farming, without which it seems very difficult, if not impossible, to feed the world's population in the near future. The FAO scenarios all predict an increase in the demand for animal and plant proteins of 30% in the most frugal scenario and 50% in the continuity scenario, in order to satisfy a growing population that is more demanding animal proteins as living standards rise

[13] source: MSA and SPIE-BDNI - processed by Institut de l'Elevage (2022)
[14] See the session of the French Academy of Agriculture on 5 June 2024 on the development of very large dairy herds in different countries around the world (already cited)

in emerging countries (FAO, 2022). According to the latest OECD/FAO projections (2024) for the period 2023-2032, global poultry consumption is expected to increase the most due to its low price and high production efficiency. Pork and beef consumption is also expected to increase, except in Europe, where it is already high and where beef is perceived as contributing to climate change. It should be noted that beef consumption will increase particularly in China, which is already the world's second largest consumer, due to the growth of the middle class. According to the same study, plant-based substitutes could develop in Europe, North America and Oceania at the expense of dairy products. However, this long-term trend remains uncertain given the uncertainties that remain about their environmental impact and consumer health. Consumption of milk and dairy products is expected to increase in other regions of the world. In many countries, animal protein consumption is well below recommendations (sub-Saharan Africa, Southeast Asia, India) and nutritional deficiencies can be significant, particularly among young children, leading to stunted growth and cognitive development (Balehegn et al., 2019). Furthermore, the development of livestock farming, whether poultry or dairy production, is a remarkably effective social tool for farmers in the "South". On the other hand, demand may not explode as expected. In China, for example, after a period of rapid growth, demand for milk has stagnated and the country is now in a state of dairy overproduction.

Prospects for the future

For more than a decade, numerous forecasts and studies have been carried out worldwide, proposing scenarios to match food production and consumption while ensuring that planetary boundaries are not exceeded, that the ecosystems in which it is produced are not damaged, and that the place of animal products in this balance is determined. There are differences between these various prospects, notably Agrimonde (Ronzon et al. 2011; Le Mouël et al. 2018) and Eat-Lancet (Willet et al. 2019), but all emphasise the need to reduce the consumption of animal proteins to a greater or lesser extent in developed countries where consumption is very high. The planet could not sustain a generalisation of our Western diets, any more than those of the Chinese, Russians and the wealthy classes of the "global South".

Scenarios or studies conducted on Europe (Poux and Aubert, 2018; Berkhout et al., 2024) or on France by IDDRI (Schiavo et al. 2021), Solagro (Couturier et al. 2016), ADEME (Barbier et al. 2022), INRAE (Soussana et al., 2023) and the Shift Project (2024) to move towards more

sustainable agriculture by considering environmental issues, particularly climate change, all lead to proposals for reducing animal protein consumption for reasons of environmental impact and resource consumption. However, these proposals vary in scale and include different options: (a) fewer ruminants to reduce GHG emissions, (b) fewer monogastric animals to reduce competition with human food for land use, while retaining ruminants to enhance grasslands and preserve biodiversity, but without consuming cereals, (c) more balanced proposals for change between the different sectors. All these scenarios have numerous limitations and uncertainties that reduce their scope. They use very simplified representations of the complexity of livestock farming, material balances with the valorisation of plant co-products, which is all the more important as cereals develop, or crops to be introduced for good crop rotations. There is often no differentiation between territories, and the internationalisation of markets (Chatellier et al., 2019) and the behaviour of the various stakeholders are ignored. With the exception of the Shift Project and INRAE, they give little or no consideration to the possibilities for technical and/or organisational improvements within the animal sectors to reduce their footprint and increase the production of services. Furthermore, most of these scenarios do not envisage possible paths for the transitions put forward and the economic models to be developed.

Need to maintain technically efficient livestock farming

It is not possible, based on these prospective studies, to make a definitive decision on the balance to be achieved and how to implement it. Based on the current state of livestock farming, consumption projections and the most reliable forecasts in this area, we support the idea that in order to meet the nutritional needs of the population at an affordable price (at least at a rigorously assessed price, i.e. one that includes all externalities, particularly health and environmental ones), technically efficient, run by specialised operators and therefore of sufficient size, are essential in different regions of the world. These farms must respect the environment and animals. The aim is to enable the development of new sustainable standard production models.

These "sustainable standard models" do not exclude higher quality production (PDO, PGI [protected geographical indication], etc.) or production methods with more demanding specifications (organic, etc.), or local production, which must continue to develop and be encouraged as it meets consumer demand and produces positive externalities. However, these

production methods alone cannot satisfy market demand in terms of volume or price, and different types of livestock farming must coexist. Globally, they complement pastoral or backyard farming systems, which play a major role in land management, economic survival and food resources for farmers (more than 800 million worldwide) and rural families. In France, where diversified production choices are possible for ruminants, productive grassland systems offer many advantages, even when managed intensively. Furthermore, livestock farming systems based on the principles of agroecology and regenerative agriculture (O'Donoghue et al., 2022) offer a promising way to reconcile production and the environment.

Producing sustainably here so as not to import unsustainable products from elsewhere

In Europe, and particularly in France, even if it is not a question of feeding the world, it is essential to embrace the global dimension of livestock farming in the current context of trade globalisation and at a time when our national production is increasingly unable to meet demand (see above). Globalisation is the subject of heated debate on a number of fronts. The debate on "mirror clauses" (applying the same requirements to imports from third countries as to production within the EU) reveals the impasse between the "produce sustainably here" *and* "buy unsustainably abroad" approaches. If this contradiction is not resolved and we rely solely on a poorly regulated market, the majority of imported products could soon come from unsustainable farms outside European borders, as is already the case, for example, with imports of chicken from Ukraine or products likely to come from Mercosur.

Assessing the services provided by intensive farming systems

The first step is to carry out a general assessment highlighting where these types of farming have advantages and bring overall benefits to society (services) and where they are unsustainable due to their impacts and weaknesses (referred to as "disservices") across the three pillars of our definition of sustainability (economic, societal and environmental). Tables 2 and 3 are double-entry tables, with the types of farming listed in rows (beef cattle, dairy cattle, pigs, laying hens, broiler chickens, fish farming, sheep, goats, insects, etc.) and the three pillars of sustainability listed in columns. They identify, in a necessarily summary, averaged and simplified first approach, the services and main sustainability issues encountered by type of livestock farming. Within each cell thus created, in Table 3, the diagnosis must be made: "Is

there a sustainability issue and why?". Reading Table 2 "column by column" reveals the main advantages and services of intensive livestock farming, while reading Table 3 column by column reveals the major trends in unsustainability that are common to all types of livestock farming. The table does not specifically include the vulnerability of territories, which can vary greatly and which, for example, can lead to different levels of eutrophication for the same loss of nitrogen or phosphorus.

Intensive livestock farming has advantages and provides services (Table 2)

Socially, it produces affordable food

Intensive systems contribute significantly to the supply of animal products at prices that are more affordable to the majority of domestic consumers. Maintaining affordable prices for meat, eggs, milk and cheese is a service to consumers, enabling them to balance their diets with foods of good nutritional quality, in line with nutrition and health recommendations, at a moderate cost. This model should particularly benefit consumers with low purchasing power. Making diets more plant-based by halving meat consumption would reduce food costs by 10% (Darmon et al. 2024

Economically, a decisive contribution to the vitality of regions

All animal production sectors contribute to increasing added value in the regions where they are located and to maintaining employment[15] . Intensive livestock farming in Brittany developed in the 1950s and 1960s as a result of the political will to maintain jobs in the region, and therefore on small farms, and to meet the objective of food self-sufficiency. Initially focused on the development of broiler chickens in closed, "off-ground" buildings, pig farming followed due to an initial crisis in the poultry sector (Diry, 1985). Only livestock farming, which provided a sufficient margin per hectare, was able to meet this expectation. This initial desire shaped the evolution of agricultural systems and sectors, with numerous upstream and downstream industries supplying inputs or adding value to livestock products, but also providing jobs. More generally, the forces that influence these processes of territorial specialisation have been the subject of numerous studies by economists and concern comparative advantages, economies of scale and agglomeration, as well as the quality of

[15] https://www.farmpedia.fr/post/en-france-l-%C3%A9levage-a-un-r%C3%B4le-pour-la-production-l-environnement-la-vitalit%C3%A9-et-le-patrimoine

industrial and commercial structuring (Roguet et al., 2015). Despite the competitiveness issues mentioned above, certain "niches" contribute to the trade balance by marketing products of recognised quality worldwide and actively participate in the dynamism of global markets. This is particularly the case for the dairy sector with cheese and infant milk powder (Chatellier, 2016).

Intensive livestock farming also generates a significant flow of numerous co-products that supply a variety of industries, including textiles (leather, wool), oleochemistry and soap manufacturing, pharmaceuticals and pet food production, a rapidly growing market (+2%/year, representing €29 billion in Europe[16]). Animal fat is increasingly used for biodiesel production (1.4 million tonnes in 2022 *vs.* 0.4 million tonnes in 2010). Some of the processed animal proteins from intensive farming by-products are also recycled into fish feed.

In environmental terms, a smaller footprint per kilogram of product

The main advantage of intensive systems is their lower footprint per kilogram of product compared to more extensive systems, particularly in terms of greenhouse gas emissions (Basset-Mens and Van der Werf, 2005). This is due to a significant improvement in productivity per animal, which means that a larger volume of product is produced from the fixed quantities of potentially polluting waste (methane, nitrogen, phosphorus) per animal. The quantity of animal products per kilogram of feed consumed is increased, both through improved instantaneous feed efficiency and through improved growth, reducing the length of time animals spend on the farm. For example, the amount of plant protein needed to produce a pig has decreased from 52 to 32 kg between 1980 and today. In the case of ruminants, however, the environmental costs of producing these processed feeds should be taken into account, compared to those of grassland.

[16] FEDIAF, 2024. European Pet Food Industry. www.fediaf.org

Establishing a diagnosis of unsustainability (of "disservices") of intensive systems

The first step is to make a general diagnosis highlighting where these types of farming are unsustainable in the three pillars of our definition of sustainability (economic, societal, environmental).

Economic and societal pillars: the challenge of competitiveness

The low competitiveness of most intensive French sectors is a major factor in their unsustainability because, unlike more extensive sectors or those producing differentiated products, product price remains the main criterion and these intensive systems cannot take advantage of economies of scope. This situation may be exacerbated in certain sectors due to economic conditions. Although this is not a new phenomenon, the trends observed over the last ten years are not encouraging. Competitiveness is steadily eroding, and cyclical factors are gradually becoming structural for certain species, particularly poultry and ruminants (Centre d'Etudes Prospectives, 2019). Other species are less affected; the laying hen, sheep and goat milk sectors have not experienced any major economic sustainability issues to date. It should be noted, however, that in the sheep meat sector, the "competitive" niche has long been left to competitors (New Zealand), leaving French products, with some local exceptions, to occupy the high-end niche in a market that is generally rather limited in volume. Extensive cattle and sheep farming systems generate the lowest incomes (€21k/year for beef and sheep meat, €30k for dairy cattle, €34k for poultry, €47k for pigs and €56k for arable farming)[17] , even though they provide services to society that are currently not sufficiently remunerated.

Depending on the species, French livestock farms face competition from within the European Union (EU), from other parts of Europe (Ukraine, United Kingdom), or from outside Europe. The reasons for the widening competitiveness gap are well known and manifold. Part of the answer lies in different responses to regulatory and societal requirements, particularly with regard to countries outside the European Union. But within the European Union, production costs are particularly affected by different wage levels between Member States, as well as by societal rules and the differentiated implementation of supposedly common rules

[17] Average data for 2010-2022 according to V Chatellier INRAE.

that can confer competitive advantages. However, other factors have also contributed to the loss of competitiveness. Production tools, farms and upstream and downstream industrial tools have been unable or unwilling to restructure and automate as in other European countries and, for the most part, no longer have the necessary critical mass (Chotteau et al., 2017). Another factor is the failure of the industry to anticipate changes in eating habits (the cutting up of poultry for ready meals *vs* whole poultry is one example). The decision to pursue a generalised policy of moving upmarket since 2017 to compensate for the lack of competitiveness and to focus on the domestic market has also proved detrimental, as it does not correspond to the majority of market demand and has encouraged imports (Duplomb et al. 2021). As a result, the out-of-home catering sector relies on imports to obtain cheaper products. The wide range of products offered by French industry to meet consumer and mass retail demand also leads to additional costs that are detrimental to the industry. Finally, the way large retailers operate in France differs from that of other European countries, particularly in terms of greater pressure on prices. Behind competitiveness lies the difficult question of the distribution of margins between the various players in the agri-food chain, a recurring issue at which the Egalim laws have addressed, without achieving the expected results, even though some prices paid to producers have shown progress.

Economic and societal pillars: the challenge of generational renewal.

The French livestock sector is also facing difficulties in generational renewal in almost all sectors. This issue affects all systems and is particularly acute in the cattle sector. This is often due to low pay and difficult working conditions, which make farming an unattractive profession, as well as the particularly high capital requirements for taking over a farm in the case of intensive systems. The image associated with animal welfare or the environment can also discourage people from setting up intensive systems, whereas extensive systems (particularly grass-fed ruminants) are sometimes more widely accepted. Today, farmers no longer feel in tune with certain production models for various reasons, but often with regard to the living conditions of their animals, and wish to move towards different production methods. As a result, the establishment of new farmers is being slowed down, contributing to a decline in production potential or an increase in the average size of livestock farms. It should also be noted that there are more early retirements in the animal sectors (particularly in pigs, mixed cattle, dairy cattle and sheep) than in cereals (Agence de Services de Paiement, 2016),

with farmers switching to agricultural employment or crop farming once their facilities have been amortised and the size of their farm allows it.

Economic and societal pillar: the issue of highly specialised animal breeding through genetic selection

Animal selection has aimed to increase productivity per individual in both ruminants and monogastric animals. It has been one of the tools used to transform a multifunctional animal that provides a range of services into a highly (or even hyper) specialised animal, increasingly focused on the production of either meat, milk or eggs. This has led to excesses that are detrimental to the image of livestock farming. The most emblematic and widely publicised example is that of fast-growing poultry breeds (Ross 308). Their muscle development is so rapid and significant that locomotor disorders, pododermatitis (Mignon-Grasteau et al., 2022), and even respiratory and cardiac disorders are common. This selection can also lead to a deterioration in product quality (see above). The EFSA (2022) has proposed a return to strains with growth limited to 50 g/day. This development can affect both the image of livestock farming in society and the economic performance of farms, such as the much shorter careers of laying hens and dairy cows than in the past, or the hyper-prolificacy of sows. This selection also leads to inbreeding problems that are increasingly difficult to resolve in certain sectors. For their part, breeders are being partly dispossessed of their place in the evolution of selection in favour of selection organisations or very powerful private companies, which are the main decision-makers and hold the knowledge of genealogies.

Societal pillar: the issue of animal welfare

Today, from a scientific point of view, ethologists and physiologists agree that welfare must refer to the mental state of the individual in its environment and not only to positive human actions towards animals (good animal care). The latter are a necessary condition, but their outcome must be assessed on the animal to ensure the effectiveness of the measures taken. Good health, satisfactory production levels or the absence of stress are not enough. Scientific research shows that farm animals have perceptions that are not only physical but also emotional. "Animal consciousness" is a reality (Le Neindre et al., 2017). What the animal feels must be taken into account, not only unpleasant subjective perceptions (frustration, pain), but also positive emotions, by promoting behaviours that are natural to the species. It

should be noted, however, that selection may have led to breeds that do not necessarily have the same behavioural needs. For example, in semi-free-range chicken farming, one of the difficulties is getting the chickens to move away from the building. The presence of nearby trees is a way to reassure them and encourage them to move away. The European Union recognises this sensitivity through several directives (Mormède et al. 2018). Animal sensitivity has been recognised in French law since 1976 and in the French Civil Code since 2015. However, it is not specified whether this refers to sensory sensitivity (common to all living beings) or emotional sensitivity (recognised in animals with a central nervous system) or both.

However, progress is encountering difficulties. Translating this recognition into practice could require profound and costly changes to production tools. The views of the various stakeholders can vary greatly, ranging from denial to a certain degree of anthropomorphism, and these animal welfare issues are addressed in different ways by the livestock industry. To respond to their customers' concerns, some distributors are taking initiatives involving their suppliers (BBFAW 2024), sometimes in partnership with animal welfare NGOs. In several Northern European countries, industry organisations are seeking to encourage innovative practices by farmers that are recognised and rewarded by consumers (Roguet 2023). The rejection of cage eggs is a prime example of this.

The stakes seem to be higher for monogastric animals (pigs, poultry), where closed housing is the norm, but also for battery calf rearing. In this type of farming, the high number of animals per unit area and the absence of measures to prevent or limit aggression between individuals lead to the development of stereotypical behaviour and the loss of opportunities to express natural behaviours associated with the species (root for pigs, perches for poultry, etc.). These are crucial factors in unsustainability. In several species, practices that harm the integrity of animals in order to prevent the consequences of aggression between individuals or towards farmers (dehorning, beak or tooth trimming, tail docking, castration) are called into question. Other indirect consequences of intensive farming, such as the reduction in the lifespan of breeding females (dairy cows, laying hens), and the "economic worthlessness" of certain young animals that are slaughtered immediately after birth (male chicks from laying hens, female ducklings from foie gras ducks, kids) are also highly questioned by society (Roguet et al., 2016). On the other hand, confinement better protects animals from contact with parasites, pathogens and wildlife than systems with outdoor runs.

The conditions under which animals are slaughtered are a recurring source of criticism of many intensive systems, although extensive systems are not spared either. Reports still too often show that regulations are not always followed. Although significant efforts have been made, articles and NGOs still point to shortcomings in slaughterhouses. One explanation for this, alongside economic constraints and gaps in staff training, is the exemption allowing ritual slaughter, which is legally limited only to the quantity ordered and is not always respected due to insufficient penalties. However, reducing animal stress is also important for working conditions and staff safety, as well as for meat quality.

Societal pillar: animal health issues and their relationship to human health

The relationship between animal health and human health is also a subject of debate. In addition to the economic losses caused by animal diseases, human health is closely linked to animal health. 60% of emerging infections are of animal origin (H1N1, H5N1 SARS, Covid 19, etc.), but not necessarily from livestock farms. Intensive, confined and dense livestock farming is considered to pose a greater risk than extensive farming. While this debate remains unresolved, it is clear that the high density of a single animal species in certain areas and the segmented internal organisation of many sectors (poultry, pork, veal, etc.) lead to the movement of animals between farms, regions and countries, facilitating the transmission of epizootic diseases. This is also the case in fish farming, where several health disasters have led to a reduction in animal density on farms. However, family-run "backyard" farms can also contribute to the spread of certain animal diseases, as was the case with African swine fever in Ukraine from 2015 onwards and in Romania in 2018 (Rose and Le Potier, 2020). Regardless of the type of farm, it is necessary to take appropriate biosecurity measures.

Slaughter in response to the spread of epizootics, which is particularly widespread in densely populated areas, is a major problem both economically and in terms of society's acceptance of livestock farming (e.g. slaughter of poultry following influenza). Vaccination is undoubtedly a promising avenue for the future, as shown by the recent example of vaccination against avian influenza in duck farming in 2023-24.

Furthermore, certain animal diseases are transmissible to humans (known as zoonoses) and close contact between humans and animals increases the risk of transmission. This is how the H5N1 avian influenza (human disease) started in Asia in places where humans

live in close proximity to poultry and pigs, particularly in traditional or family-based production systems. Finally, as humans and animals share the same pharmacopoeia, antibiotic resistance is a major problem that causes tens of thousands of deaths in Europe (Cassini et al. 2019). However, it should be noted that the EcoAntibio plan has achieved very significant results. In France, veterinary laboratories sold 415 tonnes of antibiotics for farm and domestic animals in 2017, compared with 1,311 tonnes in 1999. Antibiotic use has been reduced by 70% in poultry, 60% in pigs, 55% in rabbits and 20% in cattle. Further progress can still be made. For example, antibiotic use is much lower in Denmark than in France (40 *vs.* 70 mg/kg live weight, European Medicines Agency, 2019), even though Danish farms are much larger and more intensive than French farms. It is therefore not a question of the type of farming, but of practices, know-how and the organisation of the sectors.

Environmental pillar: a significant contribution to climate change

Environmental issues are very much present in public debates (Intergovernmental Panel on Climate Change, IPCC or GIEC, 2023). The issue of climate change currently overshadows other considerations, and ruminants, especially cattle due to their larger biomass compared to small ruminants, emit methane, a powerful greenhouse gas that contributes to global warming. In France, livestock farming accounts for 12% of national GHG emissions calculated in CO2 equivalent, and methane accounts for 60% of total livestock emissions (CITEPA, 2023).

However, it should be noted that CO2 equivalent emissions calculations do not take into account the dynamics of methane, which is a short-lived gas in the atmosphere (12 years) unlike CO2 (> 100 years) (Cain et al, 2019). This method of calculation overestimates its effect on global warming in the event of a reduction in emissions, as is currently the case in European livestock farming. These authors propose another metric that takes this dynamic into account. This puts the consequences of livestock farming into perspective, even if it does not exempt us from the need to reduce emissions intensity in order to achieve public policy objectives.

Furthermore, the potential contributions of intensive livestock farming to reducing GHG emissions from agriculture remain largely overlooked in the debate: facilitating the development of diversified crop rotations with nitrogen-fixing legumes through their ability to utilise a wide variety of biomass; contributing to soil fertility through the return of organic matter and fertilisation (especially since animal feed contains legumes), at a modest GHG cost

(since emissions are mostly related to milk or meat) (Peyraud and Mc Leod, 2020), energy production from the methanization of effluents (Dourmad et al., 2019). Ruminant systems can also claim carbon storage through temporary grasslands, associated hedgerows and intercropping, although this is undoubtedly less than in extensive grazing systems where animals benefit from much more space.

Environmental pillar: major impacts on water and air quality

Intensive systems, even though they control their emissions per kilogram of product better, emit much more per unit of surface area due to animal concentration, especially since these systems are located within areas that are themselves specialised. They have undeniable and well-quantified impacts on ecosystems. Emissions from livestock farming into the atmosphere (ammonia, odours) and into water (nitrogen, phosphorus) are present in almost all types of production, although some are less visible, mainly due to the small size of the animals and/or farms (sheep and goats). Emissions into aquifers and aquatic ecosystems are present everywhere, more specifically in highly specialised areas with intensive livestock farming, as shown by the development of green algae in Brittany (Peyraud et al., 2014). When emissions from food production are included in those from animals, 80% of the nitrogen of agricultural origin present on average in all European aquatic environments is linked to livestock farming (Leip et al. 2015), and livestock farming also accounts for 90% of ammonia emissions from European agriculture (European Environment Agency 2018). These emissions are concentrated in Europe's intensive livestock farming regions (notably Denmark, the Netherlands, Belgium, Brittany and the Po Valley). This issue is therefore more related to the geographical concentration of agricultural activities than to the way each livestock farm is organised. Conversely, in areas of livestock farming and mixed farming, there are fewer pesticides in groundwater than in regions of arable farming or specialised crops (vines, horticulture) (SOLAGRO[18]) due to the presence of untreated grasslands and more diversified crop rotations that facilitate the control of pests and weeds (Tamburini et al., 2020).

[18]https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://solagro.org/images/imagesCK/files/presentation_resultats_adonis_v31082023.pdf&ved=2ahUKEwjYp9rOr82LAxV-cKQEHW2ZGFcQFnoECBgQAQ&usg=AOvVaw3stNQD8aS1l5_Q4ex7_V3Y

Environmental pillar: damage to biodiversity

Through its effects on global warming and eutrophication, as well as its demand for grain, the production of which requires the use of phytosanitary treatments, intensive livestock farming contributes to biodiversity loss (Benton et al. 2021; Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, IPBES, 2019). However, it is mainly criticised for its contribution to deforestation for soybean production. A recent assessment by the European Commission shows that, through the deforestation incorporated into total European final consumption (palm oil, soybeans, meat, cocoa, corn, wood, rubber), the EU27 is responsible for 10% of global deforestation, 60% of which is for soybeans (European Commission 2019). Europe has decided to ban imports of soybeans produced through deforestation, but implementation has been postponed until 2025. In any case, as long as soybeans are imported, we will indirectly contribute to deforestation, increasing the deforestation linked to meeting the needs of other parts of the world, particularly China. The direct impact of livestock farming on biodiversity also concerns the effect of spreading manure. This can be very positive by stimulating microbial activity in the soil and ultimately its fertility (Lemaire et al., 2023), notably through an increase in microbial abundance, numerous enzymatic activities and soil respiration (Houot et al., 2014). Conversely, the effect is more negative in the case of antibiotic resistance gene transfer.

Environmental pillar: livestock farming has lost part of its ecological role as a recycler

Intensive systems are based on a largely linear approach to agriculture (resources – products – waste) that underestimates animals' ability to recycle biomass. Optimising rations to maximise individual production limits the use of less digestible plant fractions that cannot be used for human consumption and favours the use of cereals, thus putting animals in competition with humans for food (known as feed-food competition). French livestock farming thus uses 22% (or 19.2 million tonnes) of the cereals produced on national territory (Cordier et al., 2021), including more than 4.7 million tonnes for ruminants, which is almost as much as for pigs (5 million tonnes). This optimisation of rations also involves the use of imported soya protein (1.6 million tonnes). Livestock farming is therefore a major consumer of arable land due to its need for grain and cultivated fodder (maize silage or sown grassland). On average, to produce 1 kilogram of protein, including the area used for imported materials, 42 to 52 m² is required for chicken, 47 to 64 m² for pork and 33 to 59 m² for dairy cattle (de Vries and de

Boer, 2010). Although the areas used are much larger for beef cattle and sheep (200 to 800 m², Joly et al., 2024), these are often extensive systems and 50 to 90% of these areas are permanent grassland that cannot be converted to arable land.

Furthermore, livestock effluents are not sufficiently exploited as organic fertilisers. Aerobic treatment of pig manure releases nitrogen in the form of N2 into the atmosphere to limit excess nitrate, but in doing so, it contributes to the opening of cycles and a waste of resources. Such practices have been heavily subsidised, and this funding can be seen as inadvertently supporting unsustainable practices (Peyraud et al. 2014). Regular and heavy spreading of manure on the same areas also contributes to increased phosphorus levels in the soil. Focused solely on food production, these systems do not take into account the production of environmental services, unlike more extensive systems, with the partial exception of dairy systems that still use grassland (more than 90% of dairy cows graze) and manage to maintain typical mixed farming landscapes with grassland, hedgerows and ecological habitats.

Environmental and health pillar: "hidden" costs

While our agri-food systems provide benefits to society, they also have costs that are not reflected in the price of the food we consume, whether animal or plant products. In France, consumer spending on food at home and away from home amounted to €288.4 billion in 2021, of which, according to INSEE[19] , €176 billion was spent on consumption at home (€39 billion on meat, €23 billion on dairy products and eggs, 9 billion for fish and shellfish, 30 billion for bread and cereals, 38 billion for fruit, 15 billion for non-alcoholic beverages and 22 billion for alcohol). Other costs attributable to food are not allocated to food production, social costs (health, safety, education, working conditions), environmental costs (degradation of natural resources, climate change, losses and waste) and economic costs (subsidies, imports, lost working days, tangible and intangible investments outside traditional accounting).

In an accounting approach, some authors (Alliot et al., 2024; Drique et al., 2024) identify the actual and traceable public expenditure in France by the French State, the European Union and French local authorities in favour of the food system to support, compensate or repair. In 2021, €19.1 billion was spent on repairing the impacts, including €11.7 billion on treating consumer diseases caused by food (cardiovascular diseases, even

[19] https://www.insee.fr/fr/statistiques/6438720

cancers, overweight and obesity) due to excess sugar and fat, so-called "ultra-processed" foods, and meat among heavy eaters. Four billion euros were spent on occupational illnesses and other social expenditure for workers (in agriculture and industry).

Repairing environmental damage cost 3.4 billion (excess nitrates affecting the quality of aquifer water and aquatic ecosystems, pesticides affecting water and air quality, and air pollution from ammonia microparticles). However, this is a default assessment, as most of the negative environmental impacts of the agri-food system are not corrected and are not covered by public expenditure.

In addition to these repair costs, there is the total amount of various forms of public support for agricultural and agri-food activities, amounting to €48.4 billion, including €28.6 billion from the French State (tax and social security exemptions, income support, subsidies, etc.). The European Union contributes €10.4 billion through the CAP budget. Local authorities spend €9.5 billion, particularly on collective catering and personnel costs (around €10 billion).

In total, public expenditure allocated to the French food system amounts to €67.5 billion for 2021, representing 23.4% of total food consumption expenditure. The authors do not distinguish between what can be attributed to different food products, especially those from intensive livestock farming. Without questioning the legitimacy of each of the identified expenditures, they consider that a significant portion could be devoted to changing the system rather than maintaining it as is, thereby avoiding numerous negative impacts.

Another approach (FAO, 2023; Duru and Fardet, 2022) develops a much broader view of costs based on the concept of negative externalities generated by an activity on its environment and borne by the community in the short and long term. This work confirms that accounting approaches fall far short of reality, particularly by not considering the cost to be borne by future generations. According to this approach, hidden costs are of the same order as food expenditure (0.9 to 1 euro for every euro spent) according to several studies on European countries summarised by Rastoin (2022). Health costs account for around 50%, environmental costs for around 40% and economic costs for around 10%. Due to difficulties in allocation or assessment, the above approach does not include health costs related to antibiotic resistance, the effects of air pollution (microparticles linked to ammonia and pesticide emissions) and water pollution (presence of pesticides), or the health impact of pesticide residues in food. This second approach also seeks to integrate the long-term costs of

biodiversity loss and soil degradation, the costs borne directly by economic actors and households, and the monetisation of losses attributable to productivity declines (e.g. the loss of productivity of an individual who falls ill) by projecting forward to 2100.

Proposed progress trajectories for intensive livestock systems

Progress trajectories that intensive livestock systems could follow can be identified (Table 4).

Reinventing intensive livestock farming by finding consensual paths for change

The above considerations show that livestock farming must absolutely and significantly evolve from what we know today in order to continue producing nutritious food while undergoing a profound transformation towards greater sustainability, despite economic mechanisms that continue to drive the expansion of livestock farms and territorial specialisation. Climate change will also require us to reinvent livestock farming. The status quo is no longer possible, but at the same time we must not allow highly competitive markets to operate without reciprocal constraints and often fuelled by societal and environmental dumping. Considerable investment is needed, particularly in buildings, to improve animal welfare and reduce environmental impacts, while also improving working conditions for farmers and, more generally, for those involved in livestock farming. Crédit Agricole estimates the needs at €5.5 billion for the monogastric sectors by 2035, bearing in mind, for example, that an open-air facility for poultry production costs almost €0.5 million.

With the development of digital technology and robotics, high-tech equipment is now available to assist with the transition. It offers solutions for greater sustainability by addressing environmental issues and monitoring individuals and groups for better animal welfare management. It also reduces the drudgery of work and saves time by freeing farmers from time-consuming tasks. However, this equipment often represents a significant investment that only farms of sufficient economic size will be able to recoup.

The evolution of livestock farming also requires better information for citizens about the reality of today's livestock farming and its diversity. The work of the Casdar ACCEPT project (Delanoue et al., 2018) has clearly shown that citizens want to know more about the farming profession and how animal products are produced, and that they are interested in the subject

of livestock farming. More surprisingly, they believe that their image of livestock farming is probably distorted by the media. A large majority of them (over 80%) do not want livestock farming to disappear, even though the image of livestock farmers is much better than that of livestock farming, and even though this positive image has deteriorated somewhat over the last 10 years. For their part, livestock farmers often consider communication initiatives to be one of the primary means of addressing societal concerns (Coty et al., 2017). This information can be conveyed in many ways: communication in schools and the media, national days, open days on farms, focus groups facilitating exchanges between stakeholders from different backgrounds, etc. The transition to more sustainable farming also requires the joint development of solutions. The establishment of debates and discussions between farmers and citizens should enable progress towards a mutual understanding of expectations and needs, and the development of avenues for progress that are acceptable to all, even if sticking points are likely to remain (particularly due to the investments required). Today, most research projects concerning social activities funded at European or national level include the participation of representatives of civil society and professional actors among their eligibility criteria.

Making progress on the three pillars of sustainability

Measures have already been implemented to improve sustainability, but they are proving to be largely insufficient as they only address one aspect at a time (e.g. the French version of the Nitrates Directive). In general, progress on social, environmental and economic issues will depend on the overall objectives of society (which will undoubtedly need to be better informed than it is at present), the livestock sectors and the public authorities. Are we looking for a kind of balance, or must each criterion meet a minimum requirement? This raises the question of synergies and antagonisms between different avenues for progress. For example, in poultry farming, selection for growth rates that are economically and environmentally attractive conflicts with animal welfare and the use of feed that is less competitive with human food. This may also be the case for reducing GHG emissions and biodiversity in ruminant farming. More broadly, there is a need to better integrate what is necessary to achieve public policy objectives in the areas of health (PNNS), climate (SNBC) and the environment (nitrates, water, biodiversity, pesticides, etc.). Beyond incremental improvements to current systems, systemic changes commensurate with the challenges at

stake must be envisaged. However, such changes often run counter to the short-term economic interests of the sectors concerned and are therefore very difficult to implement, even when there is political will, as demonstrated by the social movements that followed the Dutch government's proposal to significantly reduce nitrogen emissions from Dutch livestock farming.

Economic pillar: protecting ourselves from low-cost imports and creating value

There are various mechanisms to support farmers' incomes or encourage desirable practices within the EU, supplemented by national provisions. However, competition remains fierce because most of our trade is conducted freely with within the EU, bringing countries with very different realities into confrontation (see above). Outside the EU, mechanisms and regulations are developed far from the field and in a global manner. The so-called "free trade" agreements negotiated by the European Commission concern non-agricultural products (aeronautics, automotive, services, etc.), the export of which we want to promote by giving our partners, in return, easier access to the EU market for their agricultural products. Free trade agreements do not take into account, or take insufficient account of, the specific obligations imposed on European farmers, undermining their competitiveness compared to those who benefit from less stringent environmental, animal welfare or social rules. Mirror clauses are expected to compensate for these disadvantages through import taxes in the EU, or even bans on imports of products that could be dangerous to consumers. These clauses are not easy to get trading partners who have no interest in them to accept. It will therefore be difficult to achieve the above objectives in the current context of open markets. Perhaps we should instead consider a carbon tax on imports, given that the European and French systems are the lowest emitters in the world (Peyraud and Mc Leod, 2020) and that all imports have a negative impact on our national carbon footprint compared to local production.

Progress can undoubtedly also come from new exchanges of trust between consumers and producers, which would be transparent and aim to distribute value more evenly among the players in the chain, going beyond the initial progress made thanks to the Egalim laws, particularly in the dairy sector. Numerous initiatives taken within the sectors, often within the framework of cooperatives, aim to better remunerate farmers who make commitments that go beyond the requirements of regulations (Roguet et al., 2018). The Comté sector, the leading AOP cheese in France and fourth in Europe, is one of the most emblematic examples of these

initiatives. It enables the entire sector, from producers to distributors, to be remunerated by marketing a product recognised for its excellent quality, for which consumers are willing to pay (Elisséeff, 2017).

More recently, with a different system, and even though the volumes involved remain relatively limited, this is also the case with the highly publicised "C'est qui le patron ?" (“Who's the boss?”) milk (Les Échos 2022), in which producers comply with specifications drawn up with the help of consumers who agree to pay the extra cost, which goes directly to the producer. Other private initiatives (processors, distributors), which are becoming increasingly numerous, seek to create value for the sectors, with a return for the producer, by seeking to meet customer demands and stand out from the competition. Beyond designations of origin, examples include Terrena's "new agriculture", GMO-free milk, antibiotic-free pork and poultry, etc. (Delanoue et al., 2018). These approaches to fair and transparent value sharing have consequences for other pillars of sustainability beyond the economy. In the Comté sector, it has a strong influence on the renewal rate of dairy farms, which is much higher than for other types of farms (Observatoire Prospectif de l'Agriculture de Franche Comté, 2022). These approaches also reduce the environmental impact of agricultural practices, the risk of antibiotic resistance, etc. In the ruminant sector, value sharing very often promotes grass-based feeding, as is particularly the case in the Comté sector, on grasslands that store carbon, preserve soils and biodiversity, and create conditions conducive to animal welfare (Alliot et al. 2021).

Societal pillar: buildings that break with the existing model for the well-being of animals and farmers

Livestock farming will also have to transform in response to developments in knowledge about the consciousness of farm animals and the societal and legal context (Orihuela 2021). Practices already mentioned will have to disappear. The priority must be to eliminate negative emotions such as pain associated with mutilation practices, but also fear and frustration. However, we will need to go further to better respect the natural behaviours of species. Innovation requires an objective understanding of animal behaviour in livestock farming, followed by behavioural engineering approaches that are not yet fully developed. However, research can already offer objective indicators for progress, and numerous tools are being developed with varying degrees of complexity depending on the species and stage of

development. Cage-free poultry farming is a prime example, but we must also consider buildings that are at least open to daylight and allow animals freedom of movement to facilitate the expression of natural behaviours. Sketches can be developed through co-design with users, and virtual tours are available[20] . Farmers have already innovated in their buildings, as shown by a number of testimonials from pig farms during the LIT OUESTEREL days in November 2024[21] .

Reducing stocking density in monogastric animals remains a major challenge. Increasing the space available per pig or poultry is an important lever for improving animal welfare, but it increases building and operating costs, which are reflected in the selling price. The same applies to outdoor access for animals, which is widely supported by the public but can expose animals to greater levels of mineral (heavy metals, etc.) and organic (dioxins, PCBs, etc.) contaminants, pathogens and wildlife, not to mention the working conditions for farmers in certain seasons. Buildings must also become more flexible in order to cope with market changes. For example, a henhouse designed for organic farming must be able to be converted if the farmer switches back to conventional farming. The end of caged hens is one example of success. As a result, 73% of laying hens will be raised cage-free in 2023, exceeding the 2017 target of 50% for 2022. However, this change is undoubtedly facilitated by the fact that, even though it is reflected in the price of eggs, the additional cost to the consumer remains modest. Finally, it is worth noting the development of highly disruptive systems, such as cage-free rabbit farming with 800 cm² burrows. Digital technologies (various sensors, image analysis, vocalisation analysis, etc.) can make a useful contribution to the early detection of malfunctions and the production of animal-based performance indicators (focusing on results rather than means).

Given the necessary investments, it is important to determine the optimal level that ensures acceptable living conditions for animals, guarantees the quality of life of farmers and is compatible with farming practices, as well as the most appropriate methods of intervention by public authorities to achieve the objectives at the lowest cost to society as a whole. If we

[20] https://www.assolitouesterel.org/nos-travaux/identification-et-conception-de-solutions-innovantes/identification-et-conception-de-solutions-innovantes-chez-les-porcs/conception-de-batiments-delevage-porcins-innovants-en-sante-et-bien-etre-animal/

[21] https://www.assolitouesterel.org/nos-travaux/animation-de-reseau-et-communication/retour-sur-les-journees-lit-expert-2024/

are to work towards a societal consensus, the final combination between respect for animal welfare, product prices and economic profitability will also be determined by consumers through their purchasing decisions.

Environmental pillar: reducing methane emissions is a priority

Reducing methane emissions from ruminants (especially cattle), which are the source of major criticism of meat and milk, is essential (Chemineau, 2023). This cannot be achieved solely by reducing livestock numbers, as there is also the issue of maintaining grassland areas. Efforts must therefore also focus on emission intensity. It is up to the public authorities to set targets for reducing emission intensity, taking into account both the decline in cattle numbers recorded in France in recent years (19.8 million cattle in 2010, 18.2 million in 2020, 17.4 in 2022) and the short lifespan of methane in the atmosphere, which means that any reduction in emissions quickly translates into a reduction in atmospheric concentrations. This reduction in emissions intensity will need to be addressed through a holistic approach combining different levers, as the solutions must not overshadow the objectives of agricultural system coherence, biodiversity and animal welfare. The climate-neutral cow approach envisaged in Denmark does not appear to be a solution (high-yield cows, fed anti-methane additives and kept in buildings that capture residual methane). French researchers agree that a 30% reduction in emissions intensity is achievable within 10 years[22] , but that this will be easier to achieve in milk than in meat. It is possible to select animals that produce fewer emissions, with a 1% gain per year possible from 2030 onwards, provided that a selection programme is launched now (de Haas et al. 2021). The ambition could be to achieve a 10% reduction by 2040.

Increasing the productive lifespan of animals is another major lever. This involves bringing forward the age at first calving, which is very late in France (around 28 months in dairy farming), whereas dairy heifers calve at 24 months in all European dairy regions. It also involves extending the animals' productive life by one lactation, which is currently too short (2.5 lactations on average), even if this means slightly reducing production per lactation. This lever could reduce emissions by 20% per kilo of milk. The use of additives can reduce emissions

[22] See Methane 2030 project; https://www.inrae.fr/actualites/methane-2030-demarche-collective-francaise-focalisee-methane-enterique

by 5 to 25% (flaxseed, Bovaer-3NOP, natural tannins, seaweed). This approach is instantaneous and reversible, but synthetic molecules such as Bovaer-3NOP may not be accepted by society. Improving the quality of fodder (genetics, conservation) and, above all, the widespread use of legumes would also reduce methane emissions by 5 to 10%, with the added bonus of significantly reducing N2O emissions. The implementation of several of these levers will also have positive effects on reducing nitrate and ammonia emissions and increasing the energy self-sufficiency of farms. Better control of effluents would also reduce emissions (El Mashad et al., 2023). Finally, carbon storage under sown grasslands and associated landscape features, as well as crops used for animal feed, can also contribute to reducing net emissions. However, all these data require a majority of farmers to adopt more virtuous practices, which raises the question of incentives. The Low Carbon Label (credit C) approach is an interesting avenue that allows the most appropriate solutions for each farm to be implemented following the CAP2ER diagnosis[23] . Incentives from private actors could also be considered, encouraging livestock farmers to adopt virtuous practices by paying slightly higher prices for milk (see above). However, there is little room for manoeuvre in an open market context. Taxation is another tool currently being developed in Denmark, provided that the revenue goes back to farmers to support investment. It should also be noted that the redevelopment of calf fattening from dairy herds would make it possible to fill our beef deficit with red meat produced with a low carbon footprint compared to suckler systems. This could be achieved through the deployment of mixed breeds. However, it is unlikely that dairy farmers will abandon more productive dairy breeds. They could then obtain calves by crossbreeding with beef breeds or/and using sexed semen.

Climate change, which some believe will be more significant and occur more rapidly than expected (Goessling et al., 2024; Tollefson, 2025), justifies prioritising the reduction of methane emissions. However, this should not cause us to forget our simultaneous concern for other emissions (ammonia, nitrates), particularly by questioning the effect of the above-mentioned measures on these emissions.

[23] https://idele.fr/detail-article/cap2err

Environmental pillar: better management of effluents to close N and P cycles more effectively

Controlling nitrogen, nitrate, ammonia and phosphorus emissions through better effluent management is possible, even if it requires significant investment (Kronberg et al. 2021) or by including it in production specifications, as in the Comté cheese industry, which recently reduced the maximum nitrogen units for liquid manure spreading[24]. Individual solutions already in place (reduction of animal emissions, collection practices, storage and localised spreading of manure) have led to progress, such as a decrease in nitrate levels in surface water in Brittany from 50 to 36 mg/L between 1995 and 2015, while levels have increased in areas of large-scale farming. However, the strategy seems to be reaching its limits, as levels have not changed on average since then. We can probably no longer count on the gains made in the past through animal efficiency and reduced waste, unless precision feeding technologies (particularly for pigs) enable further gains.

Among other solutions, collective strategies can be facilitated by consultation between stakeholders in the region. The aim is to develop a truly circular bioeconomy for livestock manure and new economic models to create value from manure. In France, only 25% of arable land receives effluent, which leaves considerable room for improvement (Houot et al. 2014). The extraction of N and P for the production of standardised fertilisers that can be sold and exported outside production areas to arable land or abroad is a promising avenue. However, this must be confirmed by a comprehensive life cycle analysis of these products, as the technologies can be energy-intensive. The rising cost of synthetic nitrogen fertilisers and the move away from Russian gas for their production may be an opportunity to make better use of the nitrogen contained in effluents by developing this new bioeconomy in areas with the highest density of livestock farming. It is encouraging that Cooperl and Terrial (a partnership between the Avril and Suez groups) are pursuing this avenue to develop a sector for the recovery of effluents through the production of standardised fertilisers that can be exported to other territories. The European Commission is also considering amending the Nitrates Directive to authorise the use of nitrogen fertilisers produced from manure or slurry (Renure for REcovered Nitrogen from manURE) above the current limit of 170 kilograms of nitrogen.

[24] https://www.comte.com/articles/nouveau-cahier-des-charges-meme-recette/

Ammonia emissions can be reduced by 80% through the implementation of best practices on livestock farms.

Proposals for changes towards livestock farming that is better integrated into the territory

De-intensifying specialised systems through an agroecological approach

Some farmers are de-intensifying their systems for economic reasons, to pay closer attention to animal welfare, or to be more in tune with changing social values and their own values. This trend is not new in dairy farming, and there are many examples (Peyramaure, 1997; Allard et al. 2002). Objective analysis of margins shows that very high production levels do not necessarily lead to better economic results for the farm, and that autonomous grassland systems can be profitable. De-intensification results in a decrease in turnover but also in a reduction in input costs, which can be even more significant. This shift is beneficial not only for animal welfare but also for the environment, thanks to the reduction in inputs, particularly chemical inputs. It is more difficult to implement in monogastric sectors, even though free-range poultry farms are partly based on this approach. These systems can also contribute to improving the nutritional value of animal products (enriched with omega-3 and antioxidants in the case of grass) and constitute a positive externality for our health. However, this option reduces overall production per unit of land used, which can also be considered negative when considering land use and respect for planetary boundaries, unless there is a drastic reduction in animal protein consumption. For example, the intensification of pig farming has freed up 400,000 hectares of land for the same pig production between 1980 and 2020. A territorial network between intensive and extensive systems could be better explored.

Maximising biomass recycling within farms

There are some notable examples of coupling between different types of production on farms. In humid tropical areas, where solar energy and water are not limiting factors for production, close combinations of plant and animal production in a complex system maximise the use of agroecological processes, even for some intensive systems, while meeting the three pillars of sustainability. This is the case at the Tosoli farm in tropical Colombia, which produces

coffee, cocoa, sugar cane, as well as fodder trees (mulberry, etc.), timber trees (Guadua bamboo, Inga hayesii) and various plants (Tithonia, Xanthosoma, Ipomoea, etc.), all of which are used to some extent for feeding and/or housing pigs, goats, rabbits, horses, chickens and ducks and/or supplying a biodigester that provides electricity to the family (Preston et al. 2014). This is also the case with agro-sylvo-pastoral systems, also in Colombia, which use different layers of vegetation, from grass to tall trees, to feed cattle permanently on pasture and which yield spectacular results in terms of animal productivity per hectare (Chara et al. 2019). These multi-species systems closely intertwine producers, consumers and decomposers of plant and animal matter, enabling recycling. They close the cycles of the main elements (C, N, P, etc.) locally and are *ultimately* carbon sinks rather than sources. Even though tropical climate conditions are far from those of temperate climates, these few tropical examples show that, at least under these conditions, high intensification and sustainability are compatible and that intensification using agroecological principles is possible (Bommarco et al. 2018). However, to our knowledge, there are no trials or examples in mainland France or Europe where the principles developed above in tropical Colombia, closely combining various plant and animal species within the same farm, are applied. For example, in the case of the permaculture research programmes conducted at the Ferme du Bec Hellouin, there is no integration of the animal component into the system[25] .

These complex systems are generally difficult to replicate on a large scale because they are of no interest to industrialists. The logistics and industrial processes involved in permaculture would require profound changes, as current economic logic (simplification, standardisation, economies of scale and agglomeration) often runs counter to these systems. However, it is conceivable that they could be used in the case of local customers who come to buy supplies from a farm or group of farms practising agroecological processing. At the very least, more experiments based on these principles should be encouraged.

Rethinking the agricultural model by linking livestock farming and crop production more closely within regions

The quest for sustainability must not be limited to sectoral approaches that focus on efficiency as seen through the prism of a single industry. The debate must be extended to the level of

[25] https://www.fermedubec.com/la-ferme/la-recherche/#rapports-scientifiques

agriculture as a whole, where livestock farming must increase its role as a biomass recycler in order to contribute effectively to agroecological and productive systems that link producer organisms, primary consumers and soil decomposers (biodiversity is also needed in the soil) for efficient recycling. New synergies between crops and livestock farming must be developed within regions (Maisse and Béranger, 2021) through circular approaches. Firstly, even though grassland-based ruminant farming seems to be the most effective solution in terms of the environment and the health value of products, livestock farming uses and must continue to use a wide variety of biomass (fodder, co-products) that cannot be used for human consumption. Thus, on average in France, with the current use of agricultural land, the proportion of protein that is not consumable by humans (from fibre-rich plants such as fodder, co-products from the agri-food industry or biorefineries, etc.) and included in animal feed is 80 to 90% for dairy cows, 65 to 79% for pigs and 33 to 55% for poultry (Laisse et al. 2018). This recycling role is naturally more important for ruminants, which are able to digest cellulose, but also in pig production, which makes use of many by-products. The use of oilseed meal other than soya is a step in this direction. However, the use of plant by-products for energy production (particularly through methanization) may compete with this strategy.

A closer reconnection between livestock farming and crop cultivation within territories allows for more diversified crop rotations and crop patterns, which would have numerous agronomic advantages (reduction in pesticides, reduction in nitrogen fertilisers, carbon storage, soil cover, better water resource management, etc.; Tamburini et al. 2020). The development of dual-purpose crops, the promotion of intermediate crops, or mixed crops (cereals and protein crops, for example), and the reintroduction of fodder legumes into cereal rotations would improve the protein self-sufficiency of livestock farming and reduce its land requirements, with hectares being used to feed humans and animals, while improving resilience to climate change. Livestock farming is, in fact, a facilitator, as the sectors adapt to the food resources available on the market. Thus, during the development of first-generation biofuels, rapeseed acreage increased from 0.2 to 1.5 million hectares, and livestock farming consumed all available rapeseed meal (2.5 million tonnes) as a substitute for imported soya. Similarly, livestock farming could use more than 1 million tonnes of protein from protein crops (i.e. more than 2.5 million hectares of peas, field beans and lupins) if they were available on the market.

This reconnection would also facilitate better use of livestock manure, which would limit the need for synthetic mineral fertilisers, with an associated reduction in GHG emissions and fossil fuel requirements for their synthesis, especially as animals would be fed more legumes, which do not require nitrogen fertilisers. Through methanization, they can also produce energy and a fertiliser whose nitrogen is quickly assimilated by plants.

This vision is completely at odds with the agricultural development model that has prevailed since the 1970s. The specialisation of intensive livestock farming on the one hand and intensive crop production (highly specialised thanks to the use of plant protection products) on the other leads to significant losses, as animals decouple the carbon (methane emissions) and nitrogen cycles and retain only 45% (poultry) to 30% (pork and milk) of the nitrogen ingested that had been coupled by photosynthesis. Beyond simply limiting the negative impacts of intensive livestock farming, such a change would restore its more positive role. Monitoring of farms in the "DEPHI ecophyto" network shows that mixed farming operations, due to the presence of grassland on the farm, use fewer plant protection products than arable farms (but in return, very good control of animal medication inputs is required).

Recoupling can take place at the farm level, but more likely at the regional level, where farms specialising in livestock farming could collaborate with farms specialising in crop production. They would exchange goods and services, thus creating one or more virtuous circles that would close biogeochemical cycles and transform the whole into a carbon sink. The challenge is therefore to de-specialise territories. Attempts at territorial recoupling do exist. For example, some farmers practise early cereal grazing (before heading) without any negative effect on the grain harvest, while others are reintroducing animals (sheep, chickens) into cereal rotations, orchards or vineyards to consume legumes and control weeds and pests. Although still few in number, these practices are increasingly being studied (see the RMT SPICEE symposium [26]). Intensive livestock farming systems are compatible with this vision of recoupling, for example by redeveloping poultry or fattening operations (pigs or cattle) in cereal-growing areas. This is already happening to some extent for poultry, probably because the investment required is lower. Beyond the financial aspects, one of the difficulties is societal acceptance of the return of livestock farming to areas where it had disappeared. These

[26] https://interactions-culture-elevage.colloque.inrae.fr/colloque-du-rmt-spicee-mars-2024

initiatives would also contribute positively to the development of more localised agri-food systems, as envisaged in the territorial food projects (PAT)[27].

To go beyond emblematic cases and have a real knock-on effect, the challenge is to counterbalance the effect of economies of agglomeration, which encourage regional specialisation. The development of upstream and downstream industrial tools is necessary for the animal sectors to function. The virtual absence of slaughterhouses in Beauce territory and other cereal-growing areas also explains the difficulty in developing poultry production there. Are major economic players (cooperatives?) in a position to take this step and invest in this direction with slaughterhouses that are obviously beyond reproach, as they scrupulously comply with regulations concerning the conditions for killing animals? Under what conditions could such decisions be taken? These developments will certainly be very costly. Indeed, in order to be competitive, specialised, capital-intensive farms need supply and processing infrastructure to achieve economies of scale (feed mills, breeding stock supply, processing industries, etc.). These changes must be part of a long-term process, with a clear vision and genuine commitment. The public authorities must take the lead. CAP subsidies and other major government expenditure (see above) will have to be redeployed. The regions also have a key role to play.

Ultimately, reconnecting crops and livestock at the regional level will require a fundamental rethinking of current systems and truly innovative approaches that break down the barriers between current categories (plants/animals, animal species, agriculture/environment, etc.). Such systems will also have to manage health problems caused by the proximity of animal species more effectively than in the past, particularly the transfer of pathogens from one animal species to another, which can potentially lead to major epizootics and zoonoses. These developments will face powerful forces of inertia, including the economic organisation of the sectors, underlying investment needs and the difficulties farmers face in adapting. The reintroduction of livestock farming in certain areas will also have to be accepted by local populations, which will require participatory approaches at a very early stage.

[27] https://france-pat.fr/

Conclusion: finding consensual paths for the evolution of intensive livestock farming in France

As it currently stands, intensive livestock farming is not sustainable. However, it is impossible to do without it, given its place in current animal production and the products and services it provides to consumers and citizens. It must therefore evolve towards greater sustainability. We have outlined above possible paths for change that will need to be accepted by society on the basis of a broad consensus.

Livestock farming provides many services to society: it supplies food with high nutritional value for humans, it is integrated into agricultural systems that enable biogeochemical cycles to be closed and plants that cannot be used by humans to be valorised, it enhances the value of land and contributes to diverse landscapes. In some parts of the world, it is virtually the only human activity possible. However, certain livestock farming practices and organisations have led to environmental and territorial imbalances, and damage to animal welfare and biodiversity. As it currently stands, intensive livestock farming is being called into question and must evolve and undergo profound change.

French livestock farming is suffering. Production is declining, as is the number of farmers or aspiring farmers, and imports are increasing, even though we have one of the highest production potentials in Europe. Competitive conditions often make it unprofitable. The negative effects are highlighted and intensive farming, which does not correspond to the idealised image of traditional farming and involves keeping animals in confinement, is widely questioned in public opinion. Society's view weighs heavily on the livestock farming profession.

Although intensive farming as it is currently practised is not sustainable, maintaining a certain degree of intensification is nevertheless necessary for a large proportion of farms (specialisation, technical expertise, minimum size, etc.) due to societal production conditions and the volumes to be produced, even if the consumption of animal products must decrease significantly in France as in other developed countries. There is no single model that can be imposed. Depending on farmers' aspirations, local production conditions (environment,

economy, etc.), consumer choices and food environments[28], different forms, or combinations of different forms, will find their place, including, alongside intensive systems, various alternatives adapted to local contexts, ranging from very extensive forms to productions recognised by quality labels and valued as such.

To meet the needs of the mass market, new production standards must be developed for a large part of the market for which intensive but revised farming remains a necessity. These farms must be able to withstand competition and contribute to more sustainable food systems from an economic, environmental and societal point of view, respecting animals and consumer health. They will be part of a complementary relationship between different farming methods and other agricultural production to balance biogeochemical cycles and reduce dependencies.

The document outlines a number of avenues and tools that are available for these changes, some of which can be implemented in the short term within current systems or are already being implemented in the field. Others will be available in the medium term. Accelerating and generalising their deployment would quickly lead to a reduction in the environmental footprint of this activity and improve animal welfare and working conditions for farmers. At the same time, farmers and industries will continue to strive for competitiveness.

These developments should be steps towards a stronger transition in the hope of achieving livestock farming that closely combines, at the farm level, groups of farms or a small region, diversified animal and plant production, according to the principles of agroecology, which are true carbon sinks and protectors of biodiversity.

This requires heavy investment that not all livestock farmers are able to bear alone and leads to potentially increased operating costs that could have an impact on product prices. Public authorities and downstream players in the sector are essential to these developments through their support for investment. Consumers who are better informed about their purchasing and consumption choices in the face of a renewed supply, and public policies aimed at promoting "made in France" and "local" products in collective catering, are also key drivers

[28] https://www.iddri.org/fr/publications-et-evenements/etude/environnement-inegalites-sante-quelle-strategie-pour-les

of this objective. Public authorities should develop public aid to support the transitions. The new systems will produce ecosystem services, for which they should also be remunerated. It is also up to the public authorities to ensure fair competition conditions that enable the livestock sectors to achieve the changes expected by society and to respond to environmental and climate challenges. Reconciling economic and social objectives (sufficient income for livestock farmers, affordable product prices, employment, etc.) and societal objectives (high level of respect for the environment and animals), as well as public health, should become the essential goal of agricultural and food policies, based, among other things, on substantial changes in policies, the European CAP and national and regional policies.

This change and the necessary remuneration of ecosystem services should also be supported by taxpayers and not by consumers, many of whom are perceived to have difficulty in bearing the cost of quality products alone. Is it one of the EU's current objectives to increase the necessary budget and ensure a different distribution of support in order to fulfil all these missions under the Green Deal? How can consumers accept a "price signal" that gives food products a meaning other than that of daily nourishment and sustenance, when the choice of how to spend the rest of their money is most often made at the expense of the food budget? Let us hope that we can answer both of these questions in the affirmative.

In addition to the financial and technical requirements of these transformations, sociological obstacles will need to be overcome in order to define collectively desired trajectories. This will involve public debates and discussions between the various stakeholders. One could imagine the creation of a societal pact for French livestock farming, similar to what the beef industry has recently achieved[29]. The reflection conducted here is not an end in itself. Its aim is to fuel public debate through written contributions, speeches and participation in various consultations. This will hopefully enable us to take the first step in what will undoubtedly be a long journey (Lao Tzu 2023) towards greater sustainability in French livestock farming.

In any case, and despite the difficulties in precisely defining the concept of intensive livestock farming, it should be noted that French livestock farming is extremely diverse,

[29] ? https://www.interbev.fr/enjeux-societaux/pacte-engagement-societal/

ranging from very extensive to highly intensive, and that it is undoubtedly this great diversity that gives it its resilience.

The French Academy of Agriculture is an ideal forum for pursuing this reflection and initiating this challenging debate.

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Other contributions and opinions

Opinion of Section 4, Humanities and Social Sciences

The draft report provides a well-argued and relevant technical and economic analysis of the evolution of the "sustainability" of intensive livestock farming, both monogastric and ruminant, in its economic, social and environmental dimensions. It is comprehensive and precise in its definition of the terminology used.

It notes the evolution in France of the production and external trade of different meats, and highlights the contribution of livestock farming to human nutrition and numerous ecosystem services. The concept of competitiveness, which is rapidly replacing that of intensity, features prominently in the draft report, which addresses the services provided by intensive livestock farming and its advantages in certain respects, and analyses its incompatibility with various aspects of the ecological transition and animal welfare. Reflecting society's growing concerns about animal welfare and environmental impact (greenhouse gas emissions and indirect effects on biodiversity and water quality), it highlights the recent deterioration in the image of livestock farming and livestock farmers in society and questions the need to maintain this type of farming.

The assessment of each pillar of sustainability, production by production, shows first of all that the economic situation of most systems is poor in the medium and long term due to increased competition.

However, 'sustainability' is often mentioned in relation to the 'competitiveness' of livestock farming systems without analysing their reciprocal impact. The impact of international trade and the role of upstream and downstream companies in the livestock sector do not seem to be sufficiently linked to the two major stages of the common agricultural policy: the regulation of trade with guaranteed prices for land-based production, and the opening up of the global market with the decoupling of most subsidies.

The hidden costs of intensive livestock farming are then discussed, leading to the characterisation of intensive livestock farming that would respect these aspects. Several paths are identified for improving the sustainability of intensive systems through a systemic approach at the farm and regional levels. Progress in sustainability is also seen as requiring the involvement of consumers and citizens, with whom a kind of social pact would need to be established.

Three weaknesses of the report correspond to topics that are not explored in depth:

- *the place of work in its various dimensions (arduousness, technicality, family or employee status) in the process of specialisation and intensification of livestock farming, as well as working conditions and their evolution thanks to technology;*
- *the combination of production concentration and the location of processing facilities,*
- *the reflection on agricultural policy that has led to the dissociation between livestock farming and crop farming.*

The recombination envisaged at farm and regional level in a systemic approach appears relevant, but the discussion remains peripheral, without questioning the nature of livestock farming.
The interaction between humans and animals, which is at the heart of livestock farming, is given little attention.
It would be appropriate to mention the work undertaken over several years on the links between human beings and non-human living beings. This would open up an epistemological and ethical debate on the place of 'intensive' livestock farming in our societies and on how human-animal relations, which are at the heart of the domestication process, have been 'technicised', reducing animals to mere objects of production and consumption serving solely economic interests.

The controversy at the origin of the Academy's reflection concerns the necessity or otherwise of specialised and intensive farms with significant use of external inputs, often exceeding the agronomic potential of their territory. The purpose of this report is to give an account of the discussion on this controversy within the working group. However, it should be borne in mind that not every controversy needs to be the subject of a report, and it is worth asking whether this is the case here.

Analysis of Section 7, Environment and Territories

Section 7 finds this report to be well written and documented. It takes into account the specific characteristics of French livestock farming within Europe, in particular the increase in imports of poultry and beef, as well as the important role of suckler cattle farming compared to dairy farming.

However, Section 7 finds that the chosen analytical framework, "low" sustainability, which considers the economy and ecology to be independent, has the effect that so-called economic considerations can lead to dead ends when they come up against the wall of environmental realities. Thus, this purely economic lens, which favours the lowest bidders in terms of price at the expense of the environment and health, particularly through unsustainable imports, may be too short-sighted, ignoring the risks and opportunities associated with environmental and therefore social change.

Conversely, "strong" sustainability clearly states that long-term strategic choices must place economic choices within the framework of planetary boundaries. Similarly, approaches such as One Health or Nexus (see the latest IPBES report) are much more systemic and promote more sustainable economic models than the weak sustainability analysis framework. In particular, they highlight the relationships between consumer income, the environment, consumption patterns and health. They take into account the high feed/food competition for monogastric animals, but also for ruminants, given the combination of a significant contribution of arable land (i.e. excluding permanent grassland) to their diet and their low energy and protein conversion efficiency. These approaches make it possible to reduce the hidden costs of food systems. They lead to the definition of "optimal" consumption of animal products, particularly meat, to meet our nutritional needs, which results in a roughly twofold reduction in European countries.

***The answer to the question of the "sustainability of intensive livestock farming" therefore depends on the chosen framework for analysis**, namely: do we start from the premise of maintaining consumption of animal products, or do we aim for a reduction of around half?*

Satisfying "demand" (basically, maintaining consumption and choosing exports) will necessarily lead to maintaining "optimised" intensive livestock farming, as described in the report. This often goes hand in hand with the search for economies of scale (increasing the size of farms, maintaining the concentration of livestock farming in certain regions, etc.). However, this choice does not allow us to meet our commitments to reduce greenhouse gas and reactive nitrogen emissions.

Conversely, reducing demand, in other words changing our diet, particularly for the sake of the environment and human health, would create the conditions for livestock farming systems with higher environmental value. This environmental value, consistent with society's expectations, could be converted into economic value, thus reconciling strong sustainability and economic resilience. Models in which ruminants are fed using greater use of grasslands would, in particular, make it possible to maintain the environmental services they provide. For the pig and poultry sectors, a reorientation towards the domestic market and a redistribution across the whole territory, in particular to reduce the massive nitrogen and phosphorus emissions caused by their geographical concentration, are options to be explored. Finally, by reducing feed/food competition, this choice would allow more arable land to be allocated to agroecological crop production.

Figures and Tables

Figure 1. Different representations of sustainability according to Purvis et al. (2019). On the left, the most typical representation with three intersecting circles; on the right, two alternative representations, in "pillars" and with concentric circles.

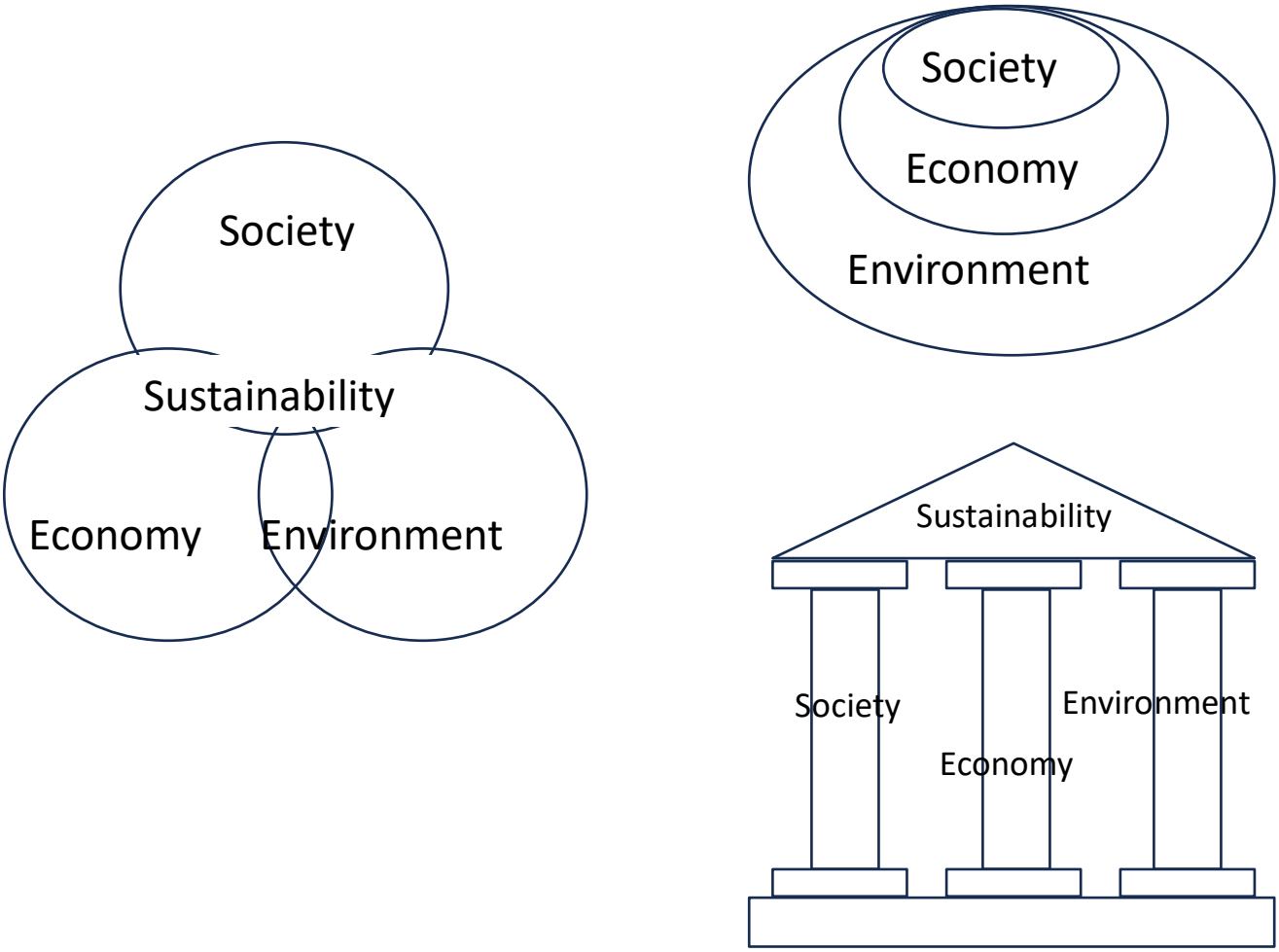

Table 1. Changes in meat supply in France by species

In thousands of tonnes carcass equivalent (unless otherwise stated)

		Production	Imports	Exports	Consumption Total	Consumption kg/capita	External balance Millions € Current value
Beef[1]	1980	1,965	277	451	1,775	30.0	+438*
	2010	1,763	415	498	1,680	25.4	+604
	2022	1,580	394	459	1,514	22.3	+630
	% 2022/80	*-20*	*+42*	*+2*	*-15*	*-26*	
Sheep and goat meat[1]	1980	180	46	1	225	3.0	-125*
	2010	137	127	19	219	3.4	-471
	2022	105	122	48	179	2.6	-525
	% 2022/80	*-42*	*+165*	*x48*	-	*-13*	
Pork[1]	1980	1,570	430	93	1,905	30.7	-491*
	2011	1,727	593	740	2112	35.5	-75
	2022	2188	668	641	2180	31.9	-131
	% 2022/80	+39	+55	x7	+14	+6	
Poultry[1]	1980	1124	22	290	859	16	+235
	2010	1,722	472	677	1529	23.7	276
	2022	1555	839	510	1909	27.9	-1024
	% 2022/80	+38	x38	+76	+122	+74	
Equines[2]	1980[1]	18.9	50.1	0.8	88.7	1.6	**
	2010[2]	6.9	21.5	6.5	19.8	0.3	**
	2022[2]	3.5	7.1	2.4	5.8	0.08	-21
	% 2022/80	-81	-86	+20	-93	-95	**
Fish farming[3]	1998	47	**	**	*150*	*2.5*	**
	2021 (or 22 or 23)	42	287	53	312	4.6	-1,473
	% 2021/98	*-10*	***	***	*+108*	*+184*	

* Original value converted at a rate of €1 = CHF 6.56; ** Not available

Sources: [1]FranceAgriMer; [2]SSP, Agreste; [3]Trout, salmon and freshwater fish (according to FranceAgriMer 2024)

Table 2. Simplified sustainability assessment by type of farming and sustainability pillar: Advantages and services of intensive farming

Species/ category	The 3 pillars of sustainability		
	Economic	**Social**	**Environmental**
Beef cattle	- Supply of organic fertilisers essential for fertilising field crops in organic farming	- Jobs in the regions concerned	-Recycling of plants not suitable for human consumption -Slight reduction in emissions into the air (open buildings) - Possibility of more optimal effluent management -Less land required (but less grassland) -Reduction in footprint per kg of product
Dairy cattle	-Added value in regions and sectors -Investment opportunities -Competitiveness on global markets -Dynamism, sector expertise -Volume per collection point (truck mileage limit)	-Jobs in the regions concerned -Low milk prices	-Recycling of plants not suitable for human consumption -Low reduction in air emissions (open buildings) -Possibility of more optimal effluent management -Less land required (but fewer grasslands) -Reduced footprint per kg of product
Broiler chicken	-Added value in regions and sectors -Investment opportunities -Competitiveness on global markets -Dynamism, sector skills	-Jobs in the regions concerned -Low meat prices	-Opportunities for significant reductions in air emissions -Potential for more optimal effluent management -High efficiency (less land use) -Reduced footprint per kg of product
Laying hens	-Added value in regions and sectors -Investment opportunities -Competitiveness on global markets -Dynamism, sector skills	-Jobs in the regions concerned -Low egg prices	-Opportunities for significant reductions in air emissions -Potential for more optimal effluent management -High efficiency (less land use) -Reduced footprint per kg of product
Pigs	-Added value in regions and sectors -Investment opportunities -Competitiveness on global markets -Dynamism, sector skills	-Jobs in the regions concerned -Low meat prices	-Opportunities for significant reductions in air emissions -Potential for more optimal effluent management -High efficiency (less land use) -Reduction in footprint per kg of product
Meat sheep	-Low intensity		-Valorisation of plants not consumable by humans -Reduction in footprint per kg of product
Milk sheep			-Valorisation of plants not consumable by humans -Reduction of footprint per kg of product
Goats			-Valorisation of plants not consumable by humans -Reduction of the footprint per kg of product
Fish farming			-Reduction in footprint per kg of product -Less extraction from natural environments

Table 3. Simplified sustainability assessment by type of farming and sustainability pillar: weaknesses and impacts of intensive systems (AW: Animal welfare)

Species/ category	The 3 pillars of sustainability		
	Economic	**Societal**	**Environmental**
Beef cattle	-Competitiveness outside the EU -Farmers' income	-Place of farmers in society ("Agribashing") -Renewal of farmers -BEA: slaughter conditions	-Enteric methane -Low efficiency -Water consumption (excluding grassland) -Service production only if low stocking density
Dairy cattle	-Industrial and supermarket pressure on milk prices	-BEA: cow housing, dehorning, mother-calf separation -Renewal of livestock farmers -BEA: slaughter conditions	-N and P discharges into aquatic environments -Ammonia discharge (less than pigs and poultry because of grazing) -Enteric methane -Water consumption (excluding grassland) -Imported deforestation
Broiler chicken	-Competitiveness within and outside the EU -Not self-sufficient -Dependence on imported protein	-BEA: stocking densities -Fast-growing breeds -Image of livestock farming -Epizootics, zoonoses -BEA: slaughter conditions	-N and P discharges into the aquatic environment -Ammonia discharge + odours -Imported deforestation -Raw materials competing with human food -Low genetic diversity
Laying hens		-BEA: stocking densities -BEA: Destruction of male chicks -BEA: questionable farming practices (beak trimming, etc.) -BEA: slaughter conditions	- N and P emissions into the aquatic environment -Imported deforestation
Pigs	-Intra-EU competitiveness -Highly variable economic results (over time) and highly diverse (between farms) determining sector dynamics - Low product differentiation at farm level	-BEA: sow farming -EBFA: fattening conditions -BEA: questionable farming practices (tail docking, teeth clipping, castration, etc.) -Epizootics -Image of farming -BEA: slaughter conditions	-N and P discharges into the aquatic environment -Ammonia discharge + odours -Imported deforestation -Geographical concentration
Meat sheep	-Competitiveness within and outside the EU -Farmers' income -Non-self-sufficient	-BEA: fattening phase -Renewal of farmers	
Milk sheep		-Discrepancy between reality and image of farming	
Dairy goats		-Renewal of breeders -Discrepancy between reality and image of farming	
Fish farming	-Competitiveness within and outside the EU		-Nitrogen, phosphorus and antibiotic discharges into the aquatic environment -Consumption of fishmeal and fish oil from marine species

Equines	-Competitiveness within and outside the EU		
Insects		-Acceptability for human consumption	

Table 4. Main paths of progress that intensive livestock farming could take and their schematic consequences, positive, negative or neutral, on the three pillars of sustainability.

Avenues for progress	**Pillars**		
	Economic	**Social**	**Environmental**
Reinventing intensive farming by finding consensual paths for change	**+**	**+**	**+**
Making progress on the three pillars of sustainability	**+**	**+**	**+**
Protecting against low-cost imports and creating value	+	+	+
New exchanges of trust between producers and consumers	+	+	+
Breakthrough buildings for animal and farmer welfare	-	+	+
Image of farming and farmers in society	+	+	=
Reduction in methane emissions	=	=	+
Closing N and P cycles	-	+	+
De-intensification of specialised systems in an agroecological approach	+	=	+
Maximisation of biomass recycling within farms	+	=	+
Rethinking the agricultural model by more closely linking livestock farming and crop production within regions	=	+	+

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