Matière
à débattre & décider

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

Recent knowledge on their strenghts and weaknesses

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complementarities between farms and activities in a territory. The analysis of efficiencies, and in particular of nitrogen recycling, makes it possible to assess the processes at work in an attempt for improvement. However, in contexts of high population density, recycling is no longer sufficient to meet needs, and external inputs are necessary (mineral fertilisers, concentrated feed) to ensure the balance of the system's functioning: the efficiency of recycling is all the more crucial because it allows these costly inputs to be used in the best possible manner. Moreover, subsidy policies for access to these inputs can have the perverse effect of making recycling less necessary, and consequently slowing down the agroecological transition. All of these considerations were highlighted by the analysis of efficiencies, which confirms the interest of this approach to reasoning the sustainability of livestock farming and its territorial contributions.

This work has revealed the central role that livestock systems can play in the agroecological transition. They are a key link in the recycling of nutrients and the completion of biogeochemical cycles, in addition to supplying foodstuffs, and can be used to develop new forms of agriculture that are both productive and environmentally friendly. However, the examples illustrate the scope for progress in order to make this agroecological transition a success: biological and ecological processes to be explored in order to improve the use of natural resources, recycling of nutrients to increase the efficiency of farms, or complementarity between crop-livestock areas and natural areas for the production of a greater number of goods and services at the territorial level.

Multi-criteria assessment of efficiency to account for the multifunctionality of livestock grazing systems

Jonathan Vayssières, Véronique Alary, Claire Aubron, Christian Corniaux, Guillaume Duteurtre, Alexandre Ickowicz, Xavier Juanes, Samir Messad, Emmanuel Tillard, Abdrahmane Wane, Mathieu Vigne

The two previous subchapters illustrate that the calculation of efficiency provides a means of orienting production towards thrifty resource management and reducing the negative environmental impacts of livestock production systems by calculating indicators such as meat production per quantity of non-renewable energy (NRE) consumed and GHG emissions per litre of milk produced (subchapter Introduction: efficiency, from a simple ratio to an operational analytical framework to support the sustainable development of livestock systems). It can also be used to account for gains in nutrient and energy use efficiency in livestock grazing systems as part of the agroecological transition (sub-chapter *Efficiency to account for the complexity of the contributions of livestock grazing systems to climate change*).

However, the multifunctionality of these livestock systems, notably in relation to the SDG, suggests that other sustainable development (SD) criteria should be taken into account in assessing the contribution of livestock grazing to the SD of territories and in

supporting the agroecological transition (FAO, 2018). This is because livestock grazing contributes to a range of non-environmental services and disservices that deserve recognition (Wedderburn *et al.*, 2021; Muller *et al.*, 2021), which vary according to contexts and farming systems and which evolve over time (Vall *et al.*, 2016).

Accordingly, this fourth sub-chapter reviews a selection of research studies that apply a range of quantitative methods and indicators to complement the previously mentioned environmental criteria. Some works go as far as assessing multi-criteria efficiency. The presentation of the various studies is based on an increase in the level of organisation: farm, household, sector and territory, in order to take into account the diversity of issues at these different levels.

Multi-criteria efficiency at farm or household level

The role of livestock in the efficiency and socio-economic viability of family farms in the western Nile Delta in Egypt

The cultivation of desert lands through the extension of irrigation canals is a priority strategy in Egypt to ensure food security in the face of population growth and land fragmentation in the Nile Delta and Valley. However, the development model for these new lands created on the desert raises many debates related to the efficiency and sustainability of agricultural systems in view of the fragility of the soil and the scarcity of water resources (Alary *et al.*, 2018). Alongside large agricultural farms, small areas (1.25 to 2.5 ha) were allocated to a group of beneficiaries, former land tenants or university graduates. The latter have developed mixed crop-livestock farming systems combining market orchards and food and fodder crops with a few head of cattle (1 or 2 cows or buffaloes) and sometimes a herd of sheep and goats not exceeding 10 head.

Based on a survey in 5 localities in the western part of the delta, we constructed a set of indicators related to the notions of technical and economic efficiency in relation to the structure of assets and socio-economic benefits in the production system (Juanes *et al.*, 2020; Alary *et al.*, 2020) (table 3.5).

The results indicate contrasting contributions of livestock to household monetary viability. Among graduates (especially in Tiba), livestock farming helped finance agricultural and family investment during the first years of settlement. Once the orchards were in production, livestock became a source of savings. For the other beneficiaries, livestock plays different roles. In the first areas developed in the 1960s near the delta (Nahda), livestock farming remained a central activity in the system from a technical and economic point of view. In the areas developed in the 1980s, even if the producers in the Bangar area benefit from monetary security thanks to cash crops, the Hamman area has frequent irrigation issues that explain the diversification of livestock activities, in particular with regard to sheep and goats, and a lower economic efficiency per hectare or per family worker. Finally, the highly diversified agricultural systems of the

Table 3.5. Socio-economic characterisation and efficiency indicators of farming systems in newly developed land in the western Nile Delta, Egypt (172 households surveyed in 2014).

Theme	Indicators	Nahda	Bangar	Hamman	Bustan	Tiba	Total
Socio-economic characteristics of the household	Household size (individuals)	11.15	7.70	6.74	9.90	7.40	8.67
	Land area (ha)	3.83	2.26	1.30	1.93	2.66	2.40
	Herd size in livestock units (1 livestock unit = 250 kg live weight)	24.49	12.40	8.23	12.12	6.14	12.69
	Annual net household income (€/year)	17,349	9,698	6,076	10,852	7,460	10,389
	Net income per capita (€/day/household member)	6.0	3.2	2.4	3.4	2.8	3.6
conomic efficiency	Net income per ha (€)	5,482	4,355	3,780	3,371	3,088	3,963
	Income per family member (€)	7,561	4,525	2,667	2,774	3,521	4,123
	Profit (ratio)	0.5	0.3	0.4	0.4	0.5	0.4
	Income from animal products/value of the herd	0.36	0.25	0.45	0.17	1.34	0.51
Technical efficiency of the dairy activity	Feed cost/litre of milk (€)	0.23	0.29	0.16	0.23	0.18	0.22
	Milk yield (litres per animal per year)	1,578	1,190	1,217	1,320	1,535	1,369
	Milk production (€) per ha	1,683	477	620	975	854	926

Bustan region, developed in the 1990s and relatively far from urban centres, mobilises a large part of the available family labour, which explains the lower efficiency per worker. However, thanks to the experience of the farmers, former settlers from the old lands, the technical performance of the livestock is good. More globally, the comparative analysis by area shows that livestock activity contributes significantly to economic efficiency and consequently to the socio-economic viability of rural households in these developed areas in the western delta. However, this contribution needs to be assessed in relation to the contrasting roles of livestock keeping in relation to the availability of natural resources (water and soil), the original settlement (former delta farmers or graduates) and the households link to urban centres. Hence, this analysis shows the need for a multi-criteria and multi-scalar approach to understand and assess the contribution of livestock to the socio-economic viability of a diversity of farms occupying a territory.

Effects of crop-livestock integration gains on the multi-criteria efficiency of dairy cattle farms on the island of Reunion

Dairy cattle farms on the island of Reunion are characteristic of intensive, high-input livestock systems. They consume large amounts of concentrated feed and nutrient-rich mineral fertilisers to fertilise grasslands with a range of associated environmental risks. In a sustainable intensification approach, the aim of this work was to identify practices that would increase the efficiency of nutrient and energy use, while seeking to maintain or even increase the productivity and economic viability of livestock farms.

To achieve this, a simulation model of dairy farming was developed (Vayssières *et al.*, 2011). It simulates the dynamics of biomass stocks and flows and of the nitrogen cycle in dairy cattle farming. The representation and quantification of all biomass flows enables a multi-criteria evaluation of each practice change on the basis of environmental, technical, economic and social efficiency indicators (Table 3.6).

Table 3.6. Consequences of various technical levers defined with the farmers on various efficiency indicators calculated with the Gamede simulation model for a typical dairy farm on the island of Reunion in 2000.

Levers	CLID (SD)	Land use efficiency UFL of fodder produced/ha/year)	Feed efficiency (litre of milk produced/kg MB)	Labour efficiency (gross margin in €/h worked)	Nitrogen efficiency (Dmnl)	Energy efficiency (Dmnl)
0- baseline, i.e. the system practiced	0.6	4,600	1.16	13.8	0.26	0.35
1- Better use of organic fertilisers produced on the farm	+ 12.5%	+ 10%	0%	– 9%	+ 24%	0%
1- Better use of fodder produced on the farm	+ 3.5%	+ 1%	+ 8%	+ 14%	+ 9%	+ 6%
3- Improved reproductive performances	0%	– 2%	+ 1%	+ 7%	+ 7%	+ 3%
All levers combined (levers 1 to 3)	+ 18%	+ 9%	+ 9%	+ 12%	+ 40%	+ 9%

With the exception of the first line (scenario 0), which is in absolute value, all results are expressed in relative value, i.e. percentage (%) of variation with reference to the values of scenario 0.
CLID: crop-livestock integration degree calculated according to an ecological network analysis indicator based on nutrient flows (Box 3.4).
Dmnl: dimensionless.
UFL: feed unit to produce milk.
GM: gross material of concentrated feed consumed.

The levers highlighted in this study related to a better use of fodder and farmyard manure produced on the farm to replace part of the imported concentrated feed and mineral fertilisers.

The results of the simulations confirm that better use of the resources available and produced on the farm (fodder, organic fertilisers and breeding animals) makes it possible to increase the multi-criteria efficiency of the farm in terms of land use, concentrated feed, labour, nitrogen and energy, while increasing the gross margin of the farms. However, there is a compromise to be found between environmental, technical and economic performance on the one hand and social performance on the other, since, for example, better use of farm resources leads to a higher workload for farmers on the one hand and higher labour efficiency on the other (Vayssières *et al*., 2011).

Multi-criteria assessment of the sustainability of dairy systems in a territory in India

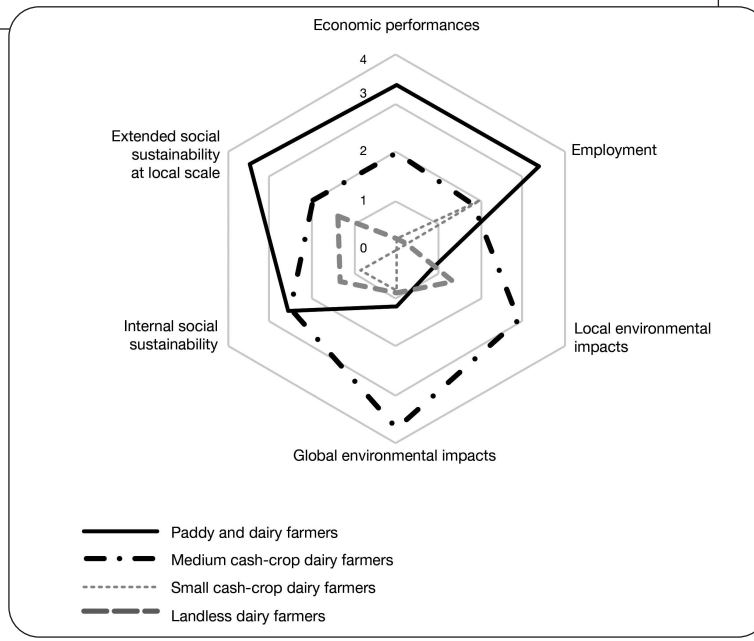
India is currently the world's leading producer of milk due to a development model for the sector supported by structured policies (the "white revolution"). Based on millions of small producers, sometimes landless, owning on average 1 or 2 cow(s) or buffalo(s), dairy farming is often put forward as a major socio-economic development lever for Indian rural societies.

A multi-criteria evaluation method was designed to analyse the internal sustainability of four contrasting dairy systems identified in Vinukonda Township (Andhra Pradesh) and to measure their contribution to the sustainable development of the territory (Marblé, 2019). This method is based on indicators of economic efficiency (e.g., wealth created per animal), employment (e.g., percentage of the active population invested in livestock production), local environmental impacts (e.g., amount of water consumed per litre of milk produced) and global impacts (e.g., GHG emissions per litre of milk produced).

The results were translated into scores and summarized along six main dimensions of sustainability: economic performance, employment, local and global environmental impacts, internal social sustainability and local scope (Figure 3.15). The contribution of dairy farming to the development of Vinukonda Township is based on the diversity of agricultural production systems. Dairy rice farmers are the most economically and socially sustainable system, while medium-sized cash crop farmers (tobacco, cotton, chilli, castor) with dairy farming represent the most environmentally sustainable system. Dairy farmers with limited access to land - small-scale cash crop farmers with dairy farming and landless dairy farmers - score low, notably in terms of social sustainability and economic efficiency, but they contribute to job creation in the area, especially the former.

In order to promote a sustainable and inclusive development of the territory, the promotion of dairy farming must integrate this diversity of systems and guarantee the inclusion of farms with limited land resources. Specifically, this means facilitating their access to

Figure 3.15. Scores obtained for the four dairy systems in Vinukonda Canton (Andhra Pradesh, India) according to six dimensions of sustainability.durabilité.



land and irrigation water so that they can intensify herd management and so increase productivity, wealth creation and income. However, this intensification must not be achieved at the cost of a disconnection between agriculture and livestock farming, as observed in other territories, leading to the consumption of mineral fertilisers and concentrated feeds in large quantities, and hence to negative impacts on the local and global environment (Vigne *et al.*, 2021b; Aubron *et al.*, 2021).

Multi-criteria efficiency at the sector and territory level

Economic efficiency of internationalized beef market value chains in Southern Africa

In most sub-Saharan countries, the meat trade is booming, driven by a combination of growing domestic and regional demand, and even a niche export market such as in Botswana and Eswatini. Meat exports are promoted by these countries for foreign exchange earnings, but also as a means of communicating their ability to produce to often very strict international standards.

The beef value chain in Eswatini, which is studied here, is based on a multitude of small-scale zebu cattle grazing producers. A significant proportion of the beef comes from the contractual transactions of live cattle with Swazi Meat Industries, a beef slaughterhouse and processing plant with exclusive export agreements for quality meat to Europe, mainly Norway. This involvement in international trade chains raises issues of competitiveness, value chain efficiency and domestic market protection.

Their performance was analysed through their contribution to the national and sectoral economy (GDP and agricultural GDP). The domestic resource cost ratio, which measures the comparative advantage of a given value chain over other value chains of products that can use the same type of resource; the nominal protection coefficient, which measures the ratio of the value of products or inputs valued at domestic market prices to those at the border (reference, i.e. without intervention); and the effective protection coefficient, which identifies potential market distortions by analysing the ratio of value added at domestic and global prices are all indicators that can be assimilated to economic efficiency indicators and provide information on the economic dimension of the sustainability of a value chain (Table 3.7).

The total value added created by the beef value chain represents approximately 2% of GDP (1.2% direct contribution and 0.8% indirect contribution) and 32% of agricultural GDP (19% direct contribution and 13% indirect contribution in the form of wage

Table 3.7. Economic performance indicators of the beef value chain in Eswatini (Wane *et al.*, 2018).

Contributions to the national and sectoral economy in 2017					Economic efficiency indicators	
	In billions of euros	Direct contribution	Indirect contribution	Total contribution		
GDP at constant 2011 prices	4.1	1.2%	0.8%	2.0%	Domestic resource cost ratio (DRC)	0.2
GDP at current prices	4.0	1.2%	0.8%	2.1%	Nominal protection coefficient (NPC)	1.2
GDP at constant 2011 prices	0.3	18.8%	12.7%	31.5%	Effective protection ratio (EPR)	0.6
Agricultural GDP at current prices	0.3	19.0%	12.8%	31.8%		

payments, tax payments, etc.). Through taxes, and after factoring in state subsidies (mainly on veterinary drugs provided to smallholders), the beef value chain has a positive impact on public finances. However, it contributes negatively to the balance of trade due to massive imports of meat from South Africa and Mozambique to meet growing local demand. The beef value chain has a comparative advantage in relation to the international market because it efficiently uses its domestic resources (land, capital and labour) to generate added value (CRI<1) by exporting quality meat. It benefits from a certain protection compared to meat imports (CPN>1).

Finally, promoting exports has benefits in terms of improving the balance of payments and bringing products up to sanitary standards to meet a stringent demand in the European market. However, targeting higher quality products for export, while massively producing and importing lower quality products for the domestic market, raises a question of sustainability, notably in a changing world where certain shocks (e.g. health) can challenge existing supply chains.

Assessing the impacts of dairy value chains in Africa: a multi-criteria approach

For the Sahelian countries, seriously weakened by various socio-economic crises and climate change, the sale of milk is a means of securing the living conditions of millions of herder and crop farming families. In 2018, these families produced 3.6 million tonnes of milk in West Africa. Most of this milk is consumed or marketed locally and only about 5% is collected by dairies (Corniaux *et al.*, 2014).

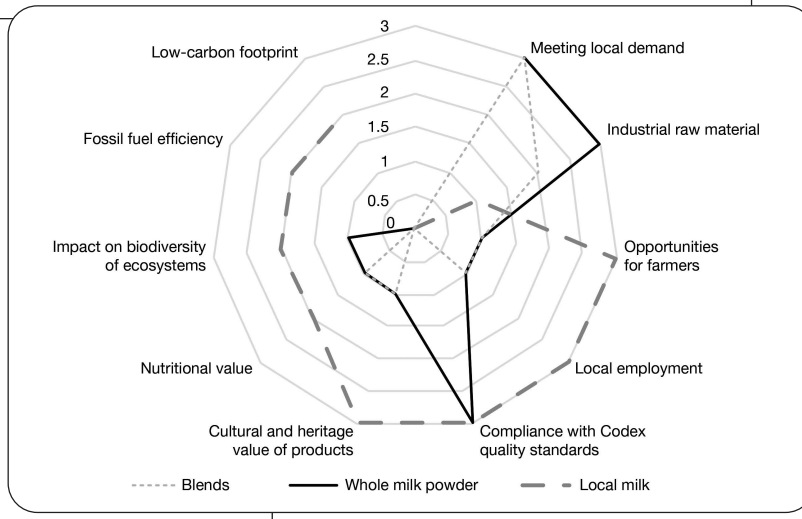
The inclusion of these farmers in the dairy value chains is constrained by the difficulties of collecting milk in agropastoral areas. Dairies face the absence of transport infrastructure, the dispersion of herds due to pastoral mobility and low milk yields per cow. Above all, the share of milk powder imports has been increased over the past 10 years by the lowering of West African customs barriers and by the renewed dynamism of exporters in the North. Many European firms have engaged in the export of vegetable fat filled milk powder blends known as "FFMP". These milk powder blends 30% cheaper than powdered milk, mostly use palm oil. They enter the West African market virtually duty free (5%). In 2019, milk powders and FFMP blends accounted for a total of almost 40% of the "dairy product" consumption in West Africa and more than 90% in some capitals (Duteurtre *et al.*, 2020).

Trade policies, which aim to facilitate the entry of cheap imported products to meet demand, are in conflict with dairy sector policies, which aim to promote local production and inclusive value chains that create employment. A multi-criteria approach was conducted to compare the impacts of dairy value chains using differing types of raw materials. This assessment was based on a literature review on the economic, social, nutritional and environmental dimensions of this trade (Duteurtre *et al.*, 2020).

Even if the import of powders has enabled local dairy industries to respond effectively to the growing demand for dairy products, it has nevertheless generated negative

socio-economic and environmental impacts. Local milk collection appears to be much more "efficient" than the use of milk powders in terms of job creation in grazing areas in relation to environmental conservation and limiting the risk of consumer deception, because strictly speaking, FFMPs are not dairy products (Figure 3.16).

Figure 3.16. Multi-criteria assessment of dairy value chains in West Africa (Duteurtre *et al.*, 2020).



Scores: 0, somewhat negative; 1, somewhat positive; 2, positive; 3, mostly positive.

This study highlighted that promoting local milk could have significant social, nutritional and environmental impacts. This study needs to be complemented by more in-depth quantitative assessments, especially on the social and environmental dimensions.

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The body of work conducted in North, West and Southern Africa as well as in the Indian Ocean (India and on the island of Reunion) illustrates the extent of the services provided by livestock grazing at several levels of organisation and their contribution to many of the SDGs. These various studies also illustrate how these different services or dis-services can be partly assessed by efficiency indicators. The experience developed in the framework of this study now allows us to provide examples of efficiency indicators to assess the contribution of livestock grazing to the SDGs (Table 3.8).

The implementation of quantitative efficiency indicators for each of the SD dimensions (environmental, technical, social and economic) in practical situations highlights a

Table 3.8. Examples of efficiency indicators to assess the contribution of livestock systems to 10 SDGs.

No	SDG title	Potential usable efficiency indicator (illustrative)
1	No poverty	No. of inhabitants paid by livestock / 1,000 An
2	Zero hunger	kg of milk, meat or protein produced / ha or / household
3	Good health and well-being	ha of (recreational) landscape maintained/ 1,000 An
5	Gender equality	No. of women involved or paid / herd or / household from livestock
6	Access to water	L of water consumed / kg of meat produced or / l of milk produced
7	Access to energy	MJ of NRE consumed / l of milk produced; MJ as biogas produced / 1000 An
8	Decent working conditions and economic growth	No. of jobs generated / 1,000 An
12	Sustainable consumption and production (equity)	kg of product lost along the chain / kg of product at herd level; € returned to the farmer / € paid by the consumer
13	Climate change	kg CO_2 eq emitted / TLU; kg CO_2 eq stored / ha of grassland or rangeland (GHG balance or carbon balance)
15	Terrestrial ecosystems	No. of species present / ha of grassland or rangeland; NH3 emissions / ha or / 1000 An

No: number.
An: animals
TLU: Tropical livestock unit.
NRE: non-renewable energy.
GHG: Greenhouse gas.

set of compromises both in the diversity of livestock systems and in the exploration of ways in which these livestock systems and the corresponding value chains can evolve. These various studies also show that it is not always possible to provide quantitative efficiency indicators for each of the services or dis-services provided by livestock grazing. In other words, efficiency cannot account for all the services and functions of livestock. The quantitative evaluation of the social dimension of SD raises questions. For example, solidarity and equity are social sustainability criteria that cannot be easily assessed in terms of efficiency.

Finally, the calculation of multi-criteria efficiency constitutes a genuine research priority, mobilising sophisticated and complex methods and tools to implement (Boxes 3.5 and 3.6) as well as original conceptual frameworks (Box 3.7). This research work is now eagerly anticipated to inform and identify sustainable development trajectories based on livestock grazing.

Box 3.5. Analysing efficiency frontiers to find the right compromise between productivity gains and environmental impact mitigation in dairy cattle systems.

Emmanuel Tillard, David Berre, Emmanuelle Payet, Philippe Lecomte, Jonathan Vayssières, Stéphane Blancard, Jean-Philippe Boussemart, Hervé Leleu

A study conducted in 2014 (Berre *et al.*, 2014) focused on the identification of a compromise between milk production and its environmental impacts in terms of greenhouse gas (GHG) emissions and nitrogen surplus in high-input dairy farming system on the island of Reunion.

A typical scenario was identified for each of the three "typical" stakeholders in the dairy sector (the farmer, the dairy cooperative and the "environmentalist"). The "farmer" and "cooperative" scenarios seek to maximise milk production without worsening the negative impacts on the environment; the cooperative retains the possibility of increasing the means of production, whereas these are kept constant in the "farmer" scenario. The "environmentalist" scenario is solely aimed at reducing the negative impacts of production on the environment. A fourth scenario, "sustainable intensification", combines maximisation of milk production and minimisation of environmental impacts.

To assess the multi-criteria efficiency of dairy farms, technical and environmental data were collected from 51 farms (Payet, 2010; Vigne, 2007) representing 61% of the island's milk production. An economic optimisation model, called the "efficiency frontier analysis", which is multi-product and multi-factor (i.e. resources and inputs mobilised), was developed to assess the margins of growth in milk production and the simultaneous reductions in GHG emissions and nitrogen surplus.

Milk production is effectively maximised in the "cooperative" scenario and environmental impacts minimised in the "environmentalist" scenario (Table 3.9). Of the four scenarios, the "sustainable intensification" scenario led to the best compromise, with a potential decrease of 238g CO_2 per litre of milk (-13.93% compared to the mean observed level) and a potential increase of +7.72 l of milk produced (+16.45%) for each kilogram of excess nitrogen.

These results are derived from an optimised management of crop-livestock interactions and production processes. However, the environmental impacts of dairy systems on the island of Reunion remain higher than those described in the literature for grassland dairy farming systems (Vigne *et al.*, 2012). These differences could be linked to aspects specific to the island of Reunion context (consumption of imported inputs, availability and quality of fodder) but also to aspects related to herd management (high stocking rate per hectare, grassland management). This confirms that the analysis of efficiency frontiers can shed new light on the comparative analysis of high-input versus grass-based tropical dairy systems.

Box 3.5. Next

Table 3.9. Optimisation of outputs and inputs and environmental efficiency of the different scenarios.

	Relative change in indicators (%)						Indicators in absolute value		
		Consumption of production factors (inputs)			Nitrogen surplus		GHG balance		Bilan GES
Scenarios	Milk production	Herd size	Feed	Labour	GHG balance	Nitrogen surplus	kg N/ ha	kg milk/ kg N	kg CO_2 eq./l milk
Livestock farmer	+ 5.8%	0%	0%	0%	0%	0%	274	49.6	1.62
Cooperative	+ 14.3%	+ 17.4%	+ 14.6%	+ 20.0%	0%	0%	274	53.6	1.50
Environmentalist	0%	0%	0%	0%	– 13.6%	– 13.7%	236	54.4	1.48
Sustainable intensification	+ 6.6%	+ 7.9%	+ 8.4%	+ 8.6%	– 8.2%	– 8.5%	251	54.7	1.47

Box 3.6. Spatialised multi-criteria evaluation of the environmental and socio-economic impacts of a livestock production chain in several territories.

Jonathan Vayssières, Alexandre Thévenot, Yves Croissant, Emmanuel Tillard

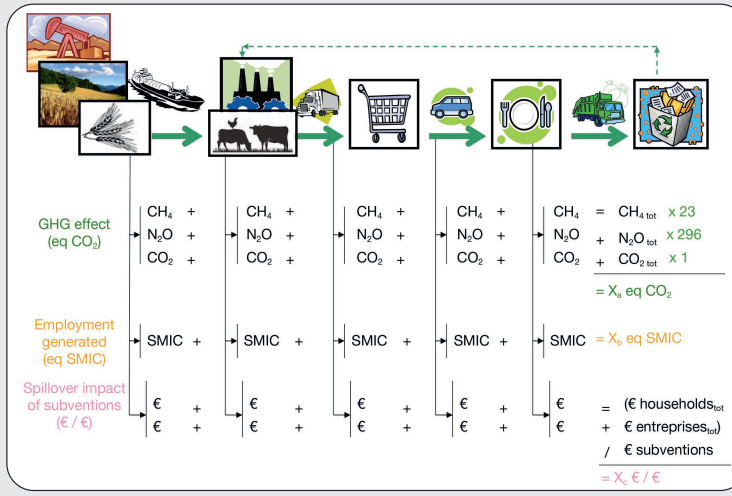
Within the framework of a close partnership with the main stakeholders in the livestock sector in the island of Reunion, we proved that it is possible to integrate two assessment methods based on the same set of inventory data: the environmental life cycle analysis and the effects method (Thévenot, 2014). These two methods, although derived from different scientific disciplines, environmental and economic sciences respectively, make it possible to localise the effect of different scenarios for the evolution of the sector on various categories of environmental (human and ecosystem health, resource depletion) and socio-economic (creation of added value and jobs) indicators along the value chain (figure 3.17). This method is illustrated here on the livestock sectors on the island of Reunion. It should be used again to study value chains built on livestock grazing systems in various regions of the world.

The results for the livestock sectors on the island of Reunion indicate that most of the environmental impacts (around 80%) are externalized from the island's territory, i.e. Europe and South America, due to the high dependence on external resources (fossil energy and raw materials used for livestock feeds). In terms of the socio-economic dimension, most (about 90%) of the job creation is carried

Box 3.6. Next

out on the island through the use of local services (breeding, slaughtering, packaging). Several options for mitigating environmental impacts have been explored with stakeholders in the sector (Thévenot *et al.*, 2013). Improving on-farm feed use efficiency, as defined by the farm-level work described above, was found to be the option with the greatest effect on value chain impacts. Human and ecosystem health and resource conservation would be improved by 2.2, 9.8 and 4.8% respectively; these impact reductions occur both on and off the island. But employment in the industrial network and the island community would also be negatively affected by - 2.2 and - 3.0% respectively. This employment loss occurs mainly on the island; it is primarily the result of a reduction in the quantities of inputs consumed, transported and consequently packaged or produced on the island. These results have been used by the sectors to promote eco-labelling or to lobby the European Commission for support for animal production on the island of Reunion. This study highlights the importance of the compromises between the environmental and socio-economic dimensions and the methodological challenges related to a real integration of evaluation methods from various disciplines at the scale of the entire sector (Vayssières *et al.*, 2019).

Figure 3.17. Multi-criteria assessment of the different environmental, social and economic impacts occurring throughout an animal production chain (Thévenot, 2014).



Box 3.7. Proposal for a conceptual framework for assessing the multifunctionality of livestock grazing systems at the territory level.

Alexandre Ickowicz, Jacques Lasseur, Bernard Hubert, Vincent Blanfort, Mélanie Blanchard, Jean-Daniel Cesaro, Jean-Pierre Müller

Within the framework of an international network on the revalorisation of livestock grazing systems included in the FAO-supported multi-stakeholder platform "Global Agenda for Sustainable Livestock"*, researchers and a group of stakeholders have contributed to the development of an analytical framework and tools aimed at recognising, evaluating and supporting multifunctionality (Hervieu, 2002) and the services provided by livestock grazing systems.

Based on a literature review and participatory workshops involving researchers, livestock organisations, local decision-makers and stakeholders in the sector, we identified the generic and specific impacts and functions associated with livestock grazing. On this basis, we have been able to structure an ontology of the contribution of these grazing livestock systems to sustainable development (Müller *et al.,* 2021) by identifying four dimensions:

- a production dimension,
- an environmental dimension,
- a social dimension,
- a territorial economic development dimension.

The last two dimensions were more specifically developed for the livestock grazing systems, where the socio-economic organisation and cultural traditions, as well as the territorial control of pastures and rangelands are predominant.

Based on this ontology, a conceptual model of the multifunctionality of grassland farming systems was constructed (Figure 3.18) identifying within each of the four dimensions:

- the system elements involved (herd, farmer, industry, plot, atmosphere, soil, etc.),
- the processes/functions describing the impacts,
- and a series of multi-criteria assessment indicators.

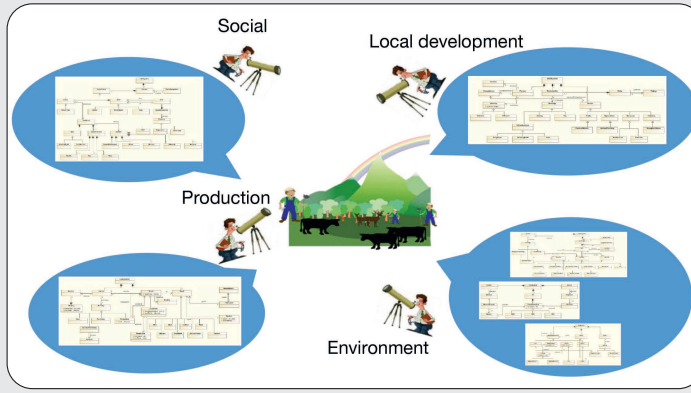
A guide to implementing the method explains the approach, the options for simplification and the possibilities of increasing complexity. It offers an initial series of efficiency indicators (e.g. animal production per hectare used; jobs created per level of production; GHG emissions per hectare used or production level; increase in the mean income per family according to the level of production; number of associations created per level of production; number of infrastructures created within the territory per level of production, etc.). Depending on the scenarios and options chosen, these indicators make it possible to compare and assess the impacts in the four dimensions and to assign them to the SDGs. This approach and these tools have been tested, validated and enriched on 6 pilot sites around the world in various contexts (Argentina, Brazil, France, Mongolia, Senegal, Vietnam;

Box 3.7. Next

Wedderburn *et al.*, 2021; Ickowicz *et al.*, 2022). These have led to the identification of several areas of application at a territorial level: decision-making assistance for the development of livestock or sector models, for the choice of activity priorities in favour of territorial development, assistance in the construction of multidisciplinary research teams, etc. This conceptual model has also led to the development of simulation models. Through several scenarios, either in the form of educational "toy models" or in the form of specific models applied to the field context, their use is intended to facilitate discussion between territorial stakeholders and the identification of compromises to be managed between several options, functions, indicators and impacts.

This approach to the multifunctionality of grazing systems should therefore make it possible to develop a multi-criteria approach based on a systemic analysis of the role of livestock grazing systems within territories that takes into account the interactions and trade-offs between dimensions and indicators. It calls for the mobilisation of a range of disciplines and stakeholders in order to account for the different points of view and interests and to collectively provide options for the sustainable development of their territory.

Figure 3.18. Illustration of the conceptual model of the multifunctionality of livestock grazing systems.



* www.livestockdialogue.org.