Traditional cow-calf systems of the northern region of Santa Fe, Argentina: current situation and improvement opportunities

Sistemas de cría tradicionales de la región norte de Santa Fe, Argentina: situación actual y oportunidades de mejora

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Abstract

Cow-calf systems are at the core of Argentina´s significant national beef industry. The objectives were: i) to characterize the productive state of traditional cow-calf systems, named BASE, from the northern region of Santa Fe province, ii) to identify technologies for the productive improvement of the BASE system, and iii) to quantify the productive and economic impact of the adoption of the identified technologies. To characterize the BASE system, the available published data were systematized and validated in a workshop with leading regional experts in the field. To identify the technologies for improvement, a survey was conducted among regional farm advisors. Finally, to quantify the impact of adopting improvements in the BASE system, a modelling study was conducted. The results showed that traditional cow-calf systems have low productive and reproductive efficiency (45 kg LW ha^{-1} $year^{-1}$ and 48% weaning rate) and little adoption of herd management and forage production technologies. The technologies identified were grazing management, training of farmers and farm staff, and seasonal mating. The modelling study showed that improvements in the production and use of forage and herd management practices would increase beef production and the gross margin of the BASE system by 70% and 96%, respectively.

Keywords
beef production • survey • technologies • simulation • opportunities

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Resumen

Los sistemas de cría son el núcleo de la importante industria nacional de carne bovina de Argentina. Los objetivos fueron: i) caracterizar la situación productiva de sistemas de cría tradicionales, nombrado BASE, del norte de la provincia de Santa Fe ii) identificar tecnologías para su mejora productiva iii) cuantificar el impacto productivo y económico de la adopción de las tecnologías identificadas. Para caracterizar el sistema BASE se sistematizó la información disponible que fue validada en un taller con expertos referentes de la zona. Para identificar tecnologías de mejora, se implementó una encuesta a asesores referentes de la región. Finalmente, para cuantificar el impacto de la adopción de mejoras en el sistema BASE se realizó un estudio de simulación. Los resultados demostraron que los sistemas de cría tradicionales tienen baja eficiencia productiva y reproductiva (45 kg de PV ha^{-1} $año^{-1}$ y 48% de destete, respectivamente) y baja adopción de tecnologías de manejo del rodeo y producción forrajera. Las tecnologías identificadas fueron manejo del pastoreo, capacitación del productor y el personal de campo y estacionamiento del servicio. La simulación demostró que mejoras en producción y uso de forrajes y manejo de rodeo podrían incrementar la producción de carne y el margen bruto del sistema BASE en un 70% y 96%, respectivamente.

Palabras claves
producción de carne • encuesta • tecnologías • simulación • oportunidades

Introduction

The livestock sector faces the challenge of producing food in the context of increasing global demand for meat, which is estimated to increase by 1.6% per year (30). Intensification has been a way to improve productivity and efficiency in the beef production sector and has contributed to an increase in food production since the mid-twentieth century (18, 38). Intensification of livestock systems is defined as an increase in meat and milk production per animal and per area of land (31). In beef production systems, there are mainly two ways of intensification: through the increase in pasture production and supplementation of animals in grazing systems, or through the confinement of animals in feedlots with high feed offers (20).

Argentina produces 3.1 thousand tonnes of beef and ranks fourth among the world's beef-producing and exporting countries (43). Beef production is a relevant activity for the country's economy because it contributes 28.7% of gross domestic income and 11% of private employment within the agricultural industry (14). However, the national average weaning rate (total of weaned calves/ total of cows × 100) is lower (63%) (26) than that in other beef-producing countries such as Australia (70%) (41) and New Zealand (80%) (42). In Argentina, more than 95% of the area used for cow-calf systems is based on natural grasslands (non-cultivated environments), with poor synchronization between forage supply and livestock nutrient demand, reduced control of animal diseases (15), mainly concerning venereal and reproductive diseases (2), and low stocking rates (less than 0.50 cow ha^{-1}) (26), resulting in low productivity, in terms of beef production per hectare (less than 90 kg ha^{-1}) (26).

Buenos Aires province is the main beef-producing region of Argentina, and different studies have evaluated the impact of technological improvements (3, 16), technical assistance on the productivity of systems (33), and pasture production (22), among others. However, for the second most important region in calves´ provision, the northern region of Santa Fe province, which provides 10% of total Argentine calves (26), there is minimal information regarding the characterization of technified systems (21), but none for traditional systems. Therefore, the objectives of the present study were: i) to characterize the productive situation of the traditional cow-calf systems (hereafter BASE system) in the northern region of Santa Fe province, Argentina; ii) to identify technologies for improving productivity based on critical technologies; and iii) to quantify the productive and economic impacts of applying technologies.

Materials and methods

Description of the region

The cow-calf systems analysed in this study are located in the north-central region of Argentina, between 28° to 30° South and 59° to 60° West in the departments of General Obligado and Vera in the province of Santa Fe. This region has approximately 900,000 ha of agricultural use (10). The climate is subtropical with average, minimum, and maximum annual air temperature of 20.1°C, 10.1°C (July) and 28.2°C (January), respectively (23). The average annual rainfall (±SD) (over the last 50 years) is 1,294 ± 310 mm, concentrated in the warmest season (82% between October and April) (24). Predominant soils belong to the Natracualf and Alfacualf groups, with drainage deficiency and saline-sodium conditions (19).

Productive characterization of the traditional systems

Different sources of information (scientific literature, technical reports, national and regional statistics and a workshop with local experts) were used to characterize the traditional (BASE) system in terms of land use, herd management, forage production, and productive efficiency indicators such as stocking rate (cows ha^{-1}), weaning rate (%), and beef production (kg of calves beef ha^{-1} $year^{-1}$ and kg of LW ha^{-1} $year^{-1}$).

Survey design: Identification and ranking of technologies to improve productivity

A digital survey (Google Forms) was designed to identify and rank technologies that could promote the improvement of traditional systems. The project's interdisciplinary team identified most region-based farm advisors and extensionists with recognized expertise in the field (n = 22) and invited them to complete the survey. The survey was structured into 10 questions. Questions 1 to 6 refer to the degree of agreement that advisors had regarding the priority of improvements in forage resources, herd management, productive and economic records, and farm infrastructure. Questions 7 to 10 refer to the technologies that advisors prioritize to improve forage resources, herd management, and farm infrastructure.

To analyze the results, radar charts were created with the average priority for each option. The prioritization patterns for each question were analyzed using principal components analysis. In addition, the relationship between the prioritizations assigned according to expertise background (agriculture or veterinary science) and work environment (private or public) of the respondents was evaluated using ANOVA. Infostat software version 2018 (12) was used for statistical analyses.

Simulation of productive and economic impact of applying technologies

1- Simulation model: The productive and economic impact of the adoption of the identified technologies in the survey described above was quantified through a participatory modelling approach (17) using Baqueano Cría software (40). This deterministic simulation model represents stabilized cow-calf systems and allows for monthly estimations of herd dynamics, forage and energy balance between feed supply and animal requirements, and productive and economic results. The main inputs of this model include herd composition, prices and live weight of cattle categories, monthly availability of forage, and prices of the main inputs (food, health, and labour). The main outputs included beef production (kg LW ha^{-1} $year^{-1}$) and gross margin (U$S ha^{-1}).

2- Simulation of BASE and improved systems: The traditional cow-calf systems, characterized in the present study (objective i) and named as BASE system, were first simulated. It was used as the baseline to simulate three further scenarios, using technologies to improve productivity and economic results (improved systems) (table 1, page 109). Based on the technologies identified as critical by the experts (objective ii of this study), three improved systems were designed (table 1, page 109): +SR+S, which includes increased stocking rate and supplementation with hay (+39% SR and +173% of hay than the BASE), +EFFICIENCY, which includes higher pregnancy rates and lower mortality rates in cows and calves; and finally +SR+S+E system was simulated, which combined the alternatives +SR+S and +EFFICIENCY. It was assumed that the greater pregnancy efficiency was the result of strategic supplementation (2.5 kg of DM of cottonseed and 1 kg of DM sorghum seed cow^{-1} d^{-1} between May and September) due to its incidence on the body condition of

cows (35), and mortality rates were reduced due to better health management, with greater expenses on cow health (+77% compared to BASE).

Table 1. Characteristics of the BASE system and improved systems include: increased stocking rate (+SR), increased reproductive efficiency (+EFFICIENCY) and the combination of both alternatives (+SR+E).

Tabla 1. Características del sistema BASE y sistemas mejorados incluyendo: aumento de carga animal (+SR), aumento de la eficiencia reproductiva (+EFFICIENCY) y la combinación de ambas alternativas (+SR+E).

Variable	Base	+SR+S	+Efficiency	+SR+S+E
Stocking rate, cows/ha	0.30	0.42	0.30	0.42
Pregnancy rate, %	62	62	85	85
Culled cows, %	18	18	5	5
Weaning rate, %	50	50	81	81
Cow mortality rate %	3	3	1	1

3- Productive and economic assumptions: Forage production and utilization for the BASE system were obtained from the database reviewed for objective (i) of this study (table 2), and the same figures were assumed for the improved systems. The mating season was assumed to occur from November to February for all systems.

Table 2. Average forage production (Tn DM ha $^{-1}$ year $^{-1}$) of the traditional cow-calf system of the northern region of Santa Fe province.

Tabla 2. Valores de producción (Tn MS ha^{-1} año^{-1}) de los recursos forrajeros de los sistemas de cría tradicionales del norte de la provincia de Santa Fe.

Environment	Dominant species	Area (ha)	Production (t DM ha $^{-1}$ year $^{-1}$)
Grasslands	*Sorghastrum setosum*	300	5.5
Forest	*Stipa spp.*	210	3.0
Low stratum vegetation	*Leersia hexandra*, *Luziola peruviana*	90	8.3

Economic values are expressed in U.S. dollars (U$S dollars). A cost of US$ 16 cow $^{-1}$ was assumed for animal health. Full-time employees were considered for all farm tasks (180 cows), with a monthly salary of US$744. Herd live weights and farm prices are listed in table 3. The purchase and sale expenses of the different animal categories were 5% and 2% of the price, respectively. The annual gross margin, defined as the difference between net income and direct costs (1), was also simulated, considering the prices of the main products for the region (feed, health, and labour).

Table 3. Herd live weight (kg head $^{-1}$) and farm price (U$S kg $^{-1}$) of different animal categories in a cow-calf system in the northern region of Santa Fe province.

Tabla 3. Peso (kg cabeza^{-1}) y precio (U$S kg^{-1}) de las diferentes categorías en un sistema de cría bovina de la región norte de la provincia de Santa Fe.

Animal class	Live weight (Kg head $^{-1}$)	Price (US$ kg $^{-1}$)
Culling cow	400	1.17
Weaned steer calf	200	2.30
Weaned heifer calf	180	2.09
Heifer	290	1.72
Purchased bulls	900	1.94
Sold bulls	800	0.89

Results and discussion

Productive characterization of the traditional cow-calf system in northern region of Santa Fe

Use of area and forage resources

Three contrasting vegetation environments were differentiated in the region: grasslands, forests, and low-stratum vegetation (27). Such environments are usually found in each farm in proportions of 50%, 35%, and 15% of the total area, respectively (11). The aforementioned diversity of environments poses a challenge for livestock management as they have different herbage mass rates, which implies different grazing management in each environment.

1- Grasslands: It is defined as plant communities dominated by various species where it predominates *Sorghastrum setosum* (Grise.) Hitchc (5, 34). The forage contribution to livestock in these environments varies from 3,000 to 6,000 kg DM ha^{-1}. Other species with high forage value, such as legumes (*i.e.*, genus *Desmodium*, *Desmanthus*, and *Vicia*) and grasses of the genus Paspalum (5), can be found in this environment.

2- Forest: The predominant species in this environment was *Schinopsis balansae* Engl. Plant communities in the forest are dominated by species of the genera *Stipa* and *Piptochaetium* (28). These environments provide forage for cattle in variable quantities and quality (1,000-5,000 kg MS ha^{-1}) according to the state of forest conservation.

3- Low stratum vegetation: These environments are dominated by hygrophilous herbaceous communities dominated by grasses such as *Echinochloa helodes* (Hackel) Parodi, *Leersia hexandra* Sw., and *Luziola peruviana* Juss. Ex J.F. Gmel., with a dry matter production of 6,000 to 8,000 kg ha^{-1} (34).

Improvement of forage production through fertilization or introduction of cultivated species such as perennial pastures or annual forage crops is almost null among the traditional farms in the northern region of Santa Fe province. Cultivated forage species are usually no more than 2% of total area in cow-calf systems some cultivated species are *Avena sativa* L., *Melilotus albus* Medik, *Medicago sativa* L., *Sorghum bicolor* L. Monech and *Chloris gayana* Kunth (6).

Productive and reproductive efficiency and herd management

Mating is continuous throughout the year, with little adoption of herd management and health technologies, such as venereal disease control (13). The age at the first mating is usually greater than 24 months. Supplementation of heifers is carried out occasionally with pasture hay (less than 1 kg DM $animal^{-1}$) in winter and, to a lesser extent, energy concentrates, such as corn and sorghum grains (6). Calve weaning is performed at 8 months of age, the weaning rate is 48%, and beef production is approximately 45 kg LW ha^{-1} $year^{-1}$ (6).

Survey results: opportunities for technological improvement

There was a high level of answers (86% of the invited regional consultants). Respondents were highly experienced experts in veterinary sciences (42%) and agriculture science (58%). The results are presented in table 4 (page 111) and figure 1 (page 112). Priority given to improve herd management was higher for professionals working in the private sector ($p < 0.05$), and in general, answers for each aspect (forage supply, herd management practices, and farm infrastructure) were independent of the career and the field of work of the respondents ($p > 0.05$).

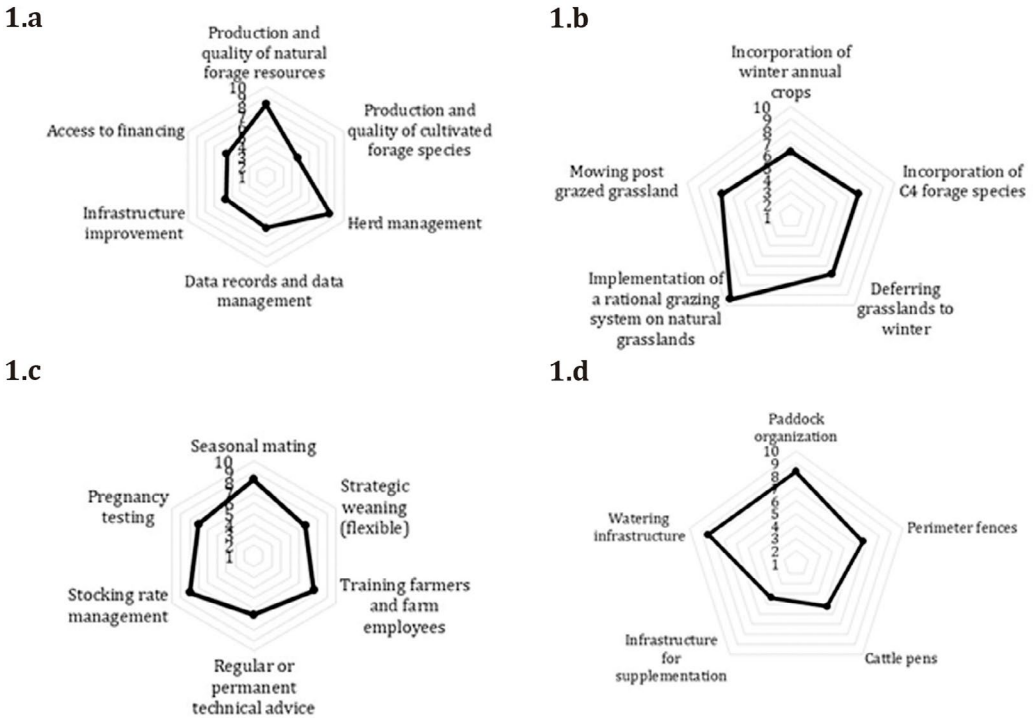
Table 4. Questions 1 to 6 used in the survey to regional farm advisors and answers.
Tabla 4. Preguntas utilizadas en la encuesta a asesores referentes y respuestas.

Questions	Possible answers	Answers
Do better and more precise information on the production and quality of NATURAL forage resources be prioritized for the improvement of cow-calf systems?	Disagree	0.0%
	Little agree	5.3%
	Quite agree	21.1%
	Strongly agree	15.8%
	Totally agree	57.9%
Do better and more information on production and quality of cultivated forage species be a priority for the improvement of cow-calf systems in northern?	Disagree	0.0%
	Little agree	21.1%
	Quite agree	26.3%
	Strongly agree	47.4%
	Totally agree	5.3%
Do herd management (health, seasonal mating, pregnancy diagnosis, and weaning management) be a priority for the improvement of cow calf systems?	Disagree	0.0%
	Little agree	0.0%
	Quite agree	5.3%
	Strongly agree	36.8%
	Totally agree	57.9%
Are productive or economic records priorities for the improvement of cow-calf systems?	Disagree	0.0%
	Little agree	0.0%
	Quite agree	26.3%
	Strongly agree	36.8%
	Totally agree	36.8%
Do you think that farmers make little use of the available records?	Disagree	0.0%
	Little agree	0.0%
	Quite agree	15.8%
	Strongly agree	36.8%
	Totally agree	47.4%
Are infrastructure improvements a priority for the improvement of cow-calf systems?	Disagree	0.0%
	Little agree	5.3%
	Quite agree	47.4%
	Strongly agree	10.5%
	Totally agree	36.8%

Productive and economic impact of technological improvements

The results of the modelling studies are shown in figure 2 (page 112). All three improved systems resulted in higher beef production and a higher gross margin than those of the BASE system. The +SR+S+E alternative showed an increase of 70% and 96% in beef production and gross margin, respectively, compared with the BASE system, despite showing higher direct costs (figure 2, page 112). These results agree with previous simulation studies (16, 17) conducted in other regions of Argentina, which showed that the combination of increased SR increased supplementation, and better reproductive management (similar to +SR+S+E in this study) would increase productive and economic results to a greater extent than if they are implemented as sole alternatives.

A change in stocking rate directly influences income as it correlates with the growth of livestock capital. However, it's essential to note that the economic efficiency of agricultural systems can be significantly influenced by factors beyond the scope of this study, such as the land tenure regime (39).



Priority in: (1.b.) forage supply, (1.c.) herd management, (1.d) infrastructure.

Prioridad en: (1.b.) oferta forrajera, (1.c.) manejo del rodeo, (1.d.) infraestructura.

Figure 1. Technologies prioritized by advisors, (10 maximum, 1 minimum). (1.a.) Priority of potential technological improvements.

Figura 1. Tecnologías priorizadas por los asesores, (10 máximo, 1 mínimo). (1.a.) Prioridad de mejoras tecnológicas potenciales.

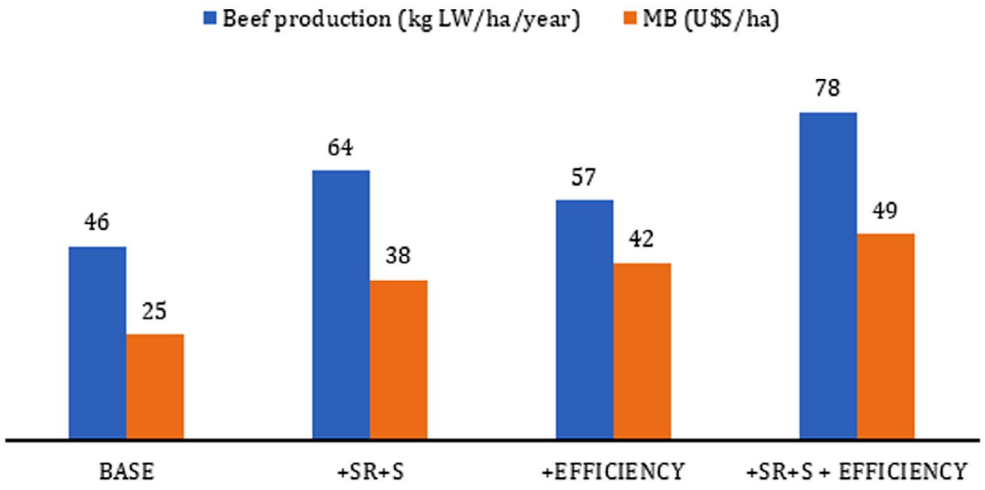


Figure 2. Beef production (kg LW ha^{-1} $year^{-1}$) and gross margin (MB, US$ ha^{-1} $year^{-1}$) of BASE system and improved alternatives.

Figura 2. Producción de carne (kg PV ha^{-1} $año^{-1}$) y margen bruto (MB, U$S ha^{-1} $año^{-1}$) del sistema BASE y las alternativas mejoradas.

Table 5 shows previous studies and compares the contrasting productive parameters between the traditional system and existing top technological systems (high use of technologies) in the same region (21). The productive potential of current top cow-calf systems (those having greater technological adoption and management skills compared to traditional farmers in the region) in this region has been recently estimated (21) and the technological gap with the BASE system is 86% in beef productivity (kg/ha/year) and 44% in weaning rate (table 5). This difference is based on the application of technologies that increase forage supply (greater area of cultivated pastures and annual forage crops) and improve herd management techniques, such as greater supplementation of cows, higher stocking rate, seasonal mating, and shorter age for first mating and weaning applied in the top systems compared to the traditional systems.

Table 5. Productive differences between the traditional and top cow-calf systems of the northern region of Santa Fe province.

Tabla 5. Diferencias productivas entre sistemas tradicionales y tecnificados de la región norte de la provincia de Santa Fe.

Productive Variables	Unit	traditional system	Top system (21)
Stocking rate	cows ha $^{-1}$	0.30	0.46
Weaning rate	%	48	69
Calf beef production	Kg LW ha $^{-1}$ year $^{-1}$	29	51
Beef production	Kg LW ha $^{-1}$ year $^{-1}$	45	83
Grasslands area	% of total area	100	90
Area with cultivated species	% of total area	0	10
Age at first mating	month	27-36	27
Mating strategy		Continuous	Seasonal (4 months)
Weaning age	Months	8	6

Fernandez-Rosso *et al.* (2020) reported 63% more beef production and 340% higher gross margin in systems that combined herd management technologies such as early weaning (2 to 4 months) and implantation of cultivated forage species, in the southwest of Buenos Aires province, compared with traditional systems of that region.

Data available from net aerial primary productivity (NAPP) and the quality of forage available in the region under study are mainly reported for cultivated pastures (32, 36). The productive and economic simulations carried out in this study were based on NAPP data of natural forage resources using a combination of unpublished data of forage cuts validated by experts (table 2, page 109). However, alternative methodologies that allow for the estimation of NAPP have been applied with promising results in other regions of Argentina, such as the green index (22), simulation models (4), and regression equations for forage cuts (17), and could be used in future studies.

In the northern region of Santa Fe Province, there have been several public policies aimed at assisting farmers in improving the productive efficiency of cow-calf systems through subsidized loans and farm advisory support by applying and monitoring health, nutritional, and reproductive management technologies (7, 29). However, the low adoption of technologies and the current low productive and reproductive efficiency (table 5), which have remained stable for years (8, 9), reflect the low effectiveness of those policies. This situation encourages a deeper understanding of the causes of farmers' scarce technological adoption. In other important beef cattle breeding regions of the country, barriers to the adoption of technologies in farming systems are mentioned. In cow-calf system studies located in Buenos Aires province, it has stood out (17, 35) as adoption barriers of technology in the cattle breeding systems of that region due to a lack of training in process technologies, the absence of suitable public policies for the region, and the producers' partial dedication to the activity. Additionally, barriers related to the lack of agricultural vocation among heirs and the absence of technical assistance in low-tech systems have also been described (17).

The applied participatory modelling methodology (17) provided preliminary information and a "what if" analysis (25) of this important productive area. However, the productive characterization of cow-calf traditional systems carried out in this study will require additional research to refine farm information and to define barriers to technological adoption in breeding systems in northern Santa Fe. This understanding might aid in the better design of public policies, which should include the social and cultural conditions of farmers (37). This methodology was also key to the conservation and sustainable development of livestock systems in other countries (44).

Conclusions

We combined the available scarce data on traditional cow-calf systems in the northern region of Santa Fe Province with the qualified knowledge provided by highly experienced farm advisors, in order to establish a benchmark and to identify challenges for future studies. Experts prioritized the improvement of forage supply and herd management to increase the productivity of cow-calf systems. Implementation of a rational grazing system for grasslands, training the farmer and farm staff on herd management, and seasonal mating were the factors selected to be adopted in the first place. The modelling study showed that increased SR, higher supplementation and higher reproductive efficiency increased production and economic results by 70 and 96%, respectively. The participatory modelling methodology applied also allowed us to identify areas in which greater research efforts are needed, such as more precise research information on farm characterisation, forage production and quality, and farmers' constraints for technological adoption, which will be relevant inputs for designing and promoting effective policies for the livestock sector.

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