Business model brief

RESEARCH PROGRAM ON Livestock

CGIAR

Photo Bioversity International and CIAT/Neil Palmer

Economic benefits of sustainable, forage-based cattle systems in Latin America

KEY MESSAGES

- Integrating improved forage varieties in sustainably intensified cattle systems is economically viable in most cases.
- By this, the net incomes of the production systems, unit profit margins, Net Present Value, benefit-cost ratio, and Internal Rate of Return can be increased, while the unit production costs, risk of economic loss, payback times, and sensitivity to external shocks (e.g., price and yield fluctuations) decrease.
- The integration of improved forage varieties in sustainably intensified cattle systems can lead to a triple-win situation:

  1) Increased food security, through more beef and dairy products available at reduced prices,
  2) Improved system efficiency and resilience reduce environmental impacts, and
  3) Better livelihoods through more economic benefits reaching producers directly.

SUMMARY

This brief provides an overview of selected economic evaluations of integrating improved forages into cattle production systems in Latin America, particularly in Colombia and Nicaragua. Economic indicators, such as Net Present Value (NPV) and Internal Rate of Return (IRR), were estimated through the application of discounted cash flow models for a broad range of forage interventions in different setups, e.g., as grass monocultures, silvo-pastoral systems, grass-legume associations or as silage. Sensitivity analyses were carried out to estimate the impact of external variables on the profitability of the suggested interventions. Results show that in most cases it is economically viable to invest in improved forages, independent of farm size or type or setup. This information is key for incentivizing cattle producers to adopt more sustainable and productive alternatives, which help increase resilience while reducing vulnerability and environmental impacts.

A smallholder dairy producer in Colombia.
Photo Alliance of Bioversity and CIAT/Neil Palmer

Alliance

Bioversity International

CIAT
International Center for Tropical Agriculture
Since 1967 Science to cultivate change

THE CHALLENGE

Forage-based cattle systems play a key role in rural economies of developing countries in terms of food security and poverty alleviation, particularly in tropical Latin America. However, they are often related to being a major cause of negative environmental impacts by contributing to increased greenhouse gas emissions, land degradation and reduction of biodiversity.

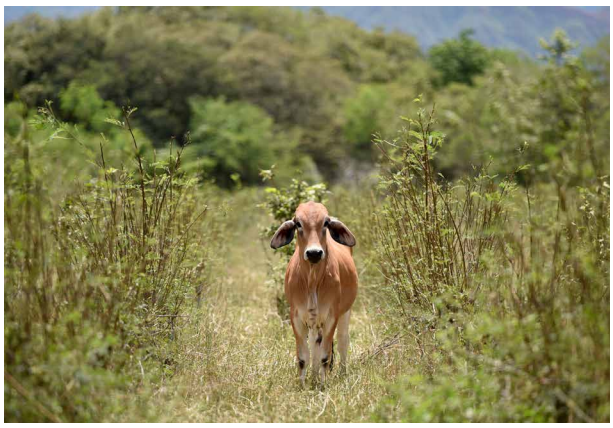
Significant resources have been allocated to research and development in forage material improvement, including selection and breeding. A broad range of improved materials were released by private and public sector actors showing superior characteristics in terms of productivity and environmental impacts compared to native or naturalized materials. Profitability is a fundamental attribute to incentivize or generate adoption of new systems by cattle producers, but this information is often not available to the livestock producer or the extension agents supporting decision-making processes.

The brief provides an overview on the economic viability of integrating improved forage varieties in sustainably intensified cattle production systems in Latin America. This information will help cattle producers, extensionists and policymakers to make more holistic and informed land-use decisions that include productive, environmental, economic, and social benefits.

DESCRIPTION OF THE BUSINESS MODEL

The business model evaluated during the CGIAR Research Program on Livestock (CRP) is the sustainable intensification of cattle systems with improved forage technologies (and management strategies) in Latin America. Previously, evaluation was focused on the agronomic (and environmental) performance in cattle systems but now a description of the economic benefits of integrating improved forage technologies is also provided.

Improved animal feeding is one step towards a more sustainable food system. Photo U.S. Department of Agriculture (CC-BY). Source: https://flickr.com/photos/usdagov/8411827143/



Silvo-pastoral system in Colombia. Photo Alliance of Bioversity and CIAT/Neil Palmer

WHAT DID WE EVALUATE?

In 2017, the Feeds and Forages Flagship Program of the Livestock CRP started economic evaluations of integrating different improved forage varieties in sustainably intensified cattle production systems in Latin America, principally in Colombia and Nicaragua. The aim was to provide cattle producers, extensionists and policymakers with economic viability indicators that help in land-use and adoption decision making processes. In a first step, a basic methodology for the economic analysis of forage-based cattle systems was developed, which then was adjusted and applied in several case studies throughout the lifespan of the CRP.

Several production systems were evaluated, i.e., dual-purpose production, calf fattening and specialized milk production, which integrate improved forages in different setups, such as grass monocultures, silvo-pastoral systems, grass-legume associations or as silage. In some contexts, the forage interventions were coupled with management strategies, such as intensive rotational grazing. In each case, the improved systems were compared with the most prominent traditional systems in each region (base scenario).

The economic analyses were based on a discounted cash flow model and the estimation of profitability indicators, such as the Net Present Value (NPV), Internal Rate of Return (IRR) and the probability of success of an investment (NPV<0). For this purpose, we applied a Monte Carlo simulation model which performed 5,000 iterations with a confidence level of 95% for each of the evaluated systems. Additionally, sensitivity analyses were incorporated to evaluate the influence of critical variables (e.g., price fluctuations and yield fluctuations) on the profitability indicators. These economic indicators help in comparing different investment projects and choosing the best alternative.

Our evaluations comprised a broad range of production systems and technological interventions in two countries: Colombia (evaluation per hectare) and Nicaragua (evaluation per typical farm). **Table 1** shows some examples of the evaluated technologies and the traditional scenarios used for comparison for Colombia.

Table 1. Some examples of evaluated interventions in Colombia

Colombia – Orinoco Region			
Scenario	**Traditional scenario**	**Intervention scenario**	
System	Dual-purpose milk system	Dual-purpose milk system	
Evaluated technologies	Grass monoculture: *Brachiaria humidicola* cv. Humidicola	Grass-legume association: *Arachis pintoi* CIAT 22160 cv. Centauro + *Brachiaria humidicola* cv. Humidicola	
Colombia – Orinoco Region			
Scenario	**Traditional scenario**	**Intervention scenario**	
System	Cattle raising and fattening	Cattle raising and fattening	
Evaluated technologies	Grass monoculture: *Brachiaria decumbens*	Grass monoculture: *Brachiaria brizantha* 26124 cv. Agrosavia Caporal	
Colombia – lower-altitude tropics (0-1,200 m elevation)			
Scenario	**Traditional scenario**	**Intervention scenario**	
System	Cattle fattening	Cattle fattening	
Evaluated technologies	Grass monoculture: *Brachiaria hybrid* cv. Cayman	Grass-legume association/silvo-pastoral system: *Brachiaria hybrid* cv. Cayman + *Leucaena diversifolia* ILRI 15551	
Colombia – Orinoco Region			
Scenario	**Traditional scenario**	**Intervention scenario**	
System	Cattle fattening	Cattle fattening	
Evaluated technologies	Grass monoculture: Native Savanna species such as *Axonopus Purpussi*	Grass monoculture – improved pastures: *Brachiaria humidicola, Brachiaria decumbens*	Silvo-pastoral system: Improved pastures such as *Brachiaria humidicola, Brachiaria decumbens* associated with shadow trees
Colombia – high-altitude tropics (>2,200 m elevation)			
Scenario	**Traditional scenario**	**Intervention scenario**	
System	Specialized milk production	Specialized milk production	
Evaluated technologies	Grass monoculture: *Cenchrus clandestinus*	Silage-grazing diet: 65% *Cenchrus clandestinus* + 35% Avena sativa AV25-T cv. Altoandina	Silage-grazing diet: 35% *Cenchrus clandestinus* + 65% Avena sativa AV25-T cv. Altoandina

Beef cattle grazing improved forages in Colombia.
Photo Alliance of Bioversity and CIAT/Neil Palmer

Smallholder dairy farmer in Latin America.
Photo Alliance of Bioversity and CIAT/Neil Palmer

WHAT DID WE FIND OUT?

Our evaluations show that, despite higher establishment and management costs, integrating improved forage technologies (and management practices) in sustainably intensified cattle systems not only make sense from the environmental and productive perspectives but also in terms of economic viability. In nearly all evaluated scenarios, the economic indicators improve by integrating improved forage technologies.

Colombia

In the Colombian Orinoco region economic indicators significantly improve when the traditional grass monoculture system with *Brachiaria humidicola* cv. Humidicola gets transformed into a grass-legume association with Arachis pintoi CIAT 22160 cv. Centauro in a dual-purpose milk system. The net income of the system, milk profit margin, Net Present Value (NPV) and Internal Rate of Return (IRR) all increase, while the unit cost of milk and calf production and the risk of obtaining economic loss decrease. The system also becomes less sensitive to changes in milk productivity.

In cattle raising and fattening systems, also in the Orinoco region, the transformation from a grass monoculture with *Brachiaria decumbens* to a grass monoculture with *Brachiaria brizantha* 26124 cv. Agrosavia Caporal leads to increased net system income, increased NPV and IRR, while the unit cost of beef production decreased. The system itself becomes less sensitive to beef market prices.

In a cattle fattening system, also in the Orinoco region, evaluation focused on the transformation from a grass monoculture with native savanna (*Axonopus purpussi*) to a grass monoculture with the improved forages *Brachiaria humidicola* and *Brachiaria decumbens* on the one hand, and to a silvo-pastoral system with the same forages and associated shadow trees on the other hand. In both intervention scenarios, the economic indicators improve compared to the traditional scenario. Nevertheless, from an economic point of view, it makes more sense investing in the improved grass monoculture than the silvo-pastoral system, since the economic viability indicators show a significantly better performance for this case. Both the NPV and the IRR increase substantially and the risk of obtaining economic loss decreases.

In a more general evaluation for a cattle fattening system in the Colombian lower tropics (0-1200 m elevation), we evaluated the transformation of a grass monoculture with *Brachiaria hybrid* cv. Cayman into a silvo-pastoral system where the legume *Leucaena diversifolia* ILRI 15551 is included. This transformation also changes the economic performance of the system, significantly increasing the net income, NPV, IRR and benefit-cost ratio, while reducing the risk of obtaining economic loss, the length of the payback period and the minimum area required to have a profitable system. Likewise, the system becomes less sensitive to beef market prices.

In a specialized milk production system in the Colombian high-altitude tropics (>2,200 m elevation), we evaluated the inclusion of silage supplementation (*Avena sativa* AV25-T cv. Altoandina) in two different percentages (35 and 65% of the total diet) in a grass monoculture grazing system with *Cenchrus clandestinus*. Although both evaluated supplementation diets are economically viable, especially when compared to the grass monoculture, the diet with only 35% silage supplementation shows the best economic performance: it more than doubles the net income of the system, increases the unit profit margin, more than doubles the NPV and increases the IRR when compared to the grass monoculture. At the same time, the unit cost of milk production is reduced, the risk of obtaining economic loss drops to 0%, and the system becomes less sensitive to milk productivity indicators.

Dairy producer in Colombia. Photo Alliance of Bioversity and CIAT/Neil Palmer

Nicaragua

In Nicaragua, we evaluated a mix of integrating improved forage technologies and management strategies in a milk and calf fattening system at different farm scales (smallholder, medium- and large-scale) in different regions of the country. The evaluations comprised the reduction of the overall pasture area, mainly through reducing the use of naturalized improved pastures, the introduction of cut-and-carry forages, protein banks and living fences, as well as intensive rotational grazing. A side effect of the presented intervention scenarios is the maintenance or increase of the farm forest area.

In the "Vía Láctea" (the Nicaraguan milkyway) and the "Dry Corridor" regions, the suggested interventions lead to increases in the net income of the system, higher unit profit margins, higher NPV and IRR, for all evaluated farm types. At the same time, the unit cost of milk production decrease to 30-50% of the costs associated with the traditional production system.

CASE STUDY : ESTABLISHING A SILVO-PASTORAL SYSTEM IN THE COLOMBIAN LOWER-ALTITUDE TROPICS (0-1200 M ELEVATION)

The profitability of including ***Leucaena diversifolia***, accession ILRI 15551 in a Colombian beef cattle production system was evaluated. The evaluation was based on data from a grazing experiment comparing a grass-legume association/silvo-pastoral system (***Brachiaria hybrid*** cv. Cayman and ***Leucaena diversifolia***) with a traditional grass monoculture (***Brachiaria hybrid*** cv. Cayman) in the Colombian lower-altitude tropics (0-1,200 m elevation), both with the purpose of beef production. A discounted cash flow model was used, developed with the simulation software @Risk, which considers inherent risk and uncertainty factors in these types of rural investment projects, under three different pasture degradation scenarios.

The results indicate that the inclusion of ***Leucaena diversifolia*** is financially profitable and substantially improves the associated risk and performance indicators. Profitability indicators increased in a range of 15–110%, and the probability of obtaining economic loss decreased from 72% to 0% (see Table 2). The results are directly related to the increases in animal productivity (49%) and efficiency resulting from including the legume. This shows that ***Leucaena diversifolia*** has significant potential to increase both animal production and profitability, which is conducive to the sustainable intensification of beef production in grazing systems.

Table 2. Establishing a silvo-pastoral system in Colombia – economic indicators

Colombia – lower-altitude tropics (0-1,200 m elevation)		
Scenario	Base scenario	Intervention scenario
Evaluated technologies	Grass monoculture: Brachiaria hybrid cv. Cayman	Grass-legume association/ silvo-pastoral system: *Brachiaria hybrid* cv. Cayman + *Leucaena diversifolia* ILRI 15551
Net income system (US$ ha-1 y-1)	356	695
Unit cost of beef production (US$ kg-1)	1.2	1.21
NPV (US$)	(473)-(288)	1,716-2,055
Prob NPV<0 (%)	72	0
IRR (%)	10-11	21-22
Payback period (years)	6	4
B/C ratio	0.96-0.98	1.12-1.13
Minimum area required to have a profitable system (ha)	6.54	3.76
Sensitivity	n/a	Reduced sensitivity to beef sales price
SUGGESTED DECISION	REJECT BASE SCENARIO	ADOPT INTERVENTION

Providing cattle producers with such information is a first step towards overcoming barriers to technology adoption, i.e., towards decreasing the misconception by producers that there are limited benefits from planting pasture legumes. However, for broader adoption to occur, providing this type of information on its own is not sufficient; improvements in the framework conditions are also needed. The establishment of such systems should be accompanied by specific training and extension programs, which in many cases would need to be developed, to overcome the lack of knowledge and experience in the use of tropical forage legumes. This should reduce uncertainties associated with technology adoption and increase adoption rates. At the same time, the access to and structure of necessary financial resources (e.g., credits), as well as the availability and access to seed or vegetative material, need to be improved to provide the necessary resources for technology adoption. This holds true especially for Colombia, where credit schemes do not respond to the producer reality (i.e. no credits available for pasture improvement, too short grace periods in livestock credits) and where a well-functioning legume seed system is non-existent.

Improved forages vs. naturalized forages.
Photo Alliance of Bioversity and CIAT/Neil Palmer

LESSONS LEARNED

Integrating improved forage varieties in sustainably intensified cattle systems is economically viable in the evaluated cases. In particular, they help to:

- ☑ Increase the net income of the production system
- ☑ Reduce unit production costs, so a liter of milk or a kilogram of meat can be produced cheaper
- ☑ Increase unit profit margins, so the profit per liter of milk or kilogram of meat produced is higher
- ☑ Increase the Net Present Value to ensure the investment is economically viable
- ☑ Increase the Internal Rate of Return so that profitability is increased
- ☑ Reduce the risk of obtaining economic losses to ensure economic security is provided
- ☑ Increase the benefit-cost ratio above one, so that for every dollar invested, more than one dollar will be returned
- ☑ Reduce the payback time, so the system generates economic gains earlier
- ☑ Reduce the minimum area required for a profitable system, which means that less area is needed for obtaining the same results and that the remaining area can be used for other purposes (e.g., environmental protection or crop cultivation)
- ☑ Reduce the sensitivity of the system to external shocks such as price and yield fluctuations

> "Before using improved forages, productivity was very low and we would only get 4 liters of milk per day to sell. Today, we reach 130 liters per day. From earning 30,000 Colombian Pesos [<10 USD] every two weeks from the sale of milk, today, we earn 1.5 million Colombian Pesos in the same period. One really sees that there is a difference."
>
> **Patricia Ulloa and Jesús Velasco, beef and dairy farmers, Colombia**

> "I am very happy, very satisfied with the results so far. Although we are in a prolonged period of drought, we still have abundant plant material. Before the change to improved forages, I used to keep between 1 and 1.5 cattle per hectare, now, I have managed to surpass that by keeping 3 to 4 cattle on the same area. This has helped to increase the profitability of my farm."
>
> **Tito Ángulo, beef and dairy farmer, Colombia**

IMPLICATIONS AND RECOMMENDATIONS

Our results show that by integrating improved forages, either as monoculture, grass-legume associations, silvo-pastoral systems, or in combination with improved management strategies (e.g., intensive, or rotational grazing), cattle producers can increase the resilience of their systems, reduce their vulnerability to external shocks and increase their livelihoods. This becomes even more relevant when climate change is considered since traditional production systems are more vulnerable to seasonal forage biomass availability, which is strongly influenced by drought or excessive water availability.

The integration of improved forages helps to counteract this and to achieve a more stable productivity throughout the year. Likewise, improved forages are more resistant to pests and diseases that can cause productivity declines and affect economic returns. By integrating improved forages, the land used for beef and dairy production can be reduced because of the higher productivity, without a reduction in economic returns. This provides new possibilities, e.g., for afforestation, conservation, or crop cultivation, which can help to mitigate climate change, increase biodiversity, and reduce hunger, among other. Improved forages also provide numerous ecosystem services that could be monetized and further increase the economic viability of the systems. We recommend including potential ecosystem services into future economic evaluations of tropical forage-based cattle systems in Latin America.

Despite the presented examples in this brief, economic evaluations of interventions in tropical cattle systems are still scarce. They are nonetheless important when it comes to deciding on whether to adopt a technology or support its dissemination. It is thus essential that these studies are extended and included from the start in research projects dealing with the selection or breeding of improved forages and their introduction into cattle systems.

Acknowledgements

This work was supported by the CGIAR Research Program on Livestock, "Feed and Forages Flagship" and implemented by the Alliance of Bioversity International and CIAT. Part of this work was done in collaboration with the Colombian NARS AGROSAVIA.

Learn more

Burkart, S. and Enciso, K. 2017. Metodología para análisis de evaluación financiera de tecnologías forrajeras. Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia. 21p. https://hdl.handle.net/10568/102376

Enciso, V.K.J., Castillo Sierra, J., Albarracín Arias, L.O., Campuzano Duque, L.F., Sotelo Cabrera, M.E. and Burkart, S. 2021. Avena sativa AV25-T (Altoandina) supplementation as alternative for Colombia's high-altitude dairy systems: an economic analysis. *Frontiers in Sustainable Food Systems* https://doi.org/10.3389/fsufs.2021.758308

Enciso, K., Castillo, J., Burkart, S., Avellaneda, Y., Vargas, J., Campuzano, L.F. and Mejía, S.L. 2020. Evaluación económica de la avena forrajera Altoandina para sistemas lecheros del trópico alto de Colombia. Mosquera (Colombia): Editorial Agrosavia. 28p. https://hdl.handle.net/10568/111083

Enciso, K., Charry, A., Rincón, A. and Burkart, S. 2021. Ex-ante evaluation of economic impacts of adopting improved forages in the Colombian Orinoquía. *Frontiers in Environmental Science* 9(673481). https://doi.org/10.3389/fenvs.2021.673481.

Enciso, K., Rincón, A., Ruden, A. and Burkart, S. 2021. Risk reduction and productivity increase through integrating Arachis pintoi in cattle production systems in the Colombian Orinoquía. *Frontiers in Sustainable Food Systems* 5(666604). https://doi.org/10.3389/fsufs.2021.666604.

Enciso, K., Sotelo, M., Peters, M., Burkart, S. 2019. The inclusion of Leucaena diversifolia in a Colombian beef cattle production system: An economic perspective. *Tropical Grasslands-Forrajes Tropicales* 7(4): 359–69. https://doi.org/10.17138/TGFT(7)359-369.

Rincón, A., Bueno, G., Díaz, R., Burkart, S., Enciso, K. 2020. Cultivar Centauro (Arachis pintoi 22160) Leguminosa forrajera para sistemas de ganadería sostenible. Colombia (Mosquera): Editorial Agrosavia. 28p. https://hdl.handle.net/10568/111087

van der Hoek, R., Mena, M., López, M. and Wiegel, J. 2019. Business as Usual (BAU) and Feasibility Study Silvopastoral Systems Buffer Zones Bosawás and Indio Maíz. International Center for Tropical Agriculture, Managua, Nicaragua. 39p. https://hdl.handle.net/10568/106874

CONTACTS

Stefan Burkart, Alliance of Bioversity International and CIAT / s.burkart@cgiar.org

Karen Enciso, Alliance of Bioversity International and CIAT / k.enciso@cgiar.org

Rein van der Hoek, Alliance of Bioversity International and CIAT / r.v.d.hoek@cgiar.org

Manuel Díaz, Alliance of Bioversity International and CIAT / m.f.diaz@cgiar.org