frontiers in Sustainable Food Systems

ORIGINAL RESEARCH
published: 11 March 2022
doi: 10.3389/fsufs.2022.722522

Public Policies for the Development of a Sustainable Cattle Sector in Colombia, Argentina, and Costa Rica: A Comparative Analysis (2010–2020)

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Projected food demand increases highlight the importance of Latin America as one of the big global future food suppliers, due to its agricultural potential, in particular regarding cattle farming. Despite the importance of the cattle sector for the region, its negative environmental impacts are numerous and the shift toward sustainability is perceived as slow and uncoordinated. This study aims at identifying successes and difficulties in the implementation of public policies for a sustainable cattle sector in Colombia, Argentina, and Costa Rica. Based on the review of scientific articles, government reports, and publications of international organizations, a qualitative comparative analysis was carried out, documenting the political developments between 2010 and 2020. Our findings suggest that public policies mainly focus on the reduction of greenhouse gas emissions and the implementation of silvo-pastoral systems. Common successes exist among the three countries, e.g., a large number of public policies for promoting sustainable cattle farming or the inclusion of goals to reduce greenhouse gas emissions and implement silvo-pastoral systems, but they also coincide in difficulties, e.g., disconnection between policies and the lack of continuity of development programs. The efforts made with regional and national public policies, in addition to legislative advances, can be seen as initial steps in a long-term process toward sustainable cattle farming, and thus, recommendations are provided for increasing their success at different stages, from the identification of the problem to its evaluation, particularly in the face of financing difficulties, disconnection among policies and initiatives, and participation of citizens and livestock producers.

Keywords: public policies, sustainable intensification, cattle, silvo-pastoral systems, climate change

OPEN ACCESS

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Specialty section:
This article was submitted to Climate-Smart Food Systems, a section of the journal Frontiers in Sustainable Food Systems

Received: *08 June 2021*
Accepted: *11 February 2022*
Published: *11 March 2022*

Citation:
Lerma LM, Díaz Baca MF and Burkart S (2022) Public Policies for the Development of a Sustainable Cattle Sector in Colombia, Argentina, and Costa Rica: A Comparative Analysis (2010–2020). Front. Sustain. Food Syst. 6:722522. doi: 10.3389/fsufs.2022.722522

INTRODUCTION

Framework of Reference

Latin America and the Caribbean plays an essential role in the global cattle industry since it contributes with more than 25% to the global beef and 10% to the global milk supply (CEPAL, 2017). The cattle sector generates both external and internal benefits, as it supports both the region's and global food security and contributes to the economy of the countries, highlighting the need to increase the efforts to preserve the growth of the sector (Núñez et al., 2015). Cattle production in the region not only goes back a long way, but also appears to be facing a promising future.

The Inter-American Development Bank (BID, 2018) projects a growth in global meat production by 100% until 2050, considering the global population growth—a scenario that would favor Latin American cattle producers due to the region's geographical position, experience, and human and natural resources.

Despite the importance of the sector for the region and its growth potential, the environmental effects of traditional or conventional cattle production systems are multiple and include e.g., impacts on water sources, soil resources, a loss of biodiversity and greenhouse gas emissions (IDB, 2018). The principal greenhouse gases generated by the cattle sector are methane (CH_4), produced in the enteric fermentation process of cattle, carbon dioxide (CO_2), resulting from land-use and land-use changes, and nitrous oxide (N_2O), emitted during manure and slurry management (Rao et al., 2015). The cattle sector contributes significantly to global warming and climate change because of deforestation for feed and forage crops, degradation of pastures and greenhouse gas emissions from cattle production (Abbasi et al., 2015).

This has led to discussions about the transition from a conventional to a sustainable cattle sector. A *sustainable cattle sector* is characterized as economically viable for farmers, respectful of the environment, and socially accepted (Varijakshapanicker et al., 2019). Related to this is the concept of *sustainable intensification*, understood as an approach that uses innovations to strengthen agricultural productivity, while reducing the environmental footprint (e.g., greenhouse gas emissions), promoting ecosystem services (e.g., soil quality improvements, reduced erosion, increased biodiversity) and supporting social development of rural communities (Rao et al., 2015).The challenge is to provide quality food for a growing human population, while managing to reduce the negative environmental impacts caused by food production (Tedeschi et al., 2015). In this regard, sustainable intensification is not reduced to specific practices, but rather involves heterogeneous processes and therefore, its implementation requires adjusting to the different agricultural systems and socioeconomic conditions of the target populations (Xie et al., 2019).

To achieve sustainable intensification, it is necessary to implement a broad set of different actions and innovations, such as the use of environmentally responsible technologies, the implementation of silvo-pastoral systems, or good animal husbandry practices, among others (Departamento Administrativo Nacional de Estadística, 2015). *Silvo-pastoral systems* are defined as the integrated use of grasses, legumes, forage shrubs and trees in livestock production systems. There exist different types of them, which include e.g., trees in pastures (living fences, scattered trees, and forest area), protein banks and shrubs, or the integration of fruit and timber trees. The benefits of silvo-pastoral systems are diverse and range from productivity increases (more forage biomass and higher nutritional quality), animal welfare (e.g., reduced heat stress, better diet), income increases and diversification (e.g., more meat and milk, fruits or timber), to environmental benefits such as better rainwater capture, soil protection and recovery, biodiversity conservation, and greenhouse gas emissions reductions, among others (IICA y Ministerio de Agricultura de la República Dominicana, 2016; Buitrago Guillen et al., 2018). Murgueitio et al. (2014) add that the presence of trees and shrubs contributes to mitigating climate change through mechanisms such as increased carbon deposits in the soil and lower nitrogen losses. They also state that the use of silvo-pastoral systems can increase beef production levels by 12 and 4.5 times, compared to extensive grazing and improved pastures without trees, respectively, while methane emissions per unit beef product are 1.8 times lower.

The implementation of such actions or innovations requires the commitment of different actors along the beef and dairy value chains, service providers (e.g., for credit, extension), and, above all, the support from the public sector. In this regard, this study differentiates between *governmental policies* and *public policies*. *Governmental policies* are all the actions carried out by a government at different levels (e.g., national, departmental, or municipal) in response to social problems, without considering citizen participation. *Public policies*, although part of the previous ones, are more complex processes that involve a strong intervention of the communities and involve four stages: (i) identification of the problem, (ii) design of the policy, (iii) implementation, and (iv) evaluation (Arias and Herrera, 2012). Yalmanov (2021) delves into this differentiation by pointing out that public policies cannot be reduced to a technical function of governments, but rather are complex dynamics influenced by socio-political forces that alter both processes and results. Likewise, it is necessary to consider the existence of individuals and groups that try to shape public policies in search of their particular interests, thus constituting a power struggle (Cochran and Malone, 2014).

To understand how governments support and manage such processes, it is necessary to have an in-depth look at how they have responded to social demands in the past, i.e., through the implementation of policies. This is precisely the objective of this article: to identify successes and difficulties in the implementation of public policies for the development of a sustainable cattle sector in Colombia, Argentina, and Costa Rica between the years 2010–2020. The selection of these countries takes into consideration that they present different social and economic realities, which allows for a comparative analysis. The countries were also selected because of the strong efforts they already made toward the transition to a sustainable cattle sector, evidenced by the existence of e.g., multi-actor platforms for sustainable cattle (in Colombia and Argentina) or the carbon-neutrality objective set by the Costa Rican government. It is worthwhile to answer the question why this study is justified. Primarily, because it adjusts to the reality of a global climate crisis that requires concrete actions, such as public policies, for both adaptation and mitigation. Likewise, the study is justified to the extent that the evaluation of such policies generates knowledge that can allow their reformulation in the medium- and long-term, overcoming the difficulties identified in pursuit of sustainability objectives. The study thus serves as a reference document for various actors, such as national and local governments, cattle producers, and value chain actors, and helps in the design, implementation, and evaluation of existing and future policies.

This article is structured as follows: Section Materials and Methods explains the methodological approach used; Section Results provides first insights into the successes and difficulties of implementing policies in the three countries of analysis, namely Colombia, Argentina and Costa Rica; Section Comparative Analysis and Discussion deals with the comparative analysis of the results among the three countries and a corresponding discussion; in Section Conclusions the conclusions of this study are presented; and Section Recommendations for Public Policy provides useful recommendations for a broad set of stakeholders.

The Latin American Cattle Sector

The Latin American cattle sector currently faces a series of circumstances that determine its development and, consequently, the public policies that govern it. Among these, productivity increases to meet the growing demand for animal-source food, climate change and the search for environmental sustainability stand out (CEPAL, 2015; FAO, 2019).

Regarding cattle production and productivity increases, beef production in the western hemisphere had a recent displacement toward South America, resulting from a reduction in cattle numbers and several years of droughts that affected both the United States and almost all of the Central American countries, mainly El Salvador, Guatemala and Honduras, but also to a lesser extent Nicaragua, Costa Rica and Panama. Between 2000 and 2013, Latin America doubled its beef exports, with exemplary cases such as Uruguay and Paraguay that exported almost two-thirds of what was produced (CEPAL, 2015). However, this contrasts with the situation on Argentina over the same period, whose cattle sector was affected by the 2008 drought and the sale of cattle in 2009, which caused a 44% drop in its beef exports (CEPAL, 2015), although with a notable recovery since 2015 (Cano, 2019). Although the United States have managed to overcome the drought-related crisis and are now again an important competitor at the global level, beef production volumes are almost 70% higher in Latin America. For their part and despite the signing of free trade agreements, the competitiveness of countries in Central America are lagging behind due to a negative perception of their animal health and food safety systems (CEPAL, 2017). Brazil is the beef export leader in the region, contributing 19.3% of the global beef trade (SAGARPA, 2018). The highlighted increases in beef production and exports in Latin American countries has also led to a greater co-responsibility for mitigating climate change. Regarding the adverse effects of cattle production on the environment, the fact that the region generates 30% of the greenhouse gas emissions of the global cattle sector stands out (FAO, 2019). This is further aggravated by the on-going deforestation, which, in addition to contributing to generating greenhouse gas emissions, causes the extinction of hundreds of species of flora and fauna and the destruction of ecosystems. In Central America the situation is particularly worrying since the forest area had a reduction of 40% between 1960 and 2000 (FAO, 2010). Regarding Latin America as a whole, the scenarios vary depending on the climatic, historical, political, and economic conditions of each country. While in Brazil, for example, there still exist large forest areas in the Amazon (which at the same time is one of the global deforestation hotspots), forests have almost disappeared in El Salvador (Sanhueza and Antonissen, 2014).

Apart from the abovementioned implications of the cattle sector on climate change and environmental degradation, climate change itself is also affecting the cattle sector, resulting in a need for climate change adaptation strategies and policies. Changes in the global climate affect the quality of water and animal feed, influence the physiological conditions of cattle, and lead to extreme climatic events (e.g., drought, flooding), among others, all contributing to variations in productivity and a reduction of areas suitable for cattle production. These ambivalent interactions between cattle farming and climate change, in addition to environmental problems caused by other economic sectors, have led the Latin American countries to adhere to environmental commitments, such as the Paris Agreement in 2015. In general terms, the treaty seeks to control the future temperature increases, protect food production systems, and promote sustainable agricultural production systems (FAO, 2019). The Latin American countries have also subscribed to the Sustainable Development Goals (SDG) promoted by the United Nations, which contain 17 goals that aim at guaranteeing prosperity at a global level. All goals set for the 2015–2030 period include components related to the livestock sector, in particular sustainable cities and communities, responsible production and consumption, climate action, and life in terrestrial ecosystems (ONU, 2021).

It should be noted that, beyond the aforementioned factors, the livestock sector in the region is complex and affected by multiple elements. These range from the economic liberalization processes of the 1980s and 1990s that still lead to repercussions, such as job insecurity and the excessive use of natural resources (FAO, 2013; Rojas Villagra et al., 2015), to issues such as political uncertainty, foreign investments, production technologies and animal diseases (CEPAL, 2017).

MATERIALS AND METHODS

To address the proposed objective, we decided to write a review article with a qualitative-descriptive approach. Literature review was used as the main data collection technique. In the analysis we related fragmented knowledge, contrasted different sources, and updated the existing literature, aiming at clarifying the state of the art of public policies that have promoted the development of a sustainable cattle sector. We selected three Latin American countries, namely Colombia, Argentina and Costa Rica and focused on the analysis of policies implemented during the years 2010–2020. This selection corresponds to the efforts made by the countries to develop a sustainable cattle sector: all of them have ratified the Paris Agreement and adopted the Sustainable Development Goals (SDGs), and both Colombia and Argentina have implemented roundtables for sustainable cattle. For its part, Costa Rica has set out the goal of achieving carbon neutrality, which stands out at the Latin American level. It is also noteworthy that, despite the efforts mentioned, in the three countries the agricultural sector is the main cause of GHG emissions (Banco Mundial, 2014), which shows the importance of investigating

their public policies to understand how they have faced both this and other environmental problems. Brazil is excluded from the study despite being the largest exporter of beef in the region (SAGARPA, 2018), since it still has excessively high figures of deforestation and GHG emissions (Observatorio do Clima, 2020), which contrasts with the progress made by the three selected countries, where, despite room for improvement, a relatively favorable outlook is observed. This, however, does not state that Brazil does not have laws or public policies oriented toward achieving sustainability of its cattle sector, but rather that the study prioritized slightly more successful experiences that allow it to be a point of reference for other countries.

Data collection was carried out from January to May 2021 and prioritized three types of data sources: (A) Scientific articles, which were especially used for defining concepts and theoretical principles regarding sustainable cattle, particularly but not exclusively in the introduction. (B) Government reports and other official documents, which include publications of national and local governments, ministries, secretaries, congresses, and other public entities of the respective countries. National and local public policies were searched in these documents (including budget figures and intervened areas), and the legislation promoted in each of the contexts addressed. They were used in both the results and analysis sections. (C) Publications by international organizations, such as the Food and Agriculture Organization of the United Nations (FAO), the Economic Commission for Latin America and the Caribbean (CEPAL), and the Inter-American Institute for Cooperation on Agriculture (IICA). Such sources were consulted to contrast the official figures and positions of the countries, specifically in the analysis section. Among the three categories, 115 sources were cited. With the aim of presenting a picture as complete as possible of each of the studied scenarios, the results considered five factors, namely (i) the context, (ii) National Development Plans, (iii) legislative advances, (iv) multi-sector initiatives, and (v) regional policies. At the end of the section corresponding to each country, a table-summary of successes and difficulties in the implementation of public policies is presented (**Tables 2**, **4**, **6**). These arise from the authors' own interpretation, considering the five elements previously exposed, while at the same time allowing the formulation of a set of recommendations for the development of the different stages of the policies (**Table 7**). Regarding the analysis, to evaluate the impact of the public policies described in each of the three scenarios, figures related to deforestation, GHG emissions and conservation of natural areas were consulted.

Hernández et al. (2014) describe that in qualitative studies, the research process is holistic, since it is not reduced to the analysis of the parts, but rather addresses the whole picture. This was especially important for the present study, as it sought to understand how the set of policies have contributed to the transition toward a sustainable cattle sector. Despite the qualitative focus of this research, the importance of quantitative information was not neglected. In turn, it is necessary to point out that, due to the breadth of identified policies and the complexity of exposing them in their entirety, those with the greatest impact in terms of budgets, intervened areas, and importance of the regions they are aimed at for respective national cattle sector of each country were selected.

RESULTS

Colombia

Context

Unliske many other Latin American countries and despite the internal armed conflict that lasted for more than 60 years, Colombia has a relatively stable political and economic system. The first neoliberal reforms were presented in the 1980s and consolidated in 1989 with the Washington Consensus, including elements such as a reduction of the role of the State in social intervention, privatizing public institutions and promoting private ownership and enterprises (Tejedor Estupiñán, 2012). With a more or less rigorous application of these principles, all national governments have since then followed the same guideline, without making abrupt changes. It is within this framework that the various economic sectors have developed, including the agricultural and livestock sectors.

Regarding the cattle sector, its contribution to the national economy is highlighted by generating 1.1 million jobs, which is equivalent to 6% of the national employment (Fedegán, 2021). With ∼35 million hectares, the sector uses most of the available land for agricultural purposes, most of it under extensive cattle ranching systems (Banco Mundial, 2019). In relation to this figure, the Rural Agricultural Planning Unit (UPRA, 2015) has stated that the sector exceeds the maximum amount of land use by 15 million hectares, making it necessary to rethink the rural land use. Colombia is the 17th largest beef producer in the world and contributes with 1.2% of the global beef supply. Exports to countries from the Middle East, Russia, and Vietnam, however, make up only 4% of the overall production volume while the rest is consumed domestically (Venugopal et al., 2021). Despite the occurrence of the COVID-19 pandemic and the fear of its implications on the sector, beef export figures showed a positive development at the end of 2020, with 3,247 tons of beef exported in September, exceeding the figures in the same months of 2019 (1,681 tons) and 2018 (1,899 tons) (Fedegán, 2021).

To this extent, the public policies addressed are located in a scenario where two characteristics stand out: (i) the stability of the political-economic model for more than three decades, and (ii) a cattle sector that, despite its limited international importance, is fundamental at the national level in terms of job creation and food security.

National Development Plans

During the last decade, the different national governments of Colombia have indicated the importance of environmental protection as the basis of their policies. In this regard, the *National Development Plan* 2010–2014 stated that environmental sustainability should be a priority and an essential practice for the wellbeing and equity of future generations (DNP, 2011). For the 2014–2018 period, this premise continued, emphasizing more strongly the importance of protecting natural reserves, regulating land use and preventing socio-environmental conflicts (DNP, 2015). The current *National Development Plan* for the period

FIGURE 1 | Actors involved in the design and execution of public policies in Colombia.

2018–2022 adds to that a long-term project perspective, which allows achieving the SDGs by 2030 (DNP, 2019).

Legislative Advances

Although the legislative framework for the cattle sector is very broad and involves elements such as animal welfare and marketing there are three regulations that stand out in the period of analysis for their influence on the sector in terms of sustainability:

- *Decree 870:* Establishes the framework for payments for ecosystem services, in addition to other incentives for conservation (Presidencia de la República de Colombia, 2017).
- *Law 1876:* Creates the National Agricultural Innovation System (SNIA) with the purpose of improving the productivity and sustainability of the national agricultural sector (Congreso de la República de Colombia, 2017).
- *Law 1931:* Establishes guidelines for the management of climate change in the decisions of public and private entities (Congreso de la República de Colombia, 2018).

Multi-Sector Initiatives

As a further effort to adapt to and mitigate the effects of climate change, multi-sector initiatives have emerged in Colombia, such as the *National Plan for Adaptation to Climate Change* and the *Colombian Strategy for Low Carbon Development* (ECDBC). In the same sense, but focusing entirely on the cattle sector, the *Colombian Roundtable for Sustainable Cattle* (MGS-Col, made up of one national and 12 regional roundtables, was established in 2014 and is an inter-institutional space where the public and private sectors, academy and NGOs converge with the aim of being a benchmark in the design and implementation of sustainable cattle programs and policies, capacity building in rural areas, inter-institutional exchange and link with global initiatives such as the *Global Roundtable for Sustainable Beef* (GRSB) (**Figure 1**). Recently, the MGS-Col presented a technical proposal for the formulation of a national level sustainable cattle policy to the Ministry of Agriculture, which is now under revision. Among the objectives of this proposal is the promotion of the cattle sector from the green growth paradigm and the

TABLE 1 | Overview on the objectives and geographical reach of the Departmental Agricultural Extension Plans (PDEA) in Colombia.

Department	Objectives related to sustainable cattle farming	Source
Antioquia	- Increase productivity, competitiveness, and sustainability in coordination with rural actors	Gobernación de Antioquia, 2020
Boyacá	- Promote the development of productive systems aimed at the conservation and proper management of natural resources	Gobernación de Boyacá, 2020
Casanare	- Improve the competitiveness and sustainability of the sector - Strengthen the contribution to food security and the development of the agricultural producer as an integral human being	Asamblea Departamental de Casanare, 2020
Cauca	- Develop skills in producers to increase the knowledge base and support behavioral change with the aim of improving competitiveness and sustainability	Gobernación del Cauca, 2020
Cesar	- Strengthen the capacities of producers to make decisions about their agricultural production systems, so that they can develop processes that respect the ecosystem	Gobernación del Cesar, 2020
Guainía	- Improve cattle production facilities for associations in the department - Complement and articulate actions through the project "Implementation of a comprehensive and fair rural extension plan" - Raise awareness about cattle regulations	Gobernación del Guainía, 2019
Santander	- Encourage producers to use water resources efficiently and develop soil conservation practices	Secretaría de Agricultura de Santander, 2020
Vichada	- Increase the profitability of the cattle sector through genetic improvement, balanced nutrition and more and better pastures - Reduce the negative environmental impacts of traditional cattle farming through the development of low carbon cattle systems and silvo-pastoral systems	Gobernación del Vichada, 2020

conservation of the environment and natural resources (Mesa de Ganadería Sostenible Colombia, 2019). Likewise, it is pertinent to refer to the zero deforestation value chains initiative for beef and dairy, which is part of the *Zero Deforestation Agreements* contemplated in the *National Development Plan* for 2018–2022. The initiative, understood as a voluntary commitment to collective action among the public and private sectors, commits the involved entities to stopping cattle-farming-related deforestation and, at the same time, developing processes of ecological restoration, such as the reestablishment of a degraded areas, among others (Alianza Colombia TFA, 2021).

Another multi-sector initiative was the *Sustainable Colombian Cattle Project* (GCS), executed from 2010 to 2019 and financed by World Bank, the Global Environment Fund, the Government of the United Kingdom, which aimed at strengthening the Colombian cattle production through the integration of environmentally friendly practices. Among the specific objectives of this project were e.g., the transformation of 35,500 hectares of traditional production systems into silvo-pastoral systems, the preservation of 15 hectares of native forests, the development of payment schemes for ecosystem services, the creation of forage nurseries, and technical assistance for 3,900 cattle farms to support sustainable intensification efforts (Ganadería Colombiana Sostenible, 2018). The *Integral Program for Productive and Environmental Reconversion of the Cattle Sector* (PIRPAG), whose objective is to support the transition of the national cattle sector toward sustainability over a period of 30 years, is another example of multi-actor initiatives in Colombia. It focuses on the modification of traditional cattle landscapes into more productive systems that include environmental commitments, allowing for a reduction and capture of greenhouse gas emissions. The initiative works in several selected regions, such as the humid and dry Caribbean and the foothills of Magdalena Medio and the Orinoco, where pilots have been carried out on integrating live fences, forage hedges and mixed forage banks into the traditional livestock systems (Lozano, 2020; Colombia Sostenible, 2021).

Finally, as one of the *Nationally Appropriate Mitigation Actions* (NAMAs), the Colombian *Sustainable Cattle NAMA* is being developed among a broad group of stakeholders. This future policy will be focused on involving public-private sector participation, addressing the mitigation of climate change through the reduction of greenhouse gas emissions as well as an increase of carbon sequestration (Ministerio de Ambiente y Desarrollo Sostenible, 2019). Its actions will impact 434 municipalities and 3.6 million hectares (Banco Mundial et al., 2021).

Sub-national Regional Level Public Policies

Parallel to the above-mentioned initiatives, there also exist various public policies implemented at the regional level. Among these, the *Departmental Agricultural Extension Plans* (PDEA) stand out, which, although they are still in the initial phase of design and implementation, are macro level policies that define the provision of agricultural extension at departmental level (**Table 1**). For the transition toward sustainable cattle systems, credit is needed. The Colombian government launched a credit line program for silvo-pastoral systems in 2020, which is being implemented at a regional level (mainly in 82 municipalities) and seeks to promote sustainable practices, such as the conservation of biodiversity and the protection of water and soil resources, in the different cattle regions of the country. The credits are directed to the purchase and planting of tree species and the implementation of living fences, among others, and is the first initiative in this regard (Ministerio de Agricultura y Desarrollo Rural, 2020).

National Level Public Policies

In 2019, the *2018–2022 Agricultural and Rural Development Policy: a field for equity* was launched. This policy aims at promoting agricultural competitiveness and productive transformation based on three pillars: (i) rural development, (ii) productivity + profitability = competitiveness, and (iii) modern and technical institutions. The sustainability component is in the second pillar and has the objective of positioning the country as leading actor at international level, boosting employment, diversifying the productive offer, and encouraging environmentally responsible production practices. To achieve this, farm planning, the establishment of silvo-pastoral systems, the division of pasture areas and the use of aqueducts that prevent contamination of water sources by animals, are the most prominent approaches. The *National Conversion Strategy* focuses on three main objectives: (i) technology (access and implementation), (ii) agricultural extension (in correspondence with Law 1876 of 2017), and (iii) financial instruments. In addition to these objectives, the policy aims at establishing a pilot cattle farm in each of the country's cattle regions (Antioquia, Boyacá, Caquetá, Cauca, Humid Caribbean (Córdoba and Sucre), Coffee Triangle and northern Valle del Cauca, Guajira, Magdalena Medio, Nariño, Orinoquía (plains), Orinoquía (flooded savannas), and Tolima-Huila), and at strengthening the 12 regional roundtables. Once the initial network has been completed, progress will be made so that in 2022, the implementation of silvo-pastoral systems on 75,000 ha in 25,000 properties will be achieved (Ministerio de Agricultura y Desarrollo Rural, 2019).

Successes and Difficulties in the Implementation of Public Policies

From the reading and analysis of the aforementioned policies, it is possible to identify a set of successes and difficulties in their implementation (**Table 2**). Successes and difficulties arise both from the political and economic context, as well as from the content of the policies and the relationship between them. The existence of macro policies stands out, such as the *National Development Plans* and legislative advances, but also do regional programs with specific objectives, facilitating short-term implementation, monitoring and evaluation. One of the main successes is the promotion of silvo-pastoral systems, which is strengthened by the creation of a specific credit line. Financial resources are precisely one of the main problems since some policies show a lack of clarity on how to finance their objectives.

TABLE 2 | Successes and difficulties in the implementation of public policies in Colombia.

Successes	Stability of the political-economic system for more than three decades
	Continuity of the promotion of a sustainable cattle sector in the National Development Plans
	Existence of a national level Roundtable for Sustainable Cattle
	Strong progress in the formulation of a national level public policy on sustainable cattle
	Promotion of silvo-pastoral systems through on regional and national policies
	Existence of a credit line for the establishment of silvo-pastoral systems
Difficulties	The national public policy framework is still very young and at its early stages
	The Departmental Agricultural Extension Plans are still very young and at their early stages, and they also do not exist for all departments with relevance to the cattle sector
	Insufficient coordination between national and regional level public policies
	Lack of clear budgets to carry out some of the policies, particularly from the National Development Plan and the Departmental Agricultural Extension Plans
	Different levels of acceptance of public policies by producers, many of whom relate sustainable cattle farming with the need for economic investment

Argentina

Context

In recent decades, the political, economic and social narratives for development pathways of Argentina have been determined by two clearly differentiable and opposed development models: the first, established between 1990 and 2002, gave a fundamental role to foreign investment and was characterized by an outward-oriented economy; the second, between 2003 and 2015, appealed to a state with greater regulation of markets, internal savings, food production with social inclusion and strengthening of commercial ties at the regional level (Taraborrelli, 2017). Since 2015, Argentina has had two governments with opposing views, with clear tendencies toward the former development models: between 2015 and 2019, liberal policies adjusted to the requirements of the International Monetary Fund were prioritized (Morresi and Vicente, 2019), while in 2019, the path that started in 2003 was resumed (Scaletta, 2020).

Regarding the cattle sector, a reactivation was sought in 2015 with the lifting of various obstacles, such as export controls and interventions in the internal market (Patrouilleau et al., 2017). According to recent figures, the Argentinian cattle herd counts approximately 53 million heads (Secretaría de Gobierno de Agroindustria de la Nación, 2019). Despite the increase in beef sales on the international market, particularly to China, and the decline in domestic demand for beef due to high inflation and lower wages, domestic consumption continues to be the basis of the sector. Argentina has recovered its privileged position in the global beef market, occupying the fifth place in production and fourth in exports (Cano, 2019). The COVID-19 pandemic, although having effects on the sector, did not slow the growth rate significantly and by October 2020, 730,000 tons of beef had been exported (Villamil, 2020). An additional aspect to highlight is the expansion of the agricultural frontier, particularly resulting from plantations of monocultures such as soy. Their growth has displaced livestock, pushing it to less productive lands and into forests (Pincén et al., 2010).

In summary, a context is revealed in which the changes in the political model and economic instability are elements of great influence on the cattle sector, despite the preservation of growth and export levels making Argentina one of the global leaders for beef.

National Development and Land-Use Management Plans

The *Participative Federal Agri-food and Agroindustry Strategic Plan* for 2010–2016 presented some of the challenges the Argentinian cattle sector was facing, such as a water deficit and drought in 2008, which obliged cattle farmers to sell their animals earlier than planned (lack of feed and water) and led to lower calf birth rates in 2009, among others. To counteract these problems, the plan proposed that by 2015 all national policies should integrate the principles of sustainable development and thus reverse the loss of natural resources (Ministerio de Agricultura Ganadería y Pesca, 2010). For its part, the *Territorial Strategic Plan* (PET), launched in 2011, recognized the cattle sector as cause of desertification, particularly through pasture overgrazing. Although the plan did not delve into the cattle sector, it proposed that all citizens need to achieve environmental sustainability and included the promotion of a sustainable productive development in the guidelines for territorial and land-use planning in rural areas (Ministerio de Planificación Federal Inversión Pública y Servicios, 2011). The *National Policy and Strategy for Territorial Development and Planning*, launched in 2016, defined the achievement of an environmentally sustainable society as the main objective, for which it proposed a series of strategies, such as improving knowledge about natural resources and including the environmental dimension as a transversal axis in public territorial policies and actions at the federal, provincial and local levels (Ministerio de Planificación Federal Inversión Pública y Servicios, 2016).

Legislative Advances

Although there are several laws that directly and indirectly influence the Argentinian cattle sector and its sustainable development, three stand out in this regard:

- *Law 26.331, Minimum Budgets for Environmental Protection of Native Forests:* promotes the sustainable management of forest reserves, in addition to creating the National Fund for the Enrichment and Conservation of Native Forests (Congreso de la Nación Argentina, 2007).
- *Law 27.066. Regime for the Promotion of Cattle Production in Arid and Semi-arid Zones:* aims at increasing the supply of bovine livestock (by-)products, which follow the principle of environmental balance (Congreso de la Nación Argentina, 2014).
- *Law 27.520. Law of Minimum Budgets for Adaptation to and Mitigation of the Global Climate Change:* establishes strategies that allow guaranteeing human and environmental development. Article 24, in particular, refers to practices to mitigate climate change linked to the agricultural and livestock sector (Congreso de la Nación Argentina, 2019).

Multi-Sector Initiatives

One of the principal multi-sector initiatives is the *Argentine Sustainable Beef Board* (MACS), an association of public and private entities, NGOs, academia, and other organizations (e.g., input and service providers), with the aim of promoting sustainability policies for the cattle sector (**Figure 2**). It currently has more than 40 members committed to the development of specific goals, such as proposing innovations in inputs and services, anticipating the response to market trends, and promoting the improvement of the beef value chain (MACS, 2021). Another multi-sector initiative is *Carne del Pastizal*, which has the objective to stimulate cattle production based on practices that respect biodiversity, in addition to generating positive impacts in economic and social terms. One of its main achievements was the export of certified grass-fed beef to Europe (INTA, 2014). At this point, it is worth mentioning that there exists no policy for the cattle sector yet that properly responds to the *NAMA concept*, although (see subchapters below) there are various actions aimed at reducing the sector's greenhouse gas emissions according to the NDCs defined at the COP21 in Paris in 2015 (Centro Agronómico Tropical de Investigación y Enseñanza, 2019).

Sub-national Regional Level Public Policies

Regarding the traditional cattle provinces in Argentina, it is necessary to refer to four important policies (**Table 3**). In these, the importance of protecting grasslands, good animal husbandry practices, and sustainable grazing stand out. Likewise, the policies consider the quality of life of ranchers and productivity, jointly exposing a sustainability project in which economic benefits and environmental guarantees are integrated.

National Level Public Policies

With the aim of finding solutions to make forests profitable for their owners and, at the same time, provide goods and services to the society, the *National Management Plan for Forests with Integrated Cattle* (MBGI) was launched in 2015, responding to Law 26.331 of 2007 and promoting the design and monitoring of forests with integrated cattle, as well as the implementation of silvo-pastoral systems (Presidencia de la Nación Argentina, 2018). As pointed out by Borrás et al. (2017), the plan is an agreement that seeks to articulate national, provincial, productive and conservation public policies. The *National Program on Natural Resources, Environmental Management and Eco-regions* (PNNAT), developed in 2015, aims at contributing to the protection of the environment in the agricultural sector through a progressive improvement of sustainability in rural areas and production systems. Regarding cattle, two projects of the plan focus on the measurement of greenhouse gas emissions and wastewater treatment, through which it is intended to contribute to both prevention and environmental remediation based on methodological tools for diagnosis and evaluation, technology development, among other measures (INTA, 2017). As one of the most important public policy instruments at the national level, *Rural Change II, Innovation, and Investment* (CRII) stands out. The program emerged in 1993 but was relaunched in 2013 with the objective to support the association of small and medium-sized enterprises, agri-food, and agroindustry to strengthen the sector. For smallholder cattle producers, which are the main group of beneficiaries of the initiative, an improvement plan instrument was developed that contains an environmental sustainability component, in which aspects

FIGURE 2 | Actors involved in the design and execution of public policies in Argentina.

TABLE 3 | Overview on the provincial cattle plans of Argentina.

Province	Objectives related to sustainable cattle farming	Source
Buenos Aires, Corrientes, Entre Ríos, and Santa Fe	Pastures and Savannas of the Southern Cone of South America: initiatives for their conservation in Argentina (2010): - To promote sustainable cattle ranching in grasslands by integrating environmental conservation practices into agricultural production.	Miñarro and Marino, 2013
Santa Fé	Santafesino Cattle Plan (2018): - Launched with the purpose of generating suitable conditions for the growth of cattle production and the adoption of good animal husbandry practices. - Overarching purpose of guaranteeing the quality of life of the Santa Fé citizens and the sustainability of the sector.	Ministerio de Producción Ciencia y Tecnología, 2018
Entre Ríos	Enterriano Cattle Plan (2020): - Beef differentiation and certification. - Implementation of good animal husbandry practices.	Ministerio de Producción Turismo y Desarrollo Económico, 2020; Secretaría de Agricultura y Ganadería, 2020
Neuquén	Plan Ganadero Bovino Provincial (2021): - Implementation of technologies in the management of grasslands and water. - Development and dissemination of sustainable grazing techniques. - Improvement of the meadow productivity. - Strengthening the adaptability to environmental changes.	Gobernación de Neuquén, 2021

TABLE 4 | Successes and difficulties in the implementation of public policies in Argentina.

Successes	National Development Plan with an environmental sustainability component
	Existence of laws that promote forest protection, environmental balance, and climate change mitigation strategies
	Development of multi-sector initiatives that promote sustainable beef production
	Existence of the Argentine Sustainable Beef Board
	National public policies articulated with the provinces
	Regional policies that promote the adoption of silvo-pastoral systems and good animal husbandry practices
Difficulties	Environmental conditions that affected and still affect the cattle sector
	High political instability that has led to changes in the development model
	Increased inflation and unstable exchange rate
	Decrease in wages and reduction in national beef consumption
	Unequal implementation of the MGBI in the provinces

such as the use of agrochemicals and good water management are included (Ministerio de Agricultura Ganadería y Pesca, 2013).

Successes and Difficulties in the Implementation of Public Policies

As highlighted in **Table 4**, the aforementioned policies present both individually and collectively a diversity of successes. The presence of a sustainable beef board, as well as the inclusion of an environmental component in the *National Development Plan* and legislative advances, configure a context for the development of the cattle sector in accordance with international treaties. The policies implemented at the regional level are contributing significantly to achieving sustainability of the sector, since they set specific objectives and focus on results. Nevertheless, there also exist some difficulties, which mainly respond to conjunctural factors, such as inflation, unemployment, and the reduction of consumption, which are largely dependent on the national government in power and can vary positively or negatively in the medium- and long-term, making it difficult to determine how they will affect the cattle sector. Faced with this uncertain panorama, the international treaties signed, and the legislation developed to date become more relevant, guaranteeing that the sustainability of the sector can be preserved.

Costa Rica

Context

Costa Rica has shown continuous economic progress over the last 25 years because of opening up to foreign investments and trade liberalization. The balance between political stability and sustained growth is reflected in human development indicators and one of the lowest poverty rates in Latin America (Banco Mundial, 2021). Costa Rica's economy has focused on the export of goods and services and is characterized by low inflation and stable exchange rates, as well as an internationally competitive export sector. However, there are lags in infrastructure, which affect the different productive sectors and, particularly, green economy efforts (Gobierno de Costa Rica, 2019).

The Costa Rican cattle sector is present all over the country, with major concentration in the regions Huetar Norte (34%), Chorotega (22%) and Central (15%), while Brunca (12 %), the Caribbean (9%), and the Central Pacific (8%) regions are less important (Ministerio de Agricultura y Ganadería, 2019). The cattle sector generates annual profits of close to US$ 1.5 billion and involves 500,000 people, highlighting its social and economic importance (Ministerio de Agricultura y Ganadería, 2017). According to the National Institute of Statistics and Censuses (INEC, 2020), the country's cattle herd counts with ∼1,600,000 animals, out of which 15.4% correspond to dairy cattle, 62.7% to beef cattle, 21.7% to dual-purpose cattle and 0.2% to cattle used for farm work. In terms of beef exports, China and the United States are the most important buyers. In 2019, China imported 14,014 tons of beef with a value of US$ 56.72 million, representing 57% of Costa Rica's beef export volume (Barquero, 2020). The United States bought 23% of the beef export volume in the same year for a value of US$ 26.5 million (Procomer, 2020). It is important to mention that the livestock sector remains stable despite the crisis generated by the COVID-19 pandemic, which is due to factors such as the productive system, local consumption, and the use of national productive inputs (Garza, 2020).

Consequently, the sector operates in a stable political and economic situation, which has allowed its development and the opening of important international markets. However, Costa Rica has not yet established itself as a fundamental actor on the global beef market, generating contributions mainly at the national level in terms of employment and food security.

National Development Plans

The 2011–2014 *National Development Plan* sets out environmental protection as one of its main objectives. It suggests the incorporation of fundamental elements of sustainable development into the national policies and the reversion of natural resource degradation, while promoting an economy with minimum levels of greenhouse gas emissions in search of carbon neutrality by 2021 (Ministerio de Planificación Nacional y Política Económica, 2010). This last goal is reiterated in the 2015–2018 *National Development Plan*, as well as the need for climate change mitigation and adaptation actions of the agricultural sector (Ministerio de Planificación Nacional y Política Económica, 2014). For the period of 2019–2022, these precepts are continued by proposing specific measures, such as interventions on cattle farms applying the *NAMA model* and the strengthening of the capacities of micro-producers through silvo-pastoral system and agroforestry models (Ministerio de Planificación Nacional y Política Económica, 2019).

FIGURE 3 | Actors involved in the design and execution of public policies in Costa Rica.

Legislative Advances

The regulations regarding environmental sustainability are very broad in Costa Rica, but there exist two important decrees with direct effects on the cattle sector[1]:

- *Executive Decree 37.017:* authorizes the use of cattle slurry to improve the chemical, physical and microbiological characteristics of the soil (Presidencia de la República de Costa Rica, 2012).
- *Executive Decree 39,482:* declares the *National Strategy for Low Carbon Cattle* (ENGBC) 2015-2034 as of public interest, taking into consideration the objective of becoming a carbon-neutral country (Presidencia de la República de Costa Rica, 2012).

Multi-Sector Initiatives

In connection with the previously described policies, the Costa Rican *Cattle NAMA* stands out as an example for multi-sector initiatives (**Figure 3**). The strategy was developed in 2013 and aims at transitioning the cattle sector toward productive efficiency, adaptation to climate change and greenhouse gas emission reductions. The mitigation potential of the NAMA is understood from the promoted practices, being mainly increased forest cover, rational grazing, living fences and improvement of pastures and fertilization (Ministerio de Agricultura y Ganadería, 2019). In turn, the NAMA is expected to improve the quality of life and income of ranchers, while raising consumer awareness of the need to reduce GHG emissions from the cattle sector (UNFCCC, 2014).

Sub-national Regional Level Public Policies

In 2015, the design of *Regional Livestock Development Plans* started, which respond to local problems, but conform to the national purpose of carbon neutral cattle production. These plans

[1]Although there exist other regulations that stimulate sustainable cattle farming in the country, they are not cited because they were launched prior to 2010. The present study covers developments between 2010 and 2020. Law 7837 of 1998 (Law for the Creation of the Cattle Corporation), Law 8408 of 2004 (Program for the Promotion of Sustainable Agricultural Production), among others, stand out.

TABLE 5 | Regional level development objectives for a sustainable Costa Rican cattle sector.

Region	Objectives	Source
Central Oriental	- Development of sustainable cattle practices for the conservation of natural resources	Ministerio de Agricultura y Ganadería, 2019
Central Sur	- Implementation of technical assistance programs - Promotion of climate change mitigation and adaptation practices on cattle farms	Ministerio de Agricultura y Ganadería, 2019
Central Occidental	- Consolidation of the payments for ecosystem services program for individuals or entities that promote silvo-pastoral systems	Dirección Regional Central Occidental, 2015
Huetar Norte	- Promotion of ecosystem service programs - Establishment of silvo-pastoral systems and agroforestry for adaptation to climate change - Enabling the access to environmentally friendly technologies at primary producer level	Ministerio de Agricultura y Ganadería, 2019
Brunca	- Promotion of actions to adapt production processes to climate change	Comité Sectorial Regional Agropecuario, 2015

are being carried out in Central Oriental, Central Sur, Central Occidental, Brunca and Huetar Norte, while Chorotega, as well as the Central Pacific and the Caribbean regions show delays (**Table 5**).

National Level Public Policies

In addition to the aforementioned initiatives, Costa Rica started the *National Strategy for Low Carbon Cattle 2015–2034*, which, among others, proposes the promotion of cattle production in areas with less exposure to climate vulnerability, an increase the establishment of silvo-pastoral systems, and a set of low-carbon technologies, which e.g., includes living fences, improved pastures, forage banks, rational grazing and the moderate use of slurry (Ministerio de Agricultura y Ganadería, 2019). These purposes continue with the *National Decarbonization Plan 2018–2050*, whose ninth axis[2] exposes the importance of consolidating the eco-competitive cattle production model based on productive efficiency and the reduction of greenhouse gas emissions (Gobierno de Costa Rica, 2018). The *Costa Rican Policy for the Agri-Food Sector and Rural Development 2010–2021* incorporates climate change and agri-environmental management as one of its four pillars. It also refers to the need of promoting sustainable production systems through an ecosystem approach, for which payment schemes for ecosystem services were adopted as an instrument (Ministerio de Agricultura y Ganadería, 2011). The *Policy for the Agricultural Sector and the Development of Rural Territories 2015–2018* emphasizes on some mitigation strategies, such as economic incentives for producers that contribute to the reduction of greenhouse gas emissions or the promotion of silvo-pastoral systems (Secretaría Ejecutiva de Planificación Sectorial Agropecuaria, 2015).

[2]The 10 axes of the National Decarbonization Plan 2018–2015 are: (1) Development of an efficient and renewable mobility system. (2) Conversion of the vehicle fleet to zero emissions. (3) Boosting cargo transportation with zero emissions. (4) Consolidation of a national electricity system of renewable energy. (5) Promotion of buildings with low emissions. (6) Modernization of the industry. (7) Promotion of a waste management system. (8) Development of efficient agri-food systems. (9) Promotion of an eco-competitive livestock model. (10). Promotion of a territorial management model that allows the protection of biodiversity.

TABLE 6 | Successes and difficulties in the implementation of public policies in Costa Rica.

Successes	Political stability for several decades
	Low inflation and stable exchange rates
	National Development Plans include sustainable production components
	Diversity of national and regional public policies framed in the objective of carbon neutrality
	Regional Livestock Development Plans with focus on environmental sustainability
	Promotion of silvo-pastoral systems through both national and regional policies
	Existence of payment schemes for ecosystem services and agroforestry programs
Difficulties	Absence of a sustainable cattle roundtable or any similar initiative
	Postponement of the carbon neutrality objective

Successes and Difficulties in the Implementation of Public Policies

As shown in **Table 6**, the political and economic stability of Costa Rica, in addition to the commitments acquired through the Paris Agreement and the 2015–2030 SDGs, has allowed continuity to a set of governmental initiatives focused on sustainable production models. The commitment to achieve carbon neutrality is also reiterative, which is promoted at both the national and regional levels. However, the absence of a sustainable cattle roundtable or any similar initiative stands out as an important bottleneck, despite its potential to contribute to the articulation of public policies, information exchange and validation, and the promotion of new practices and technologies.

COMPARATIVE ANALYSIS AND DISCUSSION

From the elements raised, it is possible to identify relationships between the studied countries Colombia, Argentina, and Costa Rica. To this extent, macro and micro aspects are highlighted that allow understanding the public policies developed, while evaluating their impacts through e.g., figures on deforestation or greenhouse gas emissions, among other indicators, taking into consideration an international scenario from which

environmental sustainability strategies are formulated and results from the individual governments are demanded.

Explanatory Factors of Public Policies

As has been outlined, public policies involve a set of stages that go from the identification of the problem to the evaluation of the implemented actions. Macro-level factors intervene in this process, such as the political will of the state institutions, understood as an ideological commitment to respond to the demands of citizens (Goldfrank, 2006), the articulation among the involved actors or the continuity and linkage of the programs. At the same time, micro-level factors related to the perception of the unions, associations and producers about sustainability strategies become relevant. To understand the policies outlined in this document, it is necessary to delve into both aspects.

At the macro-level, the *National Development Plans* and legislative advances of the three countries show a willingness of state institutions to promote a sustainable cattle sector. This circumstance is expressed in their *National Development Plans* and legislative advances. The strategies proposed by all are quite similar, focusing on the need to reverse the loss of natural resources, reduce greenhouse gas emissions, stop deforestation, and promote the use of silvo-pastoral systems. Although these documents usually contain general lines regarding the problems, often without being expressed in tangible indicators or results, it is necessary to recognize that they have also been the starting point for large-scale initiatives. In relation to this, the carbon-neutrality objective proposed by Costa Rica stands out, a commitment that has made the country an international benchmark for sustainability. The political will of the three countries is also expressed by the existence of national and regional multi-sector initiatives. In this regard, the capacity for articulation among the actors stands out, linking public, private, academic, and various other entities to achieve a common goal—the sustainability of the cattle sector and value chains. This aspect is fundamental since it responds to the very concept of public policy where decisions are not made by a top-down decision but are the result of collaborative efforts. It should be noted that the *Roundtable for Sustainable Cattle* in Colombia and the *Argentine Sustainable Beef Board* have had a preponderant role in the processes, since they are considered as important pools of national and international actors with different institutional backgrounds. Both institutions support the sharing of feedback and experiences made by their members with sustainable cattle practices. In the case of Colombia, its main contribution has been the creation of a base document for the formulation of a National Public Policy on Sustainable Cattle, which is currently under review by the Ministry of Agriculture and would not have been developed without the initiative of the Roundtable.

Regarding the continuity and association of the programs, disparate circumstances are evident. In the case of Costa Rica, the carbon-neutrality objective has been preserved by the different governments and *National Development Plans*, as well as in the multi-sector and regional initiatives, such as the *Cattle NAMA*. In Argentina, although not as well as defined as in Costa Rica, national policies have managed to articulate with the provinces, i.e., regarding the adoption of silvo-pastoral systems. The situation in Colombia, however, has not been so favorable, since for many years, there was no public policy that coordinated local sustainability efforts, and thus, they rather developed independently and in a disorderly manner.

These macro-level factors, which are related to the actions of governments and institutions, converge with the way in which producers perceive the public policies that seek to integrate them. In relation to silvo-pastoral systems, Braun et al. (2016) describe their numerous advantages, but also warn of their disadvantages and, consequently, occurring preventions of producers toward the implementation of related policies. Some of these difficulties refer to the lack of familiarity with the new strategies, in addition to the need for higher initial investments and a certain level of complexity compared to traditional cattle farming systems. The Ministry of Agriculture and Livestock of Costa Rica (Ministerio de Agricultura y Ganadería, 2019) reaffirms these arguments, adding that new technologies including silvo-pastoral systems, face a conservative attitude by the producers, which is due to risk aversion, minimal interest in on-farm investments, and a lack of available information. In the studied scenarios and countries, micro-factors are present to a stronger or lesser extent, with the common denominator of difficulties in financing and training for change, which leads producers to perpetuate their traditional practices. The continuation of the public policies developed in Costa Rica and Argentina, however, suggests a gradual overcoming of these barriers, while they are still more present in Colombia.

The convergence of macro- and micro-level factors has made the implementation of public policies a complex process in different regards, which highlights the importance of strengthening collaborative actions among state institutions, private sector, and other organizations, since this helps overcoming the fears producers have regarding sustainability-related policies.

From International Requirements to National Results

There exist various high-level environmental commitments that involve Colombia, Argentina, and Costa Rica, such as the Paris Agreement and the SDGs 2015–2030. These agreements are mechanisms of the international community to put pressure on national governments to regulate their production systems, beyond political or economic interests. This is how the adhesion of the countries to these initiatives, although voluntary, is not precisely due to a genuine interest, but to an imperative to which it is necessary to respond. To understand how the analyzed countries have acted in the face of such international demands by developing and adjusting their public policies and, at the same time, analyze their impact, it is important to consider some figures. In this regard, reference is made to factors such as forest cover, deforestation, and GHG emissions, which offers an overview of the current situation in terms of sustainability advances.[3]

[3]It should be noted that comparisons between countries are not exact due to the availability of data, which may vary over time or by the way in which they are disaggregated.

Argentina currently counts with 53,654,545 hectares of native forest (Ministerio de Ambiente y Desarrollo Sostenible de Colombia, 2021). As indicated by the Dirección Nacional de Bosques (2021), however, the loss of forest land for 2020 was 333,222 hectares, a rather worrying figure, and 27.8% of this deforestation corresponds to agriculture and livestock sector (only surpassed by fires, with 57.3%). According to the latest National Inventory of Greenhouse Gases, the country's total emissions for 2016 were 364 million tons of CO_2, of which 21.6% correspond to the livestock sector (Secretaría de Ambiente y Desarrollo Sustentable, 2019).

In Colombia, the achievements in terms of environmental sustainability are mixed. For the 2018–2022 period, the national government intends to implement 150,000 hectares of silvo-pastoral systems, agroforestry systems, productive reconversion, and fish farming (DNP, 2019), a low figure when compared to other countries. It has also set the goal of planting 180 million trees by the end of the period, an initiative to which the departmental governments have adhered (Ministerio de Ambiente y Desarrollo Sostenible de Argentina, 2021). Beyond these objectives, which will have to be evaluated in due course, recent figures are worrying: By 2020, according to official figures, the country generated approximately 298 million tons of CO_2 across all economic sectors (Gobierno de Colombia, 2021). Likewise, deforestation affected 2.8 million and 159,000 hectares of forest land from 2000 to 2019 and in 2020, respectively (CONPES, 2020). Although the causes of this phenomenon are multiple, including the exploitation of timber, the construction of roads, illicit crops, among others, extensive cattle farming has a share of this responsibility, and as Kaimowitz (2019) points out, largely explains the destruction of ecosystems both in Colombia and in the rest of Latin America. The author also states that cattle farming is a placeholder for guaranteeing land possession, which is much more lucrative than the production of beef or milk. This scenario is worrisome, since if sustainability initiatives in many cases have little effects on real cattle farmers, much less will they have effects if cattle farming is not the main activity. Another factor that needs to be taken into consideration is the Peace Agreement signed between the Colombian State and the Revolutionary Armed Forces of Colombia (FARC) in 2016, with the aim of ending the internal armed conflict that lasted for over 60 years. Contrary to what might be expected, the Peace Agreement intensified the already existing environmental problems, including deforestation, since the State has not taken control of the territories abandoned by the guerrilla, and reconfigured the relationships between the actors who dispute the land (e.g., landowners, peasants, illegal armed groups) (Armenteras, 2019).

Costa Rica exhibits both a stable political system and significant progress in terms of sustainability: Between 2011 and 2016, CO_2 emissions were ∼7 million tons per year (Gobierno de Costa Rica, 2020) and in 2018 11.7 million tons (RAND Corporation, 2020), very low figures compared to Colombia and Argentina. For its part, it should be noted that deforestation continues to be a major problem, mainly linked to the cattle sector, an activity that occupies a large part of the affected areas (MINAE et al., 2018). Between 2000 and 2016, however, the country's forest cover has increased permanently, going from 46.53 to 54.56% in this period (OCDE, 2020). There are also notable advances related to the payment of ecosystem services, which between 2010 and 2020 supported the protection of 585,945 hectares of forest land (FONAFIFO, 2021).

Consequently, the elements exposed for the three countries configure a mixture of successes, difficulties, and contrasts. In the first place, it should be noted that external demands must be understood in positive terms, since they allow the development of strategies that would not be carried out spontaneously. In other words, the importance of international organizations and treaties is recognized in a role of oversight of national governments so that they respond, through public policies and legislative advances, to the demands and problems of their citizens. Likewise, it is important to recognize that international organizations not only exercise a controlling role over national governments, but also promote financing mechanisms for the benefit of developing countries. Deforestation and GHG emissions continue to be a common problem in the three countries, although with more worrying figures in Colombia and Argentina. This highlights that those public policies that are more closely coordinated with each other and implemented over a long-term period are reflected in more encouraging processes and impacts, such as in Costa Rica.

CONCLUSIONS

The sustainable development of the cattle sector is an unquestionable need. International demands, in addition to the role of different actors, deny any possibility of continuing with traditional production practices. This scenario commits the national governments to take forceful actions, which are not always reflected in the same ways, since each country has particularities that determine the processes and, therefore, the results. Colombia, Argentina, and Costa Rica demonstrate such contrasts, and understanding their public policies implies going beyond the figures, taking into consideration their social and economic conditions.

To this extent and although the three countries express a political will to promote sustainable cattle practices, they are at different stages. This does not mean, however, that the realities are completely opposite to each other. On the contrary, the general perception is relatively similar insofar as they are all in a process of evolution and still have many objectives to achieve in the framework of the commitments made at the COP21 in Paris in 2015 and with the SDGs 2015–2030. Even though the results achieved so far are not fully satisfactory, the implemented policies should not be abandoned, but rather persist and be expressed in tangible effects. It is necessary to strengthen both the articulation between the initiatives and their actors, while overcoming the fears producers to adhere to the transition process toward sustainability.

It is important to point out that the public policies analyzed in this document have positive impacts in at least two senses. In the first place, their contributions to the environment

TABLE 7 | Recommendations for the design and implementation of public policies.

Stage	Recommendations
(1) Financing	- Promote taxes for the responsible entities/individuals of GHG emissions or deforestation
	- Strengthen payment systems for ecosystem services
	- Involve the private sector in public initiatives and projects
(2) Identification of the problem	- Update the figures on deforestation, GHG emissions, and other environmental indicators to identify the most affected territories
	- Develop spaces for dialogue with communities and producers to hear their opinions
	- Evaluate previous public policies to identify successes and difficulties and thus determine aspects for continuance or reformulation
(3) Design	- Articulate local public policies with regional and national policies
	- Socialize the policies with the different actors (producers, communities, and others)
	- Prioritize sustainability goals over private interests
(4) Implementation	- Involve communities in projects
	- Strengthen technical training plans for producers
	- Support producers in the development of infrastructure
(5) Evaluation	- Create digital platforms where citizens know budgets, objectives, and other characteristics of the initiatives
	- Periodically evaluate the set objectives (promoted by the governments, but with citizen participation)
	- Publish final reports comparing objectives and results

stand out, fostering the protection of natural resources for present and future generations. These include, for example, the implementation of a significant number of silvo-pastoral and agroforestry systems in Colombia, the conservation of forests in Argentina, or the advances in carbon neutrality in Costa Rica. Second, they lead to the benefits for the cattle sector, making it essential that producers understand that they favor themselves when implementing the strategies. This is because environmentally responsible measures prevent problems such as climate change and land degradation, phenomena with direct impacts on cattle production. In the short term, the attitude of certain international markets reluctant to buy beef and dairy products from deforestation areas stands out: sustainable practices can capture new buyers and contribute to the economic profitability of the sector at a time when socially responsible consumption is gaining strength worldwide, meaning that consumer choices are being made increasingly by considering environmental and social repercussions products and services might involve (Izquierdo et al., 2018).

Finally, it is emphasized that although the policies achieved so far provide valuable contributions, it is necessary to assume them as a first stage in a long-term process. As such, it is critical to support their continuity and increase their scalability, to achieve the goal of a wider adoption of sustainable production alternatives, such as silvo-pastoral systems. This process implies the contribution of all actors, from international organizations to public entities, cattle producers, unions and associations, the private sector, academia, and society.

RECOMMENDATIONS FOR PUBLIC POLICY

We recommend that for all the evaluated countries, public policies should be developed that contain clear objectives and budgets, facilitating their development, application, and evaluation. The national extension systems and technical assistance programs need to be strengthened to provide the involved actors (i.e., cattle producers) with required information and knowledge and stimulate the transition toward sustainable cattle farming. For Argentina, we recommend the state institutions to increase their efforts regarding deforestation policies, mainly for the Gran Chaco region. Colombia should formulate more ambitious objectives in terms of the implementation of silvo-pastoral systems, and in Costa Rica actions of national and international institutions should be articulated with the objective of establishing a multi-sector platform for sustainable cattle (like the *Roundtable for Sustainable Cattle* in Colombia or the *Argentine Sustainable Beef Board*). Such platforms stimulate sharing the different experiences made within the sector and thus help in both their achievement and in coordinating common objectives at the national level. Likewise, we recommend that in Colombia, the advances made with the Colombian Roundtable for Sustainable Cattle should continue, since they allow for the consolidation of efforts and, in the future, the monitoring of the National Public Policy of Sustainable Cattle. For all countries, we recommend the consolidation of using technological innovations that contribute to the monitoring of deforestation. Finally, communication channels should be established between the studied (and other Latin American) countries that support knowledge exchange, mutual learning and the sharing of successes and difficulties in the implementation of public policies related to the sustainable intensification of the cattle sector. **Table 7** proposes more specific recommendations for the three countries, considering the difficulties identified (**Tables 2**, **4**, **6**) in our study. Common problems are highlighted, such as the lack of economic resources to develop public policies and enforce laws, for which some financing options are proposed. Likewise, the importance of promoting citizen participation in each of the stages of the policies is highlighted, achieving not only that the objectives are consistent with the needs of the territories and communities, but also that the processes carry out an adequate management of public resources. It should be noted that, while the differences between the three countries are recognized, such recommendations fit all of them, whether in the national context or in local settings. In turn, due to the economic, cultural, and political similarities in Latin America, the points made are relevant at the regional level.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

LL, MD, and SB: conceptualization, methodology, writing the original draft and review and editing, and resources. LL and MD: formal analysis. SB and MD: supervision. SB: funding acquisition and project administration. All authors contributed to the article and approved the submitted version.

FUNDING

This work was funded by the CGIAR Research Program on Livestock. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

ACKNOWLEDGMENTS

We thank all donors who globally support our work through their contributions to the CGIAR System. The views expressed in this document may not be taken as the official views of these organizations. CGIAR is a global research partnership for a food-secure future. Its science is carried out by 15 Research Centers in close collaboration with hundreds of partners across the globe.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.