

# Silvopastoral systems, a powerful approach for cattle ranching to adapt to climate change

**Cattle ranching, one of the most important sectors of Colombia's rural economy, generates income for more than half a million rural families and guarantees a significant share of national supply of beef and dairy production. Extensive ranching—the dominant form of ranching in Colombia—is often unproductive, detrimental to the environment, and highly vulnerable to climate events. This brochure describes a more sustainable cattle ranching model—silvopastoral systems—that enables ranching to adapt to the rigors and risks of a rapidly changing climate. The information presented here draws on a case study\* conducted for the Colombia Mainstreaming Sustainable Cattle Ranching Project (CMSCR).\*\***

\* Mariángela Ramírez Díaz and Karina Pérez. Case Study on the Climate Resilience of Sustainable Livestock Production under Silvopastoral Systems. Study commissioned by the World Bank, within the context of the Colombia Mainstreaming Sustainable Cattle Ranching Project. November 2019.

\*\*The project was implemented by an alliance between the World Bank, the Federation of Colombian Cattle Ranchers (FEDEGAN), the Center for Research in Sustainable Agricultural Production Systems (CIPAV), The Nature Conservancy (TNC), and the Fund for Environmental Action and Children (Action Fund), with financial support from the Department of Business, Energy, and Industrial Strategy of the United Kingdom (BEIS) and the Global Environment Facility (GEF). The project also has institutional support from the Colombia Ministry of Environment and Sustainable Development (MADS) and the Colombia Ministry of Agriculture and Rural Development (MADR).



## A region's climate determines the productivity and feasibility of its agro-ecosystems

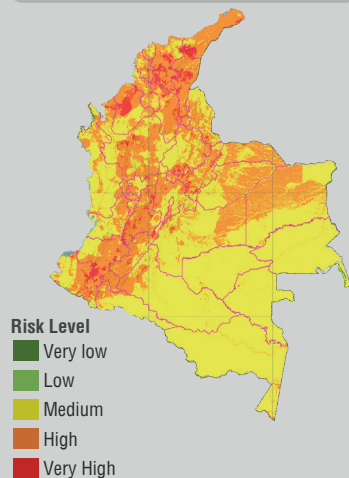
The primary features of a region's climate are rainfall (precipitation) and temperature. Climate is typically subject to variability, meaning that rainfall and temperature can vary as a result of naturally occurring, short-term climatological events. In Colombia, climate variability is propelled by two main climate events: the phenomena known as El Niño and La Niña.

## Climate change threatens Colombia more than nearly all other countries

The Climate Risk Index (CRI) measures a country's exposure and vulnerability to extreme climate events. According to the 2021 CRI, Colombia ranks among the countries that are most highly exposed and vulnerable to climate change. Climate risk varies across Colombia, but for the country as a whole, global warming is expected to increase average temperatures by as much as 2 °C by the end of this century. Although this increase might not seem extreme, it is important to note that an increase of "only" 1°C degree could significantly increase mortality in cattle (Howden *et al.* 2008).

**In Colombia, climate change is projected to increase temperatures by an estimated 1–2 °C to reach 22 °C by 2100**

### Territory's environmental vulnerability<sup>1</sup>



1) Ideam; 2) Global Climate Risk Index, 2021.

### Vulnerability reference data

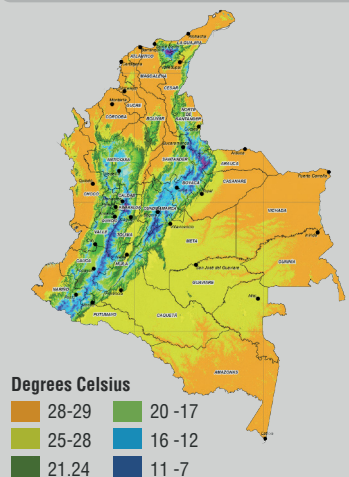
- Colombia's ranking in the Global Climate Risk Index<sup>2</sup>:

**28th position**  
in 2021

**38th position**  
from 2000 - 2019

- Categorization of the most exposed and vulnerable countries to extreme events based on:
  - ✓ Risk exposure
  - ✓ Threat response capacity

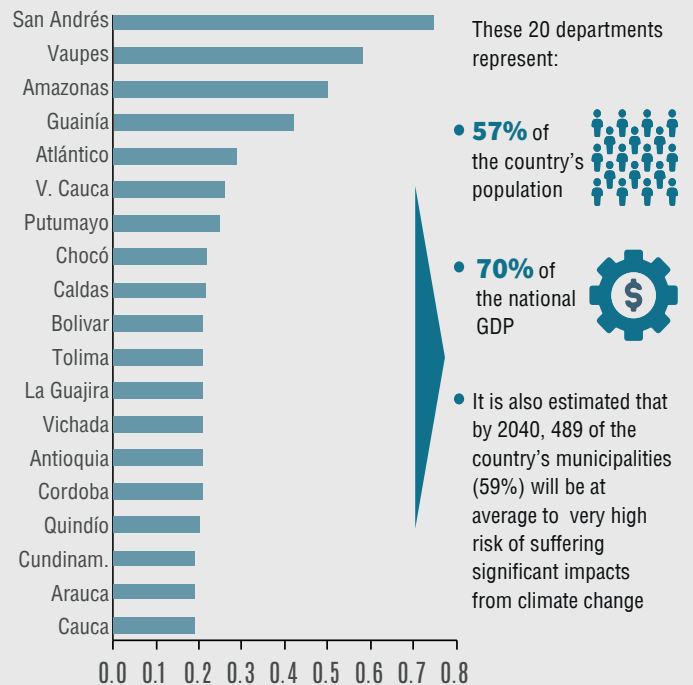
### The average temperature in Colombia is 22.2 °C



(1) Changes vs. average current temperature of 22.2°C  
Source: Third National Communiqué on Climate Change 2017 (TCNCC).

**Climate change in the long term will negatively affect 57% of the population and 70% of GDP**

**20 departments with highest risk due to climate change Scale of 0 to 1**



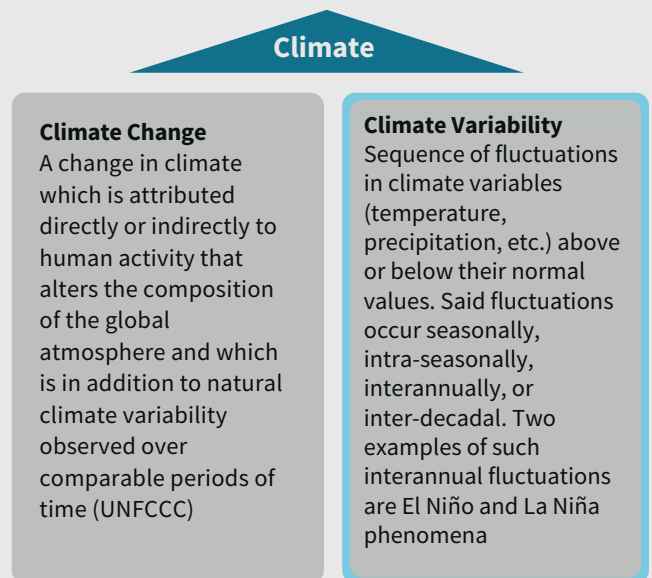
\* The evaluation of this risk indicator considers not only environmental variables, but also food security, health, housing, and infrastructure. This indicator is based on the combination of the threat plus vulnerability to the threat.

Source: Third National Communiqué on Climate Change (TCNCC) 2017.

## Climate variability and the cattle sector in Colombia

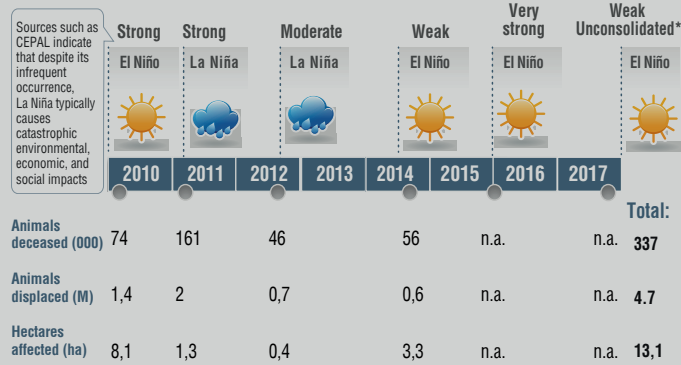
Climate change affects cattle production mainly by increasing the intensity and frequency of climate events. As a result, it is paramount to invest in enhancing the climate resilience of the sector.

### Fundamentals of climate, climate change, and climate variability



In Colombia, El Niño and La Niña climate events have affected over **20%** of the cattle inventory and over **35%** of all land on which cattle are raised.

**El Niño has caused the greatest impacts due to its recurrence and its effects throughout the entire country**

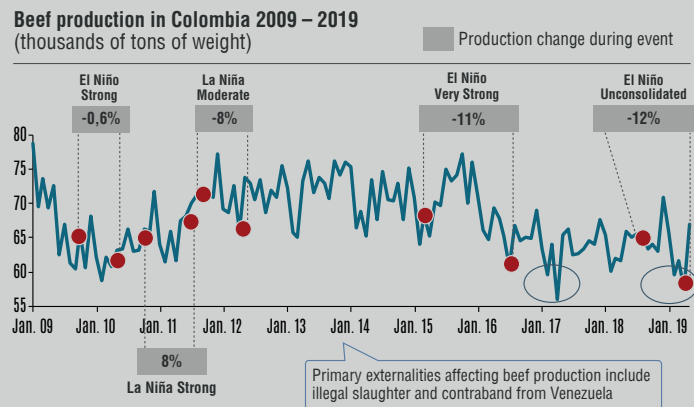


Source: National Oceanic Atmospheric Administration (NOAA), FEDEGAN  
 \*Although the El Niño phenomenon of 2018-2019 never consolidated itself, it did cause a draught in a number of areas.

**Colombia's milk and beef production have been hit hard by climate events over the past decade**

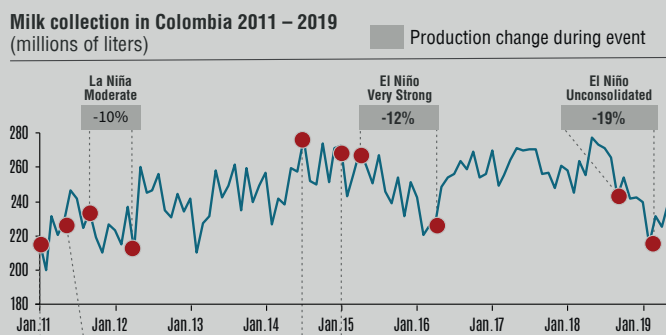
Climate shocks have depleted the profitability of cattle ranching. The figures below show how climate shocks have negatively affected both milk and beef production, leading to productivity losses that are estimated to range from 10% to 19%.

**Beef production losses clearly coincide with El Niño and La Niña in Colombia**



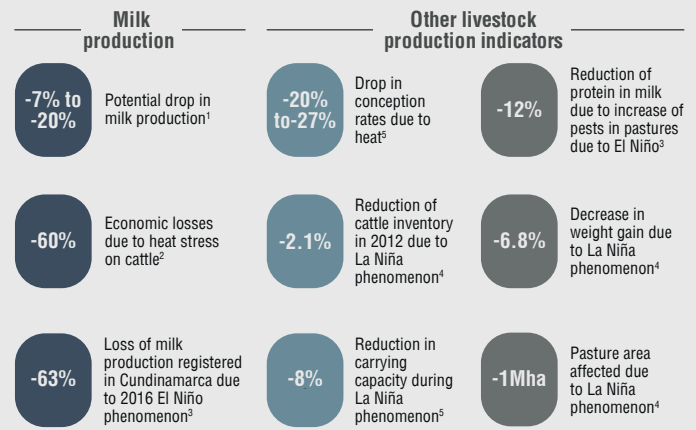
\* Notice of El Niño threat, which ultimately never consolidated itself.  
 Source: FEDEGAN based on data from ESAG – DANE Cattle Slaughter Survey, Consultants' own analysis.

**Milk production losses clearly coincide with El Niño and La Niña in Colombia**



\* Milk productivity evaluated based on milk collection statistics. Source: Price Monitoring Unit of the Ministry of Agriculture and Rural Development (MADR), Consultants' own analysis.

**Many indicators reveal that milk and beef production are vulnerable to the effects of climate shocks**

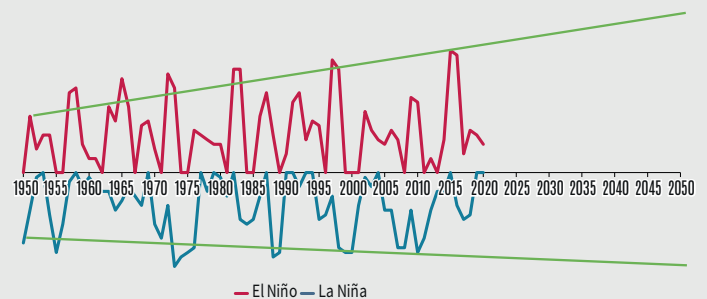


(1) Colombia: Cattle Sector 2015 IADB- DNP, (2) Wolfenson et al. (2000), (3) Cattle ranching farm located in San Francisco, Cundinamarca, (4) FEDEGAN 2019, economic studies, (5) Effects of climate changes on animal production and sustainability of livestock systems 2010.

**The cattle sector has a significant challenge going forward, as climate variability is projected to manifest through more intense and more frequent climate events**

El Niño and La Niña climate events differ in intensity and frequency, but scientists agree that in the future both events are likely to become more intense.

**Potential for climate change to exacerbate future climate events**  
 The Oceanic Niño Index (ONI)



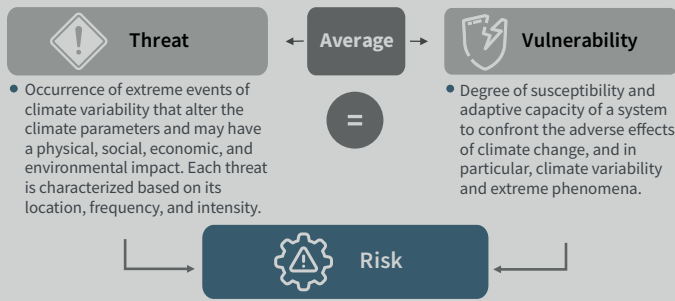
Source: NOAA  
 Note: This index shows abnormally warm phases of tropical pacific ocean temperatures in red (El Niño) and the Oceanic Niño Index (ONI) abnormally cold phases in blue (La Niña). The green lines indicate the potential exacerbation of climatic events in the future.

**Understanding Climate Risks in the Cattle Ranching Sector in Colombia**

Climate risk can be understood as the sum of two elements: threats and vulnerability. Threats are represented by the frequency with which climate events occur and by their severity. Vulnerability is understood as the degree of susceptibility of the cattle ranching system to those recurrent events.

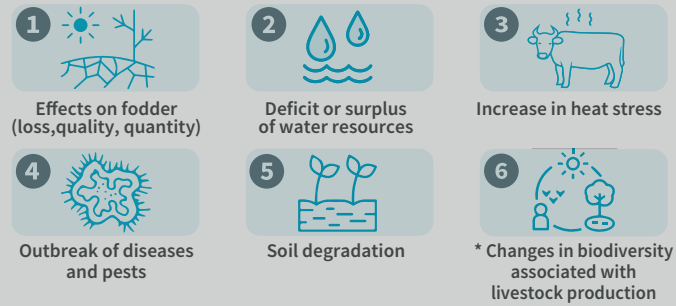


## A system's climate risk is a combination of two variables: threats and vulnerability



Source: IPCC 2014 – Intergovernmental Panel on Climate Change.

## Six main impacts of climate events on cattle production



As a result, the following production indicators are affected:

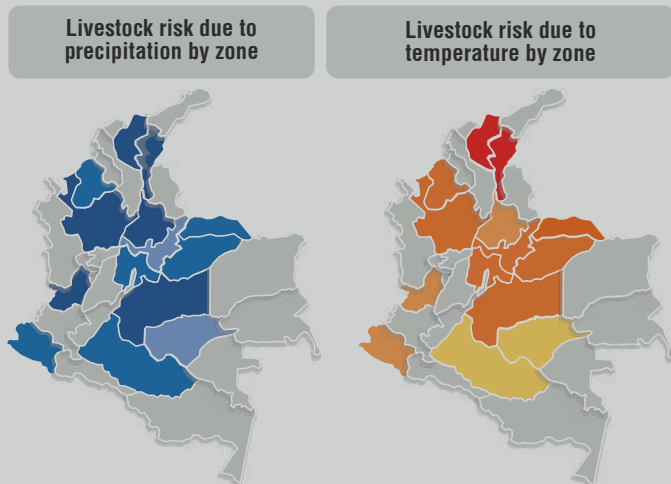
- ✓ Average days of postpartum interval
- ✓ Milk and beef productivity
- ✓ Milk and beef quality
- ✓ Mortality rate

Note: Validation of impacts by indicator in livestock production based on an in-person workshop with the CIPAV team and managers/owners of the Lucerna and Hatice ranches in the Cauca Valley. \* This study mainly considered changes in soil and biodiversity, although it also took into account changes in the ecosystem and the functional connections and interactions among species that provide the ecosystem with a greater capacity for self-regulation in response to a climate event.

## Climate risks in the cattle ranching sector varies greatly across regions

Two regions—Antioquia and the Caribbean—are especially exposed to major climate risks, as shown in the figure.

### Cattle ranching and climate risks by department, Colombia



Category	Color	Scoring
High	Dark Blue	>=7 y <10
Medium High	Medium Blue	>=6 y <7
Medium	Light Blue	>=5 y <6
Medium Low	Very Light Blue	>=4 y <5
Low	White	<4 a 1

Category	Color	Scoring
High	Red	>=7 y <10
Medium High	Orange	>=6 y <7
Medium	Yellow-Orange	>=5 y <6
Medium Low	Yellow	>=4 y <5
Low	Light Yellow	<4 a 1

Source: Consultants' own analysis.

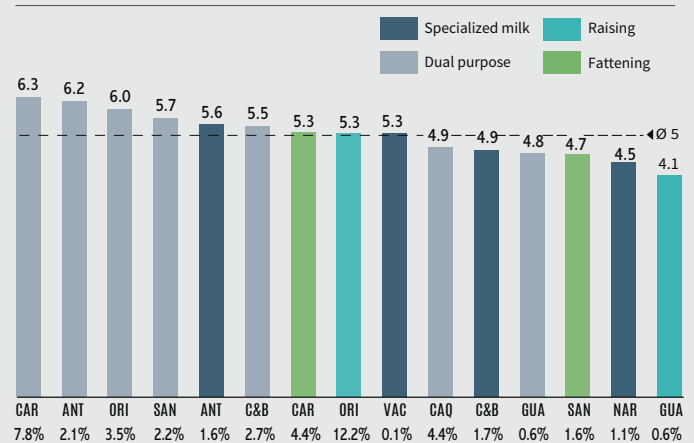
Notes: (1) The risk perception analyses apply to those places where livestock production is carried out, and exclude protected zones. (2) Scores for each department reflect the risk to cattle ranching from climate events based on an assessment of threats and vulnerability. Risk was scored on a 1–10 scale in which 1 = lowest risk and 10 = highest risk.



## Dual-purpose (meat + dairy) and dairy-only production systems face the highest climate risks

An assessment of climate risk by region and production model shows that dual-purpose systems in the Caribbean, Antioquia, and Orinoquía regions and specialized milk production systems in Antioquia have the highest exposure to climate risks.

### Risk perception score by production model and region



Dual purpose and specialized milk production account for 47% of the country's cattle inventory

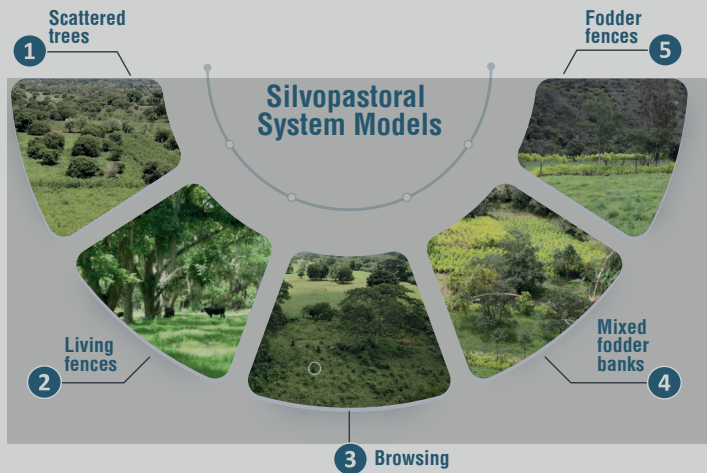
Percentages below the bars indicate the share of the national cattle inventory. ANT: Antioquia, CAR: Caribe, ORI: Orinoquía, C&B: Cundinamarca and Boyacá, VAC: Cauca Valley, CAQ: Caquetá, NAR: Nariño.

## Silvopastoral systems have proven to significantly reduce climate risk in cattle ranching.

Silvopastoral systems (SPS) are grazing systems in which planted trees and shrubs are interspersed with fodder crops, such as grasses and leguminous herbs. SPS can be subdivided into non-intensive and intensive systems. Both types of systems are dynamic, and although their implementation varies by region, both types share four distinguishing features: increased tree cover, pasture management, increased forage and shrubs, and good farm management practices. These systems, which integrate agroforestry with cattle production, not only help to mitigate and adapt to climate change but are recognized as a sustainable way of producing milk and beef. They are often proposed as an effective tool to make cattle ranching more stable, profitable, and resilient—in other words, less risky—as climate change accelerates. The CMSCR Project proved that SPS reduced the risk and vulnerability associated with climate variability by increasing the capacity of cattle ranching operations to adapt and respond to climate events.

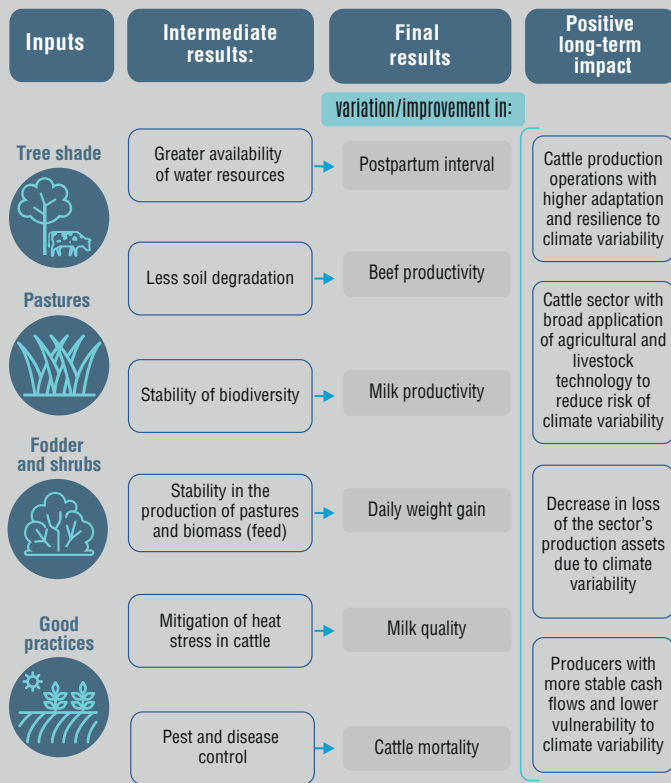
The purpose of the CMSCR Project was to generate more productive, efficient, and sustainable conditions for raising cattle. The project developed capacity to implement SPS, provided technical assistance to support good ranching practices, and validated and integrated approaches to monitor the impacts of different production systems on biodiversity, carbon emissions, and productivity.

**The Colombia mainstreaming sustainable cattle ranching project designed and implemented five models of SPS.**



As shown in the figure below, SPS have direct and indirect impacts on the farm ecosystem and on the indicators of agricultural productivity. Note that a newly established SPS will require three to four years to reach maturity and protect a farm from the impacts of climate variability.

**There are four entry points for SPS to strengthen the resilience of cattle ranching systems**

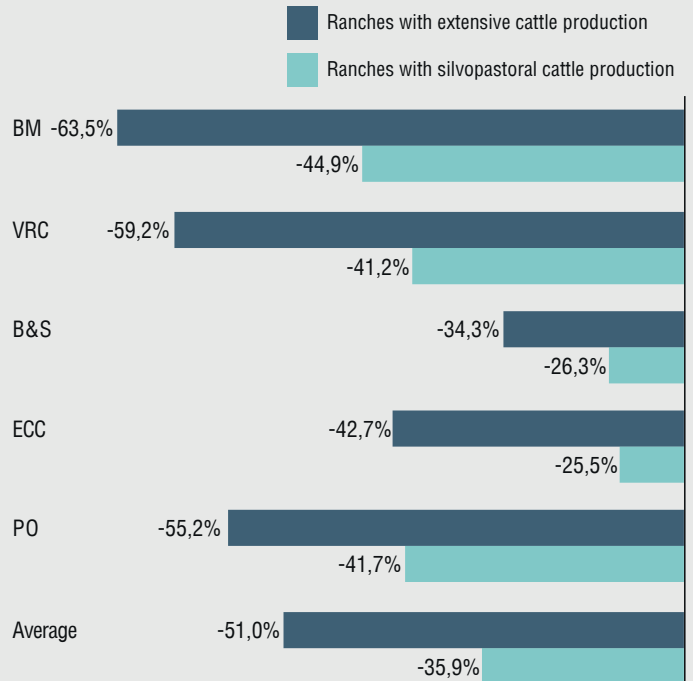


Source: Colombian Mainstreaming Sustainable Cattle Ranching Project, Consultant's own analysis.

On pilot farms set up by the project to test SPS, SPS proved more resilient to climate events than traditional ranching systems. Between 2017 and 2019, farms that implemented SPS reduced losses in biomass production by as much as 20% in some regions during the dry and wet seasons. Across all regions of Colombia over the same period, losses in biomass production on farms with SPS were 15 percentage points lower on average than losses on farms practicing traditional extensive cattle ranching. The adjoining figure illustrates the adaptive benefits from SPS.

**Percentage change in biomass between wet and dry seasons**

First and second half of 2017, first and second half of 2018 and first half of 2019

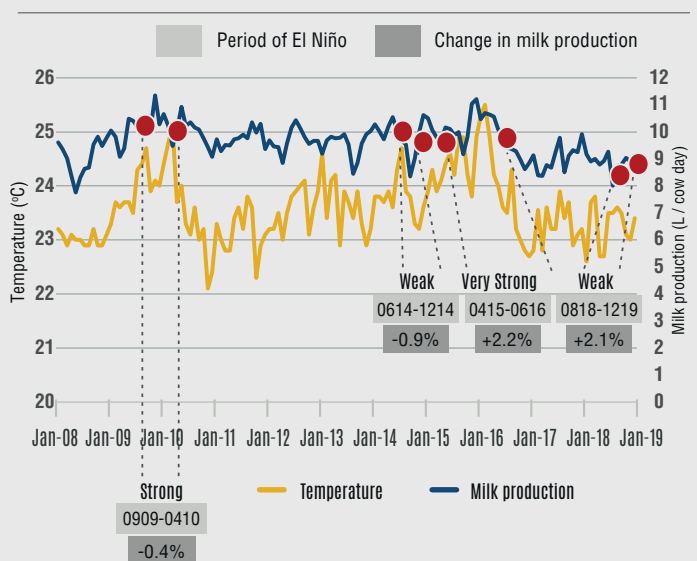


BM: Low Magdalena, B&S: Boyacá and Santander, ECC: Coffee-Growing Ecoregion, PO: Orinoco Piedmont, VRC: Río Cesar Valley Source: Data from ranches in operating zones of the Colombia Mainstreaming Sustainable Cattle Ranching Project.

**SPS can strengthen the resilience of production systems exposed to climate events.**

El Hatico, is located in Valle del Cauca and operates under well-established, mature SPS that have been maintained for 20+ years. The production indicators monitored on this farm confirm the superior climate resilience of SPS. For example, during periods of El Niño and La Niña, milk productivity dropped by as much as 19% nationwide, reflecting losses from the dominant traditional ranching systems. In contrast, at El Hatico, milk productivity declined only slightly—by 0.4–0.9% during El Niño events, and by 0.4%–5.5% during La Niña events as presented in the following graphs.

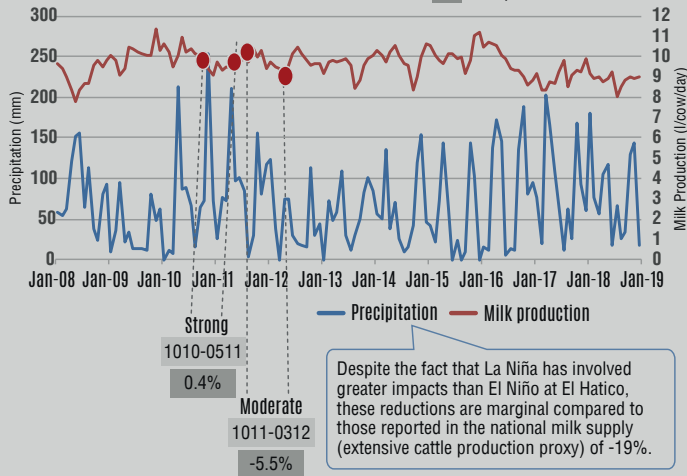
**Relationship between temperature and milk production, 2008 - 2018**



Source: Colombia Mainstreaming Sustainable Cattle Ranching Project with information of El Hatico

During La Niña events, milk production losses on El Hatico ranch were much lower than reported reductions in the national milk supply

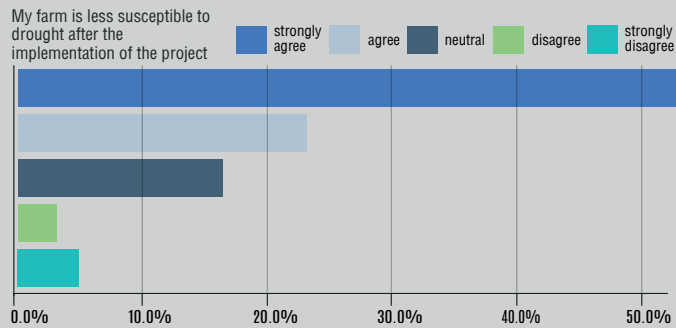
### Relationship of change in precipitation to milk production (La Niña)



Source: Consultants' own analysis, El Hatico database.

Also, seventy percent of the ranchers surveyed and participating in the CMSCR Project reported that implementing SPS had strong positive effects on drought resilience on their ranches.

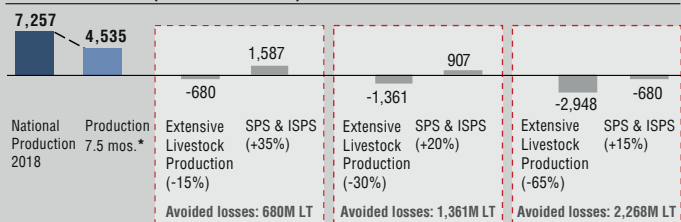
### Perceptions of farmers who implemented sustainable ranching practices



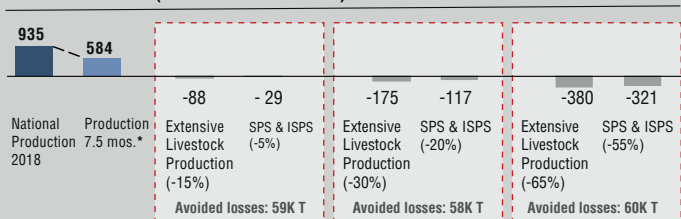
It is estimated that the implementation of SPS throughout Colombia would virtually eliminate climate-related losses in milk production and reduce losses in beef production by 30%, compared to traditional extensive practices.

### Widespread implementation of silvopastoral systems across Colombia would reduce climate-related losses in milk production to zero and cut losses in beef production by one-third

#### Milk Production (million of liters)



#### Beef Production (thousands of tons)\*\*



\* 7.5 mos. has been the average duration of El Niño and La Niña phenomena from 2009 to 2019.

\*\*Tons - channel equivalence - ISPS: Intensive Silvopastoral Systems

Source: FEDEGAN, Consultants' own analysis.

### Key takeaways

- SPS are a proven, powerful approach to reduce the vulnerability of cattle ranching and adapt to an increasingly variable climate.
- It is paramount to identify ways to mainstream SPS in Colombian cattle ranching. As the severity and frequency of climate events increase, so will the adverse effects on the sector, ecosystems, and the profits and welfare of cattle ranchers.
- Investing in resilience through SPS is a win-win strategy, not only for cattle ranchers but also for buyers, processors, and retailers of milk and beef, whose supply chains will become more resilient as SPS become more widespread in Colombia.
- Financial institutions should recognize the resilience embedded in SPS as a driver of reduced vulnerability, which makes climate-smart agriculture projects more attractive for them to finance.
- The reduced vulnerability and increased resilience of cattle ranching under SPS should be seen as a pillar of competitiveness in the ranching sector. For that reason, it is imperative for the public and private sectors to jointly develop a strategy for positioning SPS and other sustainable cattle ranching practices as the new normal in Colombia.

Design and infographics Luz Angela Ochoa Fonseca (World Bank Consultant).  
Photos The World Bank.

