Restoration Cases Flagship Collection

Case #8:

Scaling up silvopastoral systems in La Vieja river basin, Colombia

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Contents

In brief

Overview

In La Vieja river basin, a small NGO began experimenting in the 1990s with silvopastoral systems on a handful of farms, growing and managing trees and shrubs in pastures. They worked closely with farmers, experimented with different techniques, and learned from the results. After several increasingly larger waves of implementation, implementers found that individualized planning and sustained technical assistance were indispensable even at large scales. Using this approach, the Center for Research on Sustainable Agriculture Production Systems (CIPAV) helped farmers implement silvopastoral systems on thousands of farms in La Vieja and across Colombia, while bringing international funders and national governments on board.

CIPAV's silvopastoral systems produce more milk and meat from healthier animals on less land than conventional systems. Farmers began to see benefits after only a few months. Silvopastoral systems also have higher plant diversity, sequester more carbon, and provide a more hospitable environment for cattle and native biodiversity. Using less land allows other areas of the farm to be dedicated to environmentally beneficial goals, such as allowing forest to regrow along waterways and marginal areas to prevent erosion and improve water resources.

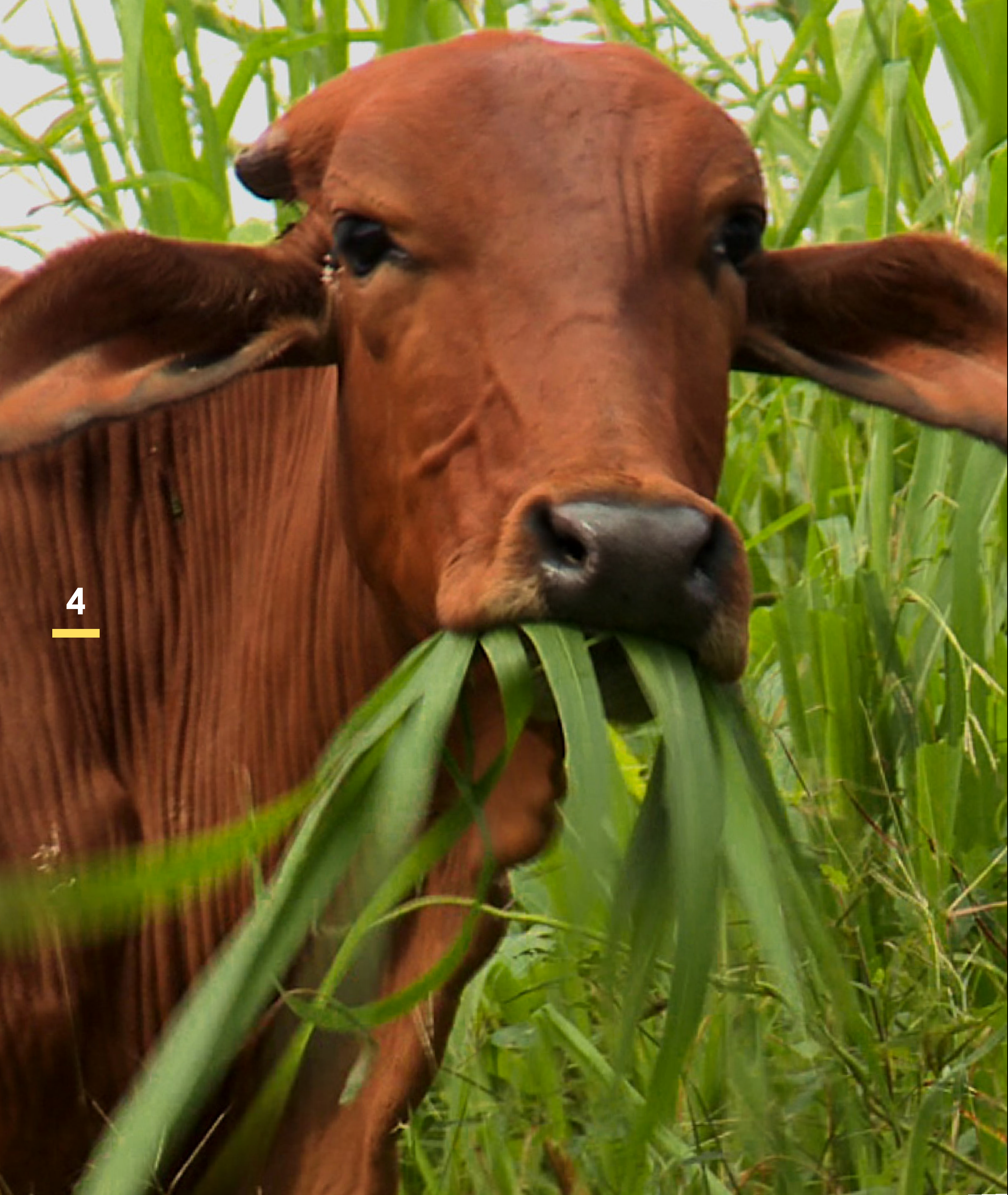
Exemplary practices

At all scales, three key components led to successful outcomes: farm-to-farm visits and demonstration sites; a customized farm plan; and ongoing technical support from trained extension agents. These components helped to create a personal connection with farmers, and were essential to adapt project goals and methods to the local context. When scaling up, CIPAV dedicated additional resources to ensure each was still provided. As CIPAV's Zoraida Calle put it: "In many ways you end up being psychologists. It means understanding the history of the person, their family, their relationship with their land."

Key lessons learned

- *Personalized planning and technical support are essential at any scale.*
- *Promote processes of collective learning between local and scientific knowledge to tailor methods to local conditions.*
- *Always be open to the input of farmers – listen and respond with "how can we make it better?"*
- *High quality, sustained technical assistance is vital and should be provided at no cost.*
- *Seeing is believing: Use peer-to-peer learning and connect similar farms.*
- *Demonstration farmers should be exceptional communicators and leaders*

Río La Vieja 5. Cartago, Valle, Colombia
Source: https://commons.wikimedia.org/wiki/File:R%C3%ADo_La_Vieja_5._Cartago,_Valle,_Colombia.JPG



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Restoration narrative

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La Vieja river basin, Colombia

Scaling up silvopastoral systems

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Background and context

La Vieja river basin in the Andes of southwestern Colombia (Figure 1) is home to some of the first and most successful silvopastoral systems in Colombia. Silvopastoral systems (SPS) involve integrating trees and shrubs into pastures, as well as restoring forests in key places, to improve productivity, diversify farm products, and/or reduce inputs. Since 1991, CIPAV has implemented these systems at larger and larger scales by working closely with hundreds of farmers in this region (especially the departments of Quindio and Valle del Cauca) and nation-wide. "When people think about scaling up, they often think of drones and remote sensing. Which can be great! But they do not replace individualized attention and support. ...And so, the strength and challenge of these projects is replicating these essential components at a large scale," says Zoraida Calle of the Center for Research on Sustainable Agricultural Production Systems (CIPAV). This philosophy is at the heart of CIPAV's approach, which has led to the regreening of thousands of hectares of pasture across Colombia.

Part of the Andes Biodiversity Hotspot, La Vieja river basin (4°26'N, 75°38'W) contains a range of forest types from tropical dry forest (precipitation 500–1000 mm/year) to premontane and montane moist forest (1000 masl to >3000 masl; precipitation up to 3000 mm/year) (Calle and Holl, 2019; Zapata Cadavid et al., 2019). The watershed is geographically and ecologically diverse and includes some of “the scarcest, most transformed and threatened ecosystems in the country” (Marull et al., 2018, p. 1075). Urban sprawl, industrial agriculture, and cattle farming pose the biggest threats to forests (Chará and Murgueitio, 2005; Marull et al., 2018). SPS were mostly implemented on rolling terrain between 700 and 1700 masl (Chará and Murgueitio, 2005; Zapata Cadavid et al., 2019).

Until the 1950s, the region had a diverse landscape including forests and traditional multipurpose smallholder farms. As European colonists established a trade-dependent economy, traditional practices were replaced by industrial agriculture and cattle grazing. Post-colonial government policies in the 1980s focused on economic liberalization, technological optimization, a subsidized sugarcane sector, and converting flatlands to intensive agriculture at the expense of mixed farms, traditional agriculture, and remaining forests. In lowland areas, industrial sugarcane monocultures displaced mixed farms and forests, increasing groundwater and synthetic fertilizer use and causing

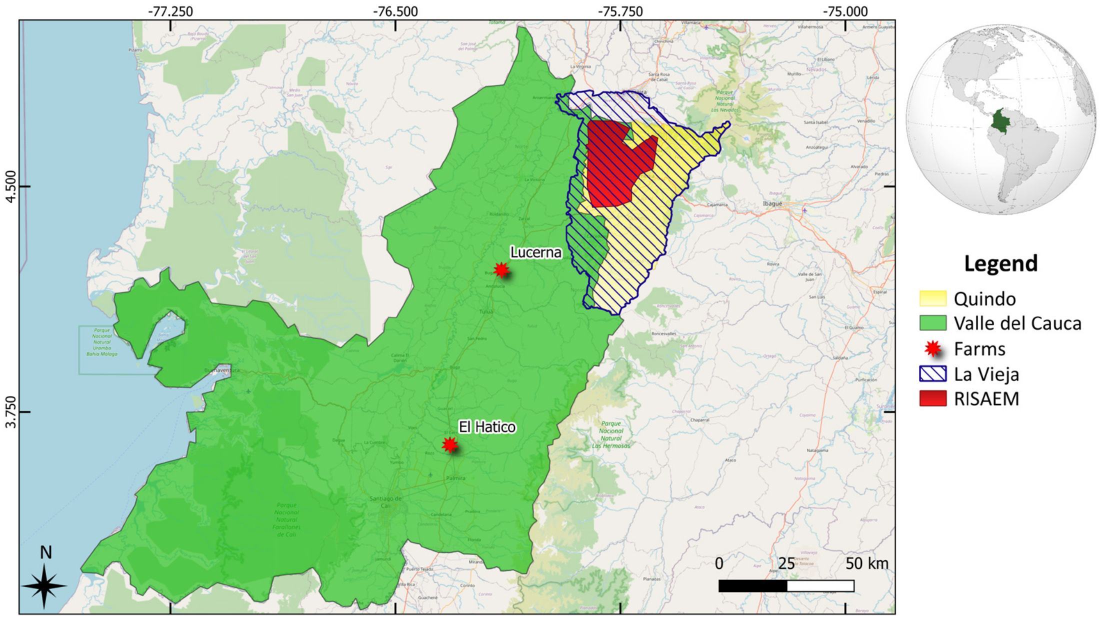


Figure 1. (a) The location of La Vieja River watershed in Colombia’s Andean region with the two initial demonstration farms (El Hatico and La Lucerna). (b) The Regional Integrated Silvopastoral Approaches to Ecosystem Management (RISAEM) project area covers 9 municipalities in the departments of Quindío (dark green) and Valle del Cauca (light green). (c) The locations of the five sub-ecoregions that participated in the Mainstreaming Biodiversity into Sustainable Cattle Ranching (MBSCR) project as well as demonstration farms in the country. Source: Calle, 2019

widespread soil degradation (Marull et al., 2018). The region also boasts renowned coffee growing areas at higher elevations, where production for international export displaced traditional agriculture (Marull et al., 2018).

When coffee and sugar prices both fell in the 1980s and 1990s, many farmers switched to cattle ranching. The national coffee regulating body *Federación Colombiana de Cafeteros* even paid farmers not to grow coffee to increase the price, advising them to switch to high intensity, high productivity cattle systems. But high-intensity ranching was not sustainable. Ranchers fruitlessly increased chemical inputs, but soon many could not afford the inputs required. This led to degraded pastures with compacted soils, de-vegetated riparian areas, poor stream water quality, and low biodiversity (Chará and Murgueitio, 2005). For example, in Quindío, over 70% of forests were cleared for agriculture and low productivity pasture (less than one cow/ha) (Calle, 2019; Chará and Murgueitio, 2005; Zapata Cadavid et al., 2019). Despite using large amounts of land, meat and milk production was low (World Bank, 2008). Pastures were typically exotic grass monocultures with less than 5% tree cover that relied on fertilizers and herbicides (Calle and Holl, 2019). Many ranchers found it increasingly difficult to earn a viable living.

The turning point: engaging ranchers to adopt silvopastoral practices

Cattle ranchers faced a crisis situation where already low farm production continued to decline. In 1991 CIPAV[1] responded with a systems approach using the principles of agroecology to improve meat and milk production, economically and environmentally (Zapata Cadavid et al., 2019) (Figure 2). CIPAV tested different SPS techniques on several farms, including El Hatico farm and Lucerna farm in Valle de Cauca, where they had long-term relationships with farmers (Calle et al., 2013; Zapata Cadavid et al., 2019). They provided technical support and designed the intervention as a research experiment. This approach improved CIPAV's subsequent work and provided proof of concept for other farms. Both El Hatico and Lucerna have now successfully used intensive silvopastoral systems (ISPS) for nearly 30 years (Figure 2) (Box 1).

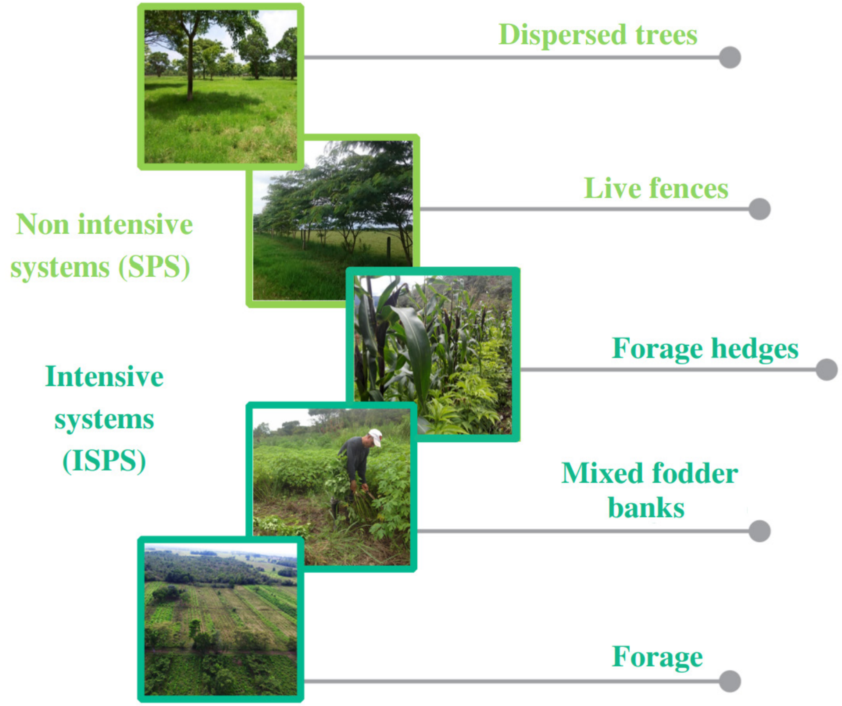


Figure 2. Intensive (ISPS) and non-intensive (SPS) silvopastoral systems. Techniques are often used in combination on the same farm. Source: World Bank, 2019

[1] *Initially set up in 1986 to find alternative uses for sugarcane byproducts during a global price crash, when sugarcane prices recovered, CIPAV began experimenting with different SPS strategies.*

For most farmers, planting trees and shrubs was a completely new and radical approach to managing pastureland. Typically, trees and shrubs were removed in favor of monoculture grass. Clearing woody vegetation was culturally accepted as a "good" ranching practice because trees were thought to compete with grass.

But in 2001, in the face of failing environmental conditions and decreasing profitability of cattle ranching, managers of 104 ranches representing nearly 3,000 ha volunteered to implement SPS (average ranch size 34 ha, ranging 1–400 ha). Funded by the World Bank and the United Nations Global Environment Facility (GEF), the initiative—Regional Integrated Silvopastoral Approaches to Ecosystem Management (RISAEM)—aimed to increase biodiversity and carbon storage on farms in La Vieja watershed (Figure 1). CIPAV was the local implementer (Figure 1b). Although poverty alleviation was not an explicit goal, the project was implemented when farmers were facing a deep economic crisis. Most had been coffee growers until a few years prior, and many had accepted perverse subsidies from the coffee sector: one to cut down all shade trees, followed years later by another to cut down the coffee itself. Farmers switched to ranching quickly without sufficient knowledge about raising cattle, which led to environmental degradation and deforestation. Based on the success of El Hatico, Lucerna, and other farms, this "pilot project" helped ranchers voluntarily implement SPS and ISPS to improve degraded pasture using biodiversity-friendly practices (Calle et al., 2013). It also tested if and how payment for environmental service schemes (PES) could accelerate the transition to SPS (World Bank, 2008; Murgueitio et al., 2011). The project targeted two key barriers to adopting SPS—access to financial capital and access to technical knowledge—by providing partial start-up funding and sustained technical support and training (Calle et al., 2013).

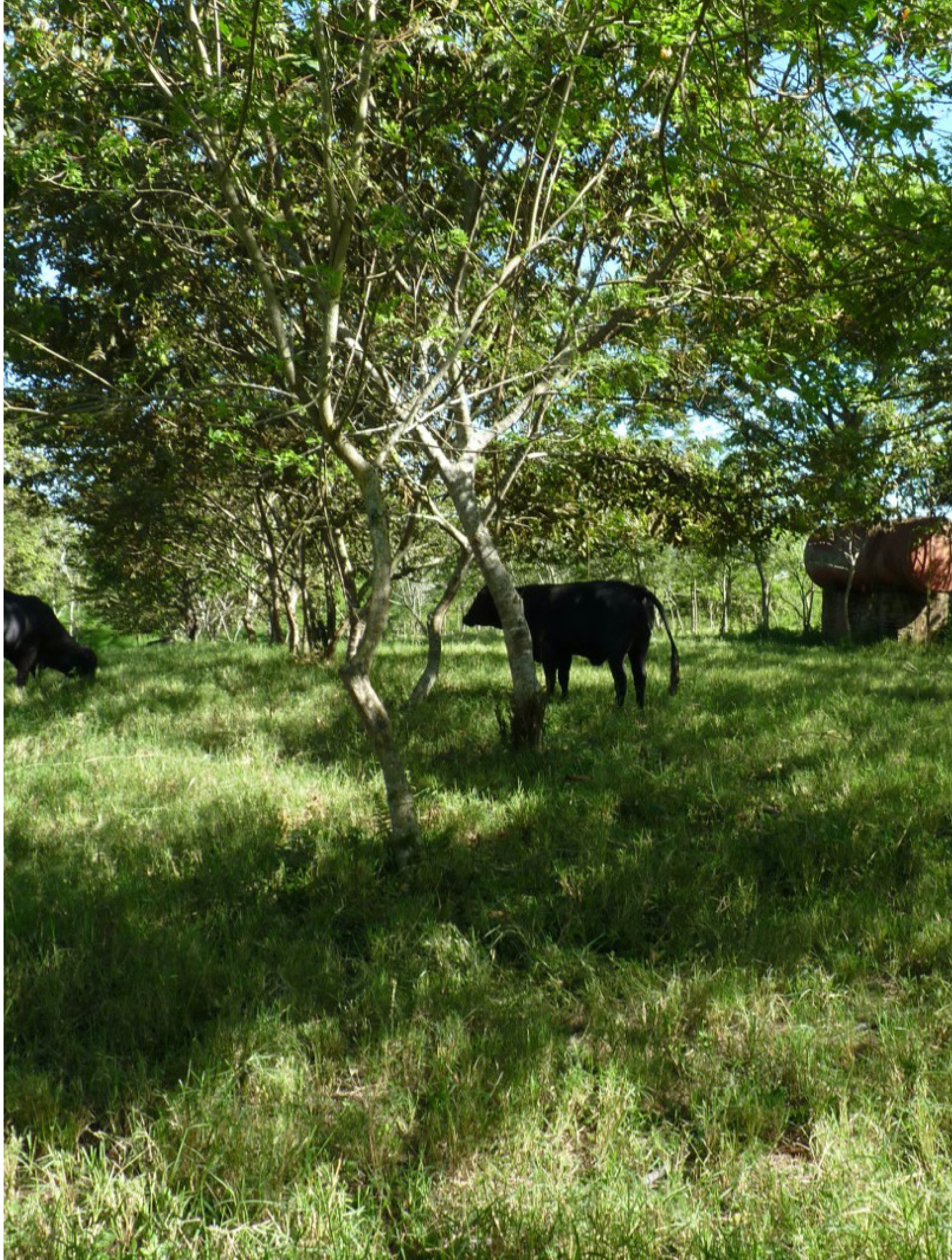
Engagement and planning

Farmers and other stakeholders could see successful outcomes on the initial farms firsthand, a key component of the recruitment strategy (Box 1). CIPAV used broad participatory consultation to engage multiple stakeholders in meetings and workshops. Stakeholders include technical experts, scientists, farmers and farmer organizations, local NGOs, local environmental government representatives, and the private sector.

Participation was voluntary but required farmers to complete a complex process to demonstrate their assets were legal, which prevented some from participating. Farmers received personalized technical assistance and found that by planting trees and fodder shrubs they could produce more milk and meat in a smaller area with few to no chemical inputs. This practice freed up land for restoration for other ecosystem services, including protecting waterways (Calle and Holl, 2019). Following the four-year RISAEM project period, most ranchers kept SPS in place, and some farms served as important demonstration sites for the larger initiatives that followed.

Based on the success of RISAEM and other pilots, SPS were implemented on a much larger scale in Colombia and elsewhere in Latin America. Prior to this large-scale project cattle ranching remained marginally profitable, suffered from increasing land degradation, and was vulnerable to climatic changes (World Bank, 2020). The Colombian government was looking for ways to improve rural livelihoods and environmental conditions by increasing the competitiveness of the cattle industry (World Bank, 2020). In 2006, after hearing about RISAEM, a representative from La Federación Colombiana de Ganaderos (FEDEGÁN, the Colombian Cattle Ranching Federation) visited El Hatico. There he saw well-fed cattle in a lush pasture. Impressed, he immediately called his farm manager and instructed him to implement SPS (A. Calle, 2021, personal communication, 19 July). His experience, along with a growing regional awareness and acceptance of SPS, led to a large-scale project—Mainstreaming Biodiversity in Sustainable Cattle Ranching (MBSCR)—led by FEDEGÁN and supported by the Colombian government with other partners (see “Actors and arrangements”). MBSCR aimed to implement SPS on ~4,000 farms across 160,000 ha in five cattle ranching regions with high biodiversity and conservation value (FEDEGÁN et al., 2020). Participating ranchers managed 1,169 farms from Quindío, Valle del Cauca, and three neighboring departments. The goal was expanding RISAEM's work to a larger and more diverse geographical area (World Bank, 2020), engaging mainly small to medium (4–200 ha) ranches in different environmental and social contexts (World Bank, 2020).

Farmers participating in the MBSCR faced all the challenges of their predecessors plus growing impacts of climate change (Calle, 2019). All participants had experienced extreme temperatures and/or weather events and many explained they participated to mitigate the direct and indirect effects of climate change (Calle, 2020), as well as improve pasture and cattle productivity, protect the environment, receive support and technical assistance, and improve soil fertility (Calle, 2020). MBSCR held 458 training events reaching more than 12,000 stakeholders, including farmers (46%), students (32%), technicians (19%), and training professionals (3%). They also provided intensive training for nearly 700 technicians to provide individualized on-farm support (World Bank, 2020) (Figure 3). A public policy committee, overseen by the Ministry of Agriculture and Rural Development, was established to relay learnings from the field to national and regional policy makers (World Bank, 2020).



Box 1: Engaging farmers

"Manuel,"[2] a local farmer in Valle del Cauca, was initially against the idea of silvopastoral systems (SPS). Like many farmers in the region, he felt that using trees was not "how ranchers do things" and had observed how solitary shade trees would cause cattle to congregate which led to compacted soil and poor grass growth under trees. But his neighbors convinced him to join a field trip to El Hatico farm, one of CIPAV's early experimental pilot sites. He reluctantly attended and was amazed by what he saw: increased productivity with no chemical inputs. He decided to give it a try and signed up to participate in the 2002 RISAEM initiative. It turned out that Manuel was one of the region's very influential and well-connected farmers. He implemented many components of SPS on his own farm, including live fences, riparian forest protection, and so forth. But he also convinced others to adopt SPS, even farms that did not officially participate in the program—the farm next door to him (owned by his wife's family) adopted many of the same practices without external technical or financial support. This story is one of many in which ranchers who were initially skeptical ended up radically changing their practices and way of thinking after seeing results firsthand, leading to neighbors and communities adopting similar practices. Pilots and building community were an essential part of this process.

[2] *Pseudonym*

Actors and arrangements

CIPAV led the development, design, and implementation of SPS during all waves of implementation. CIPAV became an NGO in 1991, with a mission to improve animal feed and nutrition. The RISAEM initiative was implemented by CIPAV, funded by the United Nations Global Environment Facility (GEF) and administered by the World Bank within the Livestock and Development Initiative (LEAD). RISAEM aligned well with the World Bank's Country Assistance Strategy, aimed at improving environmental, economic and social conditions through decentralized environmental management.

A public-private partnership between FEDEGÁN, CIPAV, the Nature Conservancy (TNC), the United Kingdom government, GEF, Fondo Acción (a private fund), and the Ministries of Environment and Agriculture funded *Ganadería Colombiana Sostenible* or Mainstreaming Biodiversity into Sustainable Cattle Ranching in Colombia (MBSCR) (Chará et al., 2019). This country-wide initiative was commissioned by the World Bank and funded initially by GEF (US$7 million) and then the UK government (US$20.7 million). FEDEGÁN managed the project's outreach and technical assistance and coordinated across levels of government (FEDEGÁN et al., 2020). CIPAV coordinated project design, conducted applied research, adapted methodologies to meet local needs, and monitored the project at the farm scale. TNC monitored landscape-level changes (Calle et al., 2013).

Figure 3. Training and educational programs on biodiversity and silvopastoral systems took place for future generations. Source: Rios, 2019

Implementation

Despite vastly different scales of implementation in phase 1 (two farms +), phase 2 (104 farms) and phase 3 (4000+ farms) (Table 1), each relied on the same three vital components: establishing demonstration farms, developing personalized farm plans, and providing excellent and extended technical support.

Key component 1: Demonstration and pilot farms.

Robust demonstration (demo) farms and pilot projects[3] were essential. Each previous scale of implementation demonstrated results for the next. CIPAV's first pilot farms—including El Hatico (Figure 4) and La Lucerna—showcased the successful economic and ecological outcomes of SPS and ISPS in real life conditions and generated long-term data on production and costs (Calle et al., 2013). After 30 years, these farms continue to inspire and educate.

In subsequent waves of implementation, CIPAV set up demo farms and pilots in different conditions. Demo farms were usually established prior to recruiting other participants (Box 1). In RISAEM, demo farms both encouraged adoption by farmers and engaged conservation organizations who were previously wary of working with ranchers. But in MBSCR, funders initially did not support demo farms. As a result, uptake was slow until demos were eventually established.

CIPAVs demo and pilot farms were exceptionally effective thanks to three key practices. First, they worked with farmers who were great communicators, able and willing to share the story of their farm. Recruits were also innovative, willing to take risks/adopt early, had a close connection to the land, and had clear intergenerational exchange (i.e., knew someone would take over their farm). Second, they created demo farms for multiple 'types' of target participants. They found that small farmers did not connect well with larger farmers and did not identify with technological solutions developed by them—and vice versa (A. Calle, 2021, personal communication). CIPAV established multiple demos to match farm characteristics including scale, regions, types of cattle, and altitude. Third, they organized site visits for potential participants including a farm tour and lunch. Host farmers would describe their successes and failures, and visiting farmers could discuss and ask questions. Host farmers sometimes sold goods, and many eventually developed small side-businesses showing people around their farms.

[3] *On demonstration farms, CIPAV worked with farmers to experiment and show results. Pilot projects were developed to scale up and test experiments from demo farms.*

Project	Main actors	Project period	Region	# of farms	Main goals
Initial Pilot Farms	Center for Research in Sustainable Systems of Agricultural Production (CIPAV); El Hatico farm + Lucerna farm (plus others in different areas of Colombia)	Since 1991	Valle del Cauca	2	Experiment with and evaluate silvopastoral systems (SPS) in real-life conditions
RISAEM: Regional Integrated Silvopastoral Approaches to Ecosystem Management in Colombia	Global environmental facility (GEF), World Bank, CIPAV	2002-2008	Valle del Cauca and Quindío (2 departments)	104	Help farmers adopt biodiversity-friendly practices to improve degraded pastures; test PES concept for productive systems/SPS.
MBSCR: Mainstreaming Biodiversity into Sustainable Cattle Ranching	GEF, United Kingdom government, World Bank, La Federación Colombiana de Ganaderos (FEDEGÁN), The Nature Conservancy, CIPAV, and Fondo Acción	2010-2020	12 departments across five sub-eco-regions	4,100	Pilot and test SPS in geographically diverse conditions; further applied research and adaptive management

Table 1. Implementation "waves" in and around Valle del Cauca. In all cases farmers voluntarily implemented silvopastoral systems (SPS) on private land.

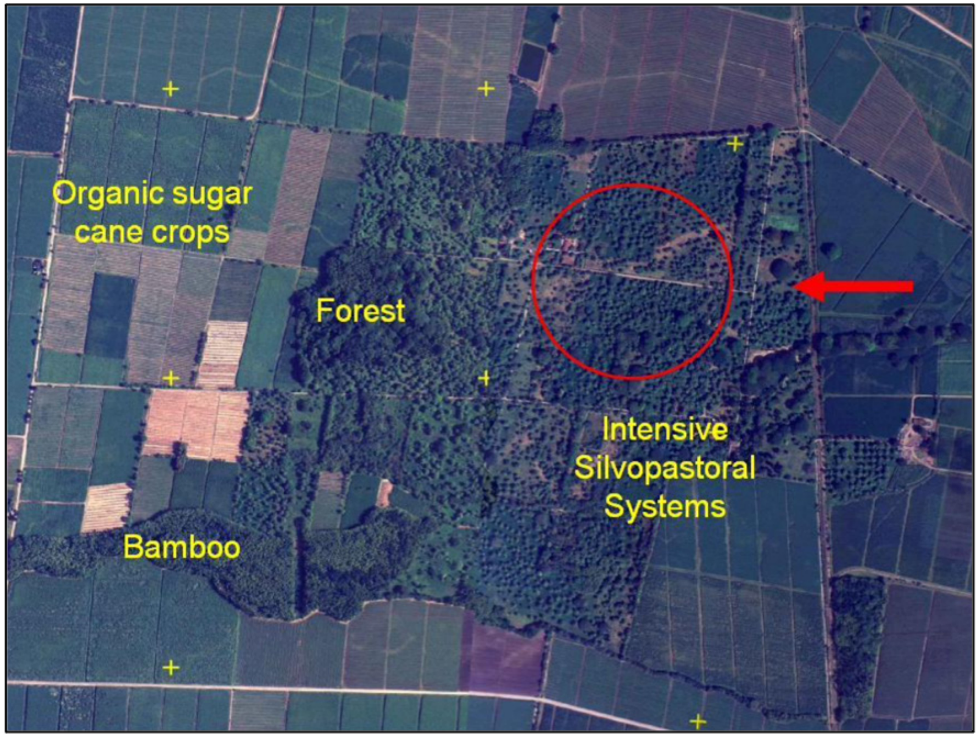


Figure 4. Aerial photo of El Hatico farm. Source: Landscape Dialogue

Key component 2: Individual farm plans.

At all implementation scales, establishing a personalized farm plan with the farmer was vital. A trained team would travel to each farm to establish past and current land use and identify the best areas for farming, ecological restoration, hydrological function, and cattle ranching. It was a visioning opportunity for the farm owner, their family, and project promoters to debate and collectively decide what the farm should look like, and they essentially mapped how farmers wanted the farm to look in 10–20 years. Farm plans incorporated economic and ecological components to identify the best actions to improve productivity while giving land back to nature.

Key component 3: Techical assistance throughout implementation.

Technical help was essential but typically not a cost farmers could afford. CIPAV trained extension workers to support farmers during implementation and for the first several years after establishment. In addition to a broad knowledge of trees and cattle ranching, extension workers needed soft skills to establish close connections to farmers, build trust, and maintain relationships. CIPAV also distributed technical bulletins on sustainable cattle production (World Bank, 2008). In 2011, during MBSCR, Yale University's Environmental Leaderships and Training Initiative (ELTI) also provided two field courses for the project's technical team (ELTI, 2019) on paddock rotation, silage technologies for fodder, protecting water sources, water harvesting technologies, creating nurseries and growing seedling, restoring and conserving fragile areas, among other topics (World Bank, 2020).

CIPAV used participatory techniques to adapt SPS to the needs of specific regions. They also reinforced a network of peer learning: farmers were connected to other farmers interested in similar topics through existing organizations, often with shared goals such as a specific breed or product (Calle et al., 2013). SPS and ISPS were implemented, often in combination, according to the needs of the farm. ISPS typically involves planting fodder shrubs at high densities (10,000–20,000 shrubs/ha) (Figure 2) after existing plant cover has been removed mechanically or with herbicides. Practitioners use either nursery seedlings or direct seeding: nursery seedlings had higher labor costs and survival rates; direct sowing produced high plant densities (more than 20,000 shrubs/ha) but was limited to flat, tractor accessible areas

(Zapata Cadavid et al., 2019). The main fodder shrub used was *Leucaena leucocephala*, with shrubs *Tithonia diversifolia* and *Guazuma ulmifolia* also used in acidic soils and at higher altitudes. Grasses were planted after shrubs were established (~45 days) (World Bank, 2008; Zapata Cadavid et al., 2019).

During MBSCR, CIPAV provided training to grow native trees and fodder plants in nurseries. A network of 116 plant nurseries was created, collectively providing 3 million+ trees and shrubs of 50+ native species important for fodder, domestic use, and biodiversity conservation (World Bank, 2020). Farmers were encouraged to fence off less productive (e.g., steep slopes) and riparian areas to allow forests to naturally regenerate. Some also planted fast-growing tree species and/or cleared grass to encourage native trees to grow (Calle and Holl, 2019).

CIPAV and individual researchers monitored the initial farms using ecological and economic indicators for applied research purposes (Zapata Cadavid et al., 2019). RISAEM farms were continuously monitored, proving longitudinal data on ecological indicators (e.g., tree species, tree stem density, ground cover and canopy cover, soil organic matter, forest dependent bird species, reduction in soil erosion (Calle and Holl, 2019; World

Bank, 2008)) and economic indicators (e.g., increase in farm income, milk produced/ha/year, stocking rate) (World Bank, 2008). Implementers also monitored land use (e.g., chemical use, voluntary live fences, regenerating forests) and water quality (e.g., biological oxygen demand, turbidity) (World Bank, 2008). Water was monitored through participatory community monitoring including many young people and women (World Bank, 2008). MBSCR built on and expanded the indicators used in RISAEM, adding landscape-level monitoring (e.g., estimated CO2 capture/removals in soil carbon and above-ground biomass) conducted by The Nature Conservancy (World Bank, 2020).

Outcomes and impacts

At all scales, implementing SPS increased production and on-farm biodiversity, reduced the need for chemical inputs, and mitigated negative climate impacts of rearing cattle. At El Hatico (now El Hatico Nature Reserve, and still a working farm), pastures previously required copious chemicals and irrigation, and tree cover was sparse—less than 10 trees/ha. But after converting all pastures to ISPS with 70+ tree species, the tree canopy promoted nutrient cycling and water holding capacity, and reduced water loss. The result: they no longer needed irrigation, and began selling certified organic milk. Milk production increased from 7,436 to 18,486 L/ha/year and pastures went from supporting 3.35 to 5 cows/ha. Cows had access to more food, and a greater variety of food: biomass, protein, and micronutrients all increased in ISPS (Murgueitio et al., 2011; Calle et al., 2013, p. 684). El Hatico has been an organically certified farm for more than 20 years, and the whole farming system relies on biological processes.

During RISAEM, farmers collectively implemented ISPS on more than 140 ha, transformed 70% of their previously treeless pasture into SPS, created more than 350 km of live fencing (a 2000% increase), preserved 23 ha of riparian corridors, and protected existing forests (Calle, 2019). These changes collectively led to the ecological rehabilitation of more than 3,700 ha in La Vieja river basin (Quindío and Valle del Cauca) (TNC and CIPAV, 2014; Calle, 2019; Calle and Holl, 2019). In 2017, 12 years after implementation, many participating farms still used SPS and maintained reforested areas (Calle, 2019; Calle and Holl, 2019).

Under MBSCR, 30,000 ha of land were converted to SPS (nearly 20% ISPS) (World Bank, 2019) and 18,238 more hectares were protected (Russi et al., n.d.). Over 2,800 ha of secondary forests recovered, and 3.1 million trees were planted, 50% for conservation purposes (Rios, 2019; World Bank, 2019). Across the country, 4,100 farmers (17% female) adopted SPS (Rios, 2019). 45 demonstration farms were established across the five project regions, educating and training farmers and children about biodiversity (Rios, 2019). The project successfully engaged mainly small-scale producers: 77.7% of participating farms were small (average 19 ha), 17% medium (average 85 ha), and 5% large (average 306 ha) (World Bank, 2020). ELTI calls this country-level initiative the "most ambitious of its kind that has taken place in Colombia or other Latin American countries . . . project activities covered 60,000 ha of cattle grazing lands located in 89 municipalities and 5 regions of the country, and benefited more than 4,500 farmers" (ELTI, 2019, p. 1).

Collectively, three implementation waves produced the following outcomes:

SPS were adopted widely. Each wave built on the previous one, demonstrating results in an increasingly broad range of contexts. Projects subsequently built interest and participation from multiple sectors, including landholders, government and industry. Widespread adoption under FEDEGÁN was largely due to the success of CIPAV's initial pilot farms and RISAEM (World Bank, 2008).

On-farm tree cover and biodiversity increased. Tree cover increased on most participating farms (World Bank, 2008; Rios, 2019; World Bank, 2019) (Figure 5), and forests showed a promising capacity to recover (Figure 6; Figure 7). After 10 years, forests restored under RISAEM had, on average, 89% canopy cover and 77% ground cover with <5% pasture grass, higher tree species density, and proportionally more late successional species than existing disturbed forests (Calle and Holl, 2019). Most farmers also installed live fences and increased tree density in pastures (World Bank, 2008) (Figure 6). Birds were more diverse in SPS than treeless pastures (Sáenz et al., 2007) (Table 1), and dung beetle abundance (an indicator of high habitat quality) increased by 30–50% (Giraldo et al., 2011). Farms participating in MBSCR collectively housed 725 plant species (Russi et al., n.d.), 522 bird species (Rios, 2019), and over 230 dung beetle species (FEDEGÁN et al., 2020; World Bank, 2020). A total of US$2.1 million was paid to ranches that improved biodiversity (approximately US$1,430/farm) (FEDEGÁN et al., 2020). Carbon emissions were lower and sequestration higher. Compared to conventional pasture, SPS sequester more carbon and produce fewer carbon emissions. The MBSCR project captured an estimated 1.13 million tons of CO2 equivalent (World Bank, 2020) and helped to avoid emission of an additional 433,970 tons of CO2 over 10 years (World Bank, 2019; FEDEGÁN et al., 2020). Converting only 20% of farmland to ISPS was estimated to reduce on-farms CO2 emissions by 40% (Rios, 2019).

Productivity increased while inputs decreased. Fodder shrubs increased pasture productivity by directly providing fodder and also improving soils for other forage plants. In ISPS, dry matter increased from 24 to 36 tons/ha/year, or over 45% on average (Calle et al., 2013). During MBSCR, SPS increased fodder by an average of 25% and lowered soil erosion from 19 to 12 tons/ha (World Bank, 2020).

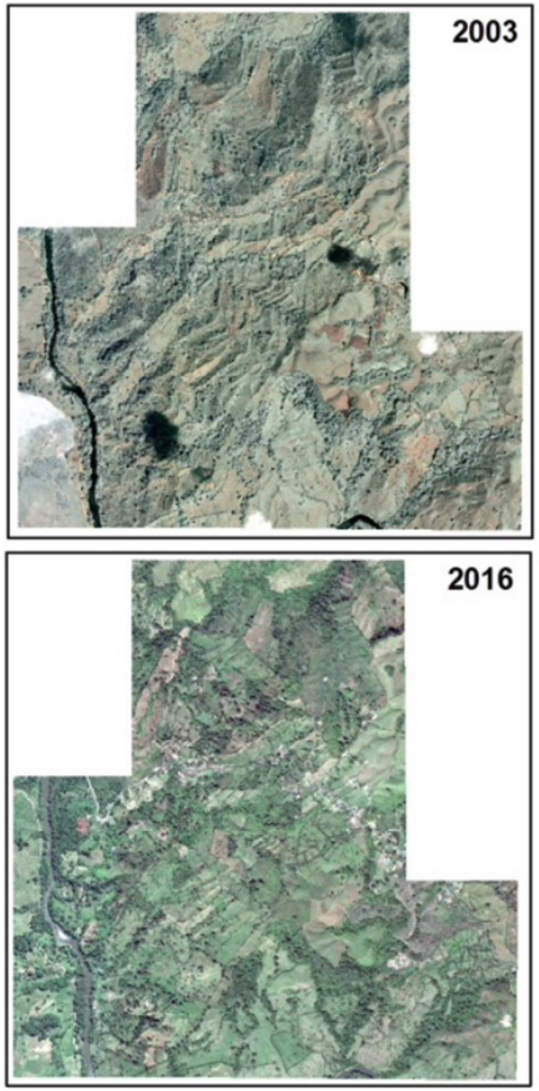


Figure 5. Satellite images of before (top) and after 13 years of SPS (bottom) at a Regional Integrated Silvopastoral Approaches to Ecosystem Management project (RISAEM) site. Note that the dark green represents forests and silvopastoral systems. Source: Calle, 2019

Figure 6. Vegetation productivity at a Regional Integrated Silvopastoral Approaches to Ecosystem Management (RISAEM) project site in Valle del Cauca in 2002 and 2015. Source: Global Environment Facility Independent Evaluation Office, 2019

Figure 7. Before (2001) and after (2008) images of Pinzacua Farm, RISAEM participant in Valle del Cauca. Source: Russi et al., n.d.

Silvopastoral systems are an example of successful ecological intensification as they have higher yields with fewer inputs (Figure 9). After switching from grass monocultures (*Cynodon plectostachyus*) to ISPS at Lucerna farm, land went from supporting 3.5 to 4.5 cows/ha and from producing 9,000 to 15,000 L/ha/year of milk. And fertilizer was completely eliminated—from 450–500 kg/ha/year of urea to no chemical inputs (Calle et al., 2013).

On average, SPS supported 23% more cows than conventional systems (World Bank, 2019). But small farms (< 10 ha) often saw a 3-fold increase using ISPS, which could often support 4 cows/ha (Figure 9) (Lafaurie, et al., 2007). After three years of SPS, milk production increased by over 30% on average, with the coffee producing region in Quindío showing an increase of 74% (Rios, 2019; World Bank, 2019). Calving intervals also decreased with SPS: 456–458 days compared with the national average of 664–700 days (Gómez, 2013 in Zapata Cadavid et al., 2019). The initial pilot farms and El Chaco (Figure 8) were lower at 380–395 days (Zapata Cadavid et al., 2019). At the same time, farmers reduced or completely eliminated chemical fertilizers and pesticides: after MBSCR, only 15% of farms used any chemical fertilizer and 32% used organic fertilizer. Milk production costs decreased by 9% (Russi et al., n.d.).

Figure 8. Eight years of transformation at El Chaco farm through an intensive silvopastoral production system. At the top is a typical cattle ranch. Below is the same ranch eight years after SPS were implemented. Source: Rios, 2019

Incomes increased. Reduced inputs and higher productivity translated into more income for farmers (Calle et al. 2013). During RISAEM, farmers' incomes increased by over 260% (World Bank, 2008). The average net income of a 10-ha farm was US$2,271 prior to adoption. Implementing ISPS on only 5 ha of pastureland increased income up to 5-fold (approximately US$12,000).

Animal welfare improved. Implementers noticed that cows in SPS systems were healthier, calmer, and more willing to move from place to place without the violent corralling common in conventional systems (Calle, 2019). CIPAV researcher Julian Chará noted that "With evenly shaded pastures, dairy cattle stay cooler and eat throughout the day. Shade and dense brush retains soil moisture and nutrients and leads to evenly distributed deposits of manure, rather than all in one spot" (Palmer, 2014). Increased biodiversity may have also meant fewer ticks and generally healthier animals (Broom et al., 2013).

Water resources improved. Reforesting riparian areas and fields regulated streamflow and improved water quality in some micro-watersheds (World Bank, 2008). Compared to unprotected streams, pastures under SPS during RISAEM showed lower turbidity, lower biological oxygen demand, lower

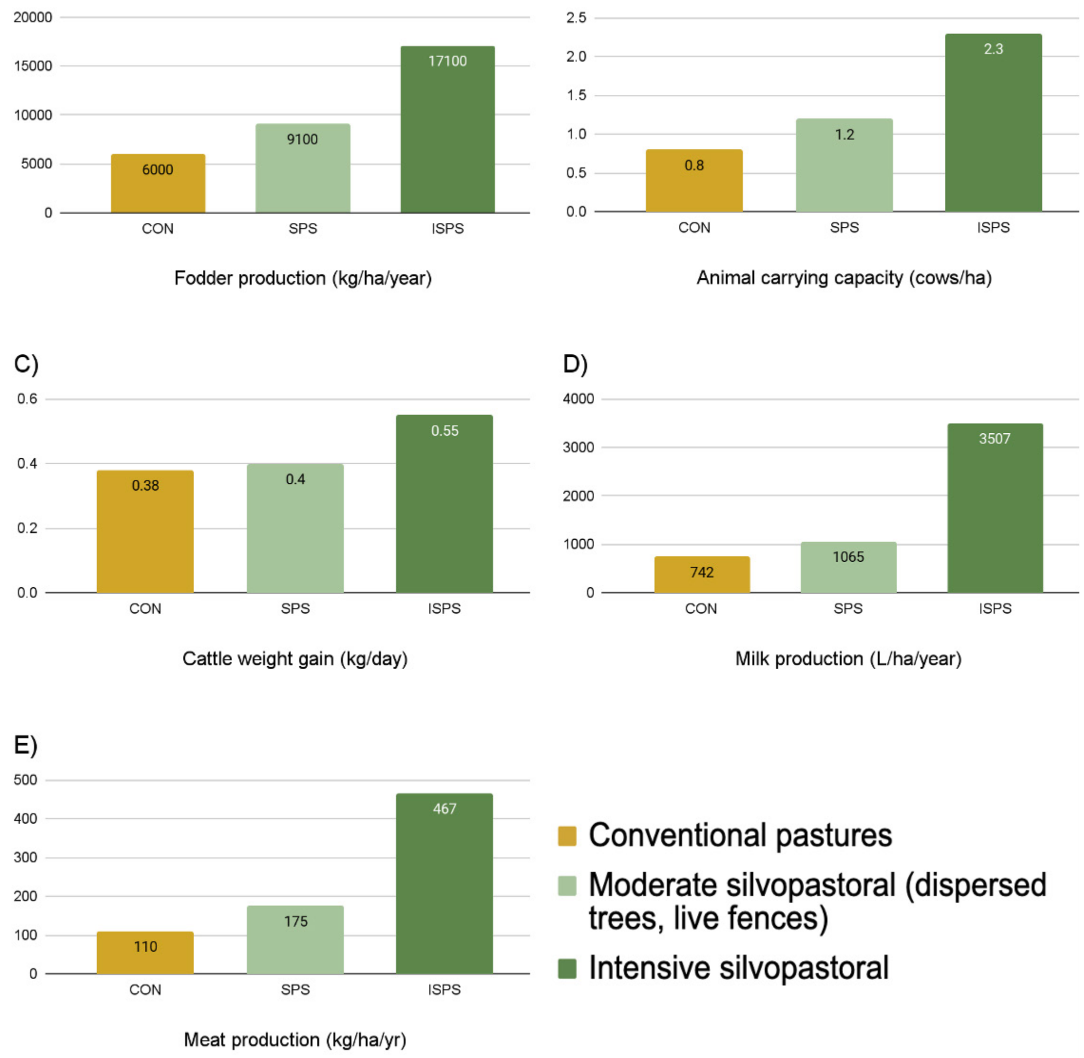


Figure 9. Productivity of three cattle ranching systems in Colombia. Note that farms did not use additional fertilizers or other chemical inputs. Each graph shows the difference in productivity when using conventional pastures, moderate silvopastoral techniques (dispersed trees, live fences), and intensive silvopastoral techniques Source: Russi et al., n.d.

coliform counts, and higher abundance of key macroinvertebrate bioindicators of stream health (Chará et al. 2006; World Bank, 2008).

People's health improved. Reduced chemical use and protected riparian areas meant less chemical exposure and cleaner water (Chará et al., 2006). Increased numbers of birds and predatory insects also reduced the number of ticks and the prevalence of tick-borne disease (Broom et al. 2013). SPS also led to a better and more agreeable working environment, more initiative among workers, and an increase in environmental awareness in some places (Broom et al., 2013).

Projects proved to be replicable and policies changed to promote scaling up. Demonstrating successful results during RISAEM was key to engage the livestock sector and influence policy (Calle et al., 2013). RISAEM caught the attention of the national government, encouraging the establishment of the Incentivo de Capitalización Rural, an incentive program promoting credit for SPS to farmers through the Ministry of Agriculture (World Bank, 2008; Nelson and Durschinger, 2015). The Colombian Strategy for Low Carbon Development (2011) references SPS explicitly.

Participatory research and establishing pilot farms also increased the capacity for others to adopt the technique. A network of demonstration farms now exists to facilitate peer-to-peer training, as well as research (Calle et al., 2013).

Key challenges

The project faced challenges on cultural, financial, and technical fronts. Most were addressed using CIPAV's three-pronged approach to individualized planning, technical support, and demonstration, although others are ongoing.

The belief that cattle and trees are not compatible is a culturally ingrained belief across Latin America. Prior to the demonstrated success of SPS, trees were thought to compete with grass and the role of trees in maintaining soil quality and forage supplies was not well understood (Frey et al., 2012; Calle, 2020). Seeing successful results firsthand was key to "facilitate the cultural change needed for ranchers to embrace tree planting" (Calle, 2019, p. 75). During "before and after interviews", many ranchers shifted from discussing how "trees hurt productivity" to citing the "multiple benefits of trees, especially for animal welfare" (Calle, 2019, p. 75).

High initial costs and lack of access to credit remains a major challenge. ISPS systems are often more profitable than traditional systems, but initial costs are prohibitive for many famers. Limited access to credit prevents many from adopting SPS (in Colombia and across the Americas), especially small farmers without formal land titles to guarantee loans. Banks are often unwilling to invest in SPS as returns on investment are not guaranteed, and loans are designed for wealthy farmers. The Colombian Government launched a line of soft credit for implementing SPS, but few farmers had the proper documentation and even fewer met the requirements. Providing support for initial costs remains a key component for adoption, and finding sustainable funding (e.g., without foreign aid) to implement SPS remains a challenge.

Dispersed farms led to a lack of landscape connectivity. Because participation was voluntary, farms were often dispersed, especially at larger scales of implementation. In the MBSCR project, the geographic spread increased travel time and thus costs of technical assistance. Single farms surrounded by non-SPS also created isolated "biodiversity islands." Future projects will seek to recruit farms closer to one another.

Youth out-migration because of lack of opportunities poses a huge challenge for the continuity of SPS, which require knowledge and investment in the land as well as labor.

A lack of expertise to plant and maintain the trees also limited adoption, as many ranchers had no prior experience with SPS.

Providing ongoing technical support for planning, implementation, and training was essential. Overgrazing is also a problem. Even though ISPS support higher cattle densities, overstocking is common and overgrazing *Leucaena* can kill plants. These systems require rest periods of 40–50 days compared to 30 with traditional pastures. Ongoing technical assistance is important to help farmers understand and manage system limits (Zapata Cadavid et al., 2019).

Enabling factors and innovations

The critical enabling factor was ongoing problems with monoculture pastures that made the cattle industry economically risky—especially for smaller farms. Because SPS could deliver solid economic benefits by increasing production, it made the technique economically viable and attractive. Increased awareness of SPS and their benefits—as demonstrated by CIPAV's previous work—was essential for widespread adoption at larger scales, as was having FEDEGÁN recognize the potential of silvopasture. A high degree of trust was also key: CIPAV founders were locals who understood the needs of local farmers. Existing relationships with early adopters allowed them to take risks, experiment and hone the technique.

Creating demonstration sites along a range of socioeconomic situations to allow farmers to learn from other similar farmers was a critical innovation, as was having farmers and technicians co-create an individualized farm plan as an engagement and negotiation tool. Empowering local people through participatory research on pilot farms was also vital. As CIPAV founder Enrique Murgueitio said, "Knowing that your knowledge is validated completely changes their self-esteem and enhances a whole community."

Another key innovation was providing free technical support from technicians trained in both "hard" and "soft" skills, including communication and interpersonal skills for establishing close connections and building trust (World Bank, 2008). Organizing knowledge exchange at multiple levels—farmer to farmer, region to region, and across Latin America—helped SPS to expand across the region and country.

Key lessons learned

- *Personalized planning and technical support are essential at any scale. Often "scaling up" brings to mind GIS, drones, and big data.* But a personal connection and individualized farm plan are essential to ensure project goals and methods are adapted to local conditions. Demonstration sites, farm plans, and access to trained extension workers are needed at all scales and ecologies.

- *Promote processes of collective learning.* Creating a "dialog of knowledge"—bringing traditional and scientific knowledge together with local knowledge—to tailor SPS to the local can make success possible in a wide range of contexts.

- *Always be open to the input of farmers. Bring the basic idea and build it collaboratively with the knowledge from local farmers through developing an individualized farm plan.* When farmers say, "This isn't going to work because...," technicians should respond with, "how can we make it better?" As CIPAV's Zoraida Calle put it: "In many ways you end up being psychologists. It means understanding the history of the person, their family, their relationship with their land."

- *High quality, sustained, and subsidized technical assistance is vital.* Technicians should have knowledge of trees, cattle, and excellent interpersonal skills. Funds should be allocated to provide this assistance for free, as farmers are often not in a financial position to train and hire extension workers.

- *Seeing is believing: Use peer-to-peer learning and connect similar farms.* "You don't want to take poor farmers to fancy/wealthy farms or vice versa," says Calle. "Farmers may feel that 'I don't have the money to do that' or the other way around 'this works for the small guy but it's not going to work for me'. As a farmer I interviewed put it: 'When they take you to a farm and it's another farmer who has a farm just like yours and you see his worker is just like yours and he's just like you and it's working for him that makes you think that you can do it.'" At all scales of implementation there need to be farms for different scales, regions, types of cattle, altitudes, and so forth.

- *Demonstration farmers should be great communicators and leaders.* Seek out innovative, risk-taking farmers with excellent communication skills, influence in their communities, and a plan for intergenerational exchange.

Learn more

Further information and resources

Video: Presentation by Zoraida Calle on "Intensive Silvopastoral Systems: Land-sparing and land-sharing" at the 64th Annual Conference of the Center for Latin American Studies https://www.youtube.com/watch?v=AQapW0Wbye0&ab_channel=CenterforLatinAmericanStudiesUniversityofFlorida

Video: World Bank on "Mainstreaming Sustainable Cattle Ranching in Colombia" (2020) https://www.youtube.com/watch?v=VptawzXkvYI&t=55s

Website: Ganaderia Colombiana Sostenible

Website: Centro para la Investigación en Sistemas Sostenibles de Producción Agropecuaria—CIPAV https://cipav.org.co/

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