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Against the Odds: Community forestry in the San Lucas Mountains, Colombia

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ABSTRACT

Community forestry can reduce deforestation, protect tropical biodiverse hotspots, and support the livelihoods of rural inhabitants, but only under the right conditions, e.g., well-defined property rights, enabling regulation, supportive bureaucracies, robust community institutions, and a peaceful environment in which collective action is possible. Since forest-rich regions often lack such auspicious circumstances, in this article, we ask whether community forestry may still be effective when they are missing and, if so, under what conditions. Using fuzzy-set Qualitative Comparative Analysis, we analysed the practices and organisational arrangements of eleven communes (*veredas*) on the western slopes of the San Lucas Mountains, in northern Colombia, characterised by a weak state presence and the chronic influence of non-state armed groups. Our findings suggest that communities can achieve low deforestation rates and promote forest regeneration when they meet three conditions: legitimate environmental leadership, support from external partners, and sustainable values and practices in relation to the natural environment. This article expands our knowledge of the conditions that make community forestry more effective in curbing deforestation and forest degradation. It provides actionable advice for civil society and local organisations that want to reduce deforestation and support vulnerable rural communities even when the 'right' policies and institutions are absent.

The power of a theory is exactly proportional to the diversity of situations it can explain.

Elinor Ostrom (1990, p. 24)

1. Introduction

Community forestry encompasses a wide variety of arrangements and practices that allow rural inhabitants to participate in varying degrees in the management of forests; it has been advocated as a means to reduce deforestation and protect biodiversity while supporting their

livelihoods (Charnley & Poe, 2007; Gilmour, 2016). Despite its diversity, there is growing consensus that community forestry requires the right institutional conditions: firstly, most empirical analyses point to the role of government in enabling and supporting community forestry as a necessary condition for achieving positive outcomes (Gilmour, 2016; Hajjar et al., 2021; Porter-Bolland et al., 2012; van der Zon et al., 2023; Wilkie & Painter, 2021). Secondly, there is abundant evidence that sustainable conservation and livelihoods outcomes are more likely when tenure rights are secure and when local users have greater control over the management of forests, i.e. management rights (Baynes et al., 2015;

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Cronkleton et al., 2011; Hajjar et al., 2021; Ostrom, 1990; Pagdee et al., 2006; Robinson et al., 2014; Wilkie & Painter, 2021). Finally, and building on Ostrom's (1990) pioneering work, communal institutions must establish equitable rules for users to access and withdraw shared resources, guarantee transparency and participation in decision-making, and enforce those regulations consistently through graduated sanctions (Baynes et al., 2015; Gibson et al., 2005; Gilmour, 2016; Ostrom, 1990; Pagdee et al., 2006; van der Zon et al., 2023). Altogether, these conditions configure governance arrangements in which community forestry is more likely to achieve its social and environmental aims (Cronkleton et al., 2011).

Yet, forests are often located in countries plagued with poor government capacity, corruption, and violence (Ireland, 2008; Hanson et al., 2009; Price, 2003). Communities sometimes manage to protect the forest despite weak statehood, as the Amazonas and San Martín cases, in northeastern Peru, illustrate (Arts et al., 2023). Similarly, in Guatemala's so called "ungovernable" region of Petén, bottom-up social mobilisation proved decisive in advancing communities' rights to participate in forest management and in promoting more equitable relations with non-governmental organisations (Cronkleton et al., 2008; Radachowsky et al., 2012; Taylor, 2010). That said, state weakness can lead to a Hobbesian scenario: in Mexico and Guatemala, some communities have faced coercion, and even death threats, from "narco-cattle ranchers," illegal loggers, and miners who endanger the forests on which their livelihoods depend (Devine et al., 2020; García-Jiménez & Vargas-Rodríguez, 2021). While the impacts of internal armed conflict on deforestation and biodiversity are mixed, its effects on community forestry are even less understood (McNeely, 2003; Price, 2003). In Nepal, for instance, community forest user groups were resilient to armed conflict between Maoist rebels and the government, but they experienced more violence, and their forest management rules weakened in areas where conflict was more intense (Cook et al., 2025; Karna et al., 2010; Nightingale & Sharma, 2014).

In this article, we explore whether community forestry is feasible in such hostile environments, despite the absence of a favourable regulatory framework and secure rights and, if so, under what conditions. To do so, we investigate the challenges of community forestry on the western slopes of the San Lucas Mountains, overlooking the Lower River Cauca Valley, in Colombia. In this extreme case study, most of the

necessary conditions for community forestry are absent. Firstly, despite repeated official promises to introduce a regulatory framework that promotes community forestry, the existing norms remained largely unchanged and calls to reinstate a concession scheme suspended in the 1990s had gone unheeded (Santos et al., 2018; Yepes Quintero et al., 2019). Recently, the national government authorised the creation of 30-year "peasant forest concessions" within forest reserves, but the impact of this measure remains to be seen (see Fig. 1). Regardless, communities still face high transportation costs, stumpage fees and low prices due to an abundant but illegal supply of timber (Agudelo-López et al., 2022; Amaya Arias, 2020; Valderrama Cuervo, 2021).

Secondly, while the forest governance arrangement is clear-cut on paper, it is less so in practice. Following Sikor's et al. (2017) conceptual schema on property rights and natural resource governance, the *authoritative rights* are held by the national government and in particular, by the Ministry of Environment, which defines the boundaries and zoning of national protected areas, and the National Land Agency, which has the power to grant collective land titles to Indigenous and Afro-Colombian communities in protected areas, so that they can meet their needs and preserve the natural environment. Corantioquia, the regional environmental authority in the area of study, holds *control rights* over forest resources, including managing forest reserves, granting timber extraction permits, enforcing environmental laws and regulations, and sanctioning offenders in collaboration with the Police and the judiciary. However, in this area of the country, the state is nearly absent and non-state armed groups police the territory, as it often happens in peripheral areas in Latin America (Feldmann & Luna, 2022; Lessing, 2021; O'Donnell, 1993). Only two communities in the area of study have been granted land titles and *use rights* over natural resources; the remaining nine consist of informal occupants who have no legal *use rights*, but they have established informal arrangements to occupy the land and manage the forest. Indeed, 68 % of the land parcels in the municipality of El Bagre lack title deeds; they are located in state-owned land, most of which has been designated as a forest reserve (Corantioquia, 2013). For several decades, their occupants have settled alongside the water streams that descend from the San Lucas Mountains, escaping violence and searching for land. Faced with the conservation-or-development dilemma, the state has chosen none: neither preventing the colonisation and deforestation of the reserve, nor providing

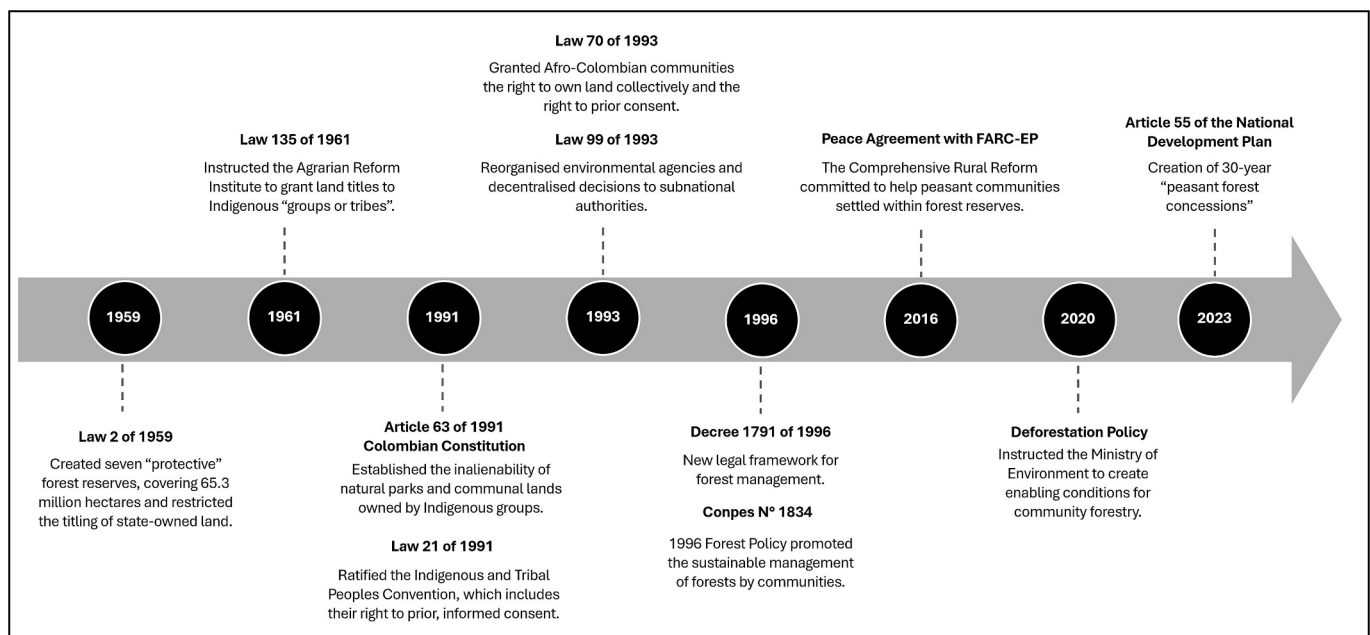


Fig. 1. Colombia's legal framework on forest management: a timeline. .
Source: Authors based on Appendix C

infrastructure and services to the population. The San Lucas Mountains have also attracted competing non-state armed groups that roam the territory seeking sanctuary or profits from illegal gold mining, illegal timber extraction and coca growing. In their attempts to establish a social and economic order that suits their agenda, these groups sometimes attempt to regulate the use of land and natural resources, but these rules are as durable as each group's transient territorial control.

Amid this uncertainty, rural communities around the hamlet of Puerto López, in the municipality of El Bagre, Antioquia, have attempted to manage the fragmented forest they inhabit in a more sustainable way. Although their communal institutions do not quite meet the “design principles” essential to sustainable common-pool resource management (Ostrom, 1990), some of them have reduced deforestation and forest degradation (Appendices A and B). Using fuzzy-set Qualitative Comparative Analysis (fsQCA), we analysed eleven of them, looking for clues about the conditions that could explain their varying degrees of success. In the next section, we hypothesise such conditions. In particular, we focus on the roles of local leaders and external partners, the communities' values and practices in relation to the natural environment, and the presence of absentee occupants who avoid interaction with communal organisations. We then describe the methodology and its execution, the findings, their significance, and their policy implications.

2. Community forestry against the odds—the importance of agency and relations

In the absence of well-defined property rights, supportive government agencies and an enabling regulatory framework, what conditions could make community forestry effective or, at least, feasible? We focus our attention on three sets of community governance conditions that could be transformed through concerted actions by local organisations: the presence and features of forest management institutions, the role of specific actors such as local leaders, partner organisations, and absentee occupants, and the communities' values, knowledge and environmental management practices in relation to sustainability. To analyse the first set, we employ Ostrom's (1990) “design principles” for managing common-pool resources (Appendix A), which, with some caveats and reformulations, have endured empirical tests and continue guiding the research on effective common-pool resource management (Cox et al., 2010; Wilkie & Painter, 2021). Following her definition, we understand institutions as “sets of working rules [that] contain prescriptions that forbid, permit, or require some action or outcome” and which are monitored and enforced by every participant (Ostrom, 1990, p. 51).

The second set of conditions draws on research on environmental and adaptive governance and focuses on how specific actors support or hamper collective action and community empowerment (e.g. Folke et al., 2005; Driessen et al., 2012; Ostrom, 2009). In particular, we consider three types of actors with a local influence: local leaders, partner organisations, and absentee occupants. Let us look at their roles in detail. Firstly, local leaders may enforce communal rules for using natural resources, promote conflict resolution, facilitate knowledge transfer between community members, motivate individual users to contribute when collective efforts are required, and represent community interests in their relations with external organisations (Baynes et al., 2015; Onyx & Leonard, 2011; Ostrom, 1990; Pagdee et al., 2006; van der Zon et al., 2023). For this to be possible, leaders must inspire trust and show commitment, persistence, vision, and entrepreneurial skills (Onyx & Leonard, 2011; Ostrom, 2009; van der Zon et al., 2023; Webb et al., 2022) to change the opinions and practices within their communities (Folke et al., 2005). Furthermore, democratic mechanisms for the selection and turnover of leaders must exist to ensure the continuity of community initiatives when the original leader leaves (Onyx & Leonard, 2011). We hypothesise that *legitimate environmental leadership* contributes to effective forestry.

Secondly, partner organisations may facilitate mutual learning of

forest management practices and strengthen communal institutions (Arts & de Koning, 2017; Da Silva Medina et al., 2022; Wilkie & Painter, 2021). Empowering partnerships may improve communities' access to funding, public goods, legal advice, training, and capacity building, facilitate their interaction with government bureaucracies and, more generally, empower them to “liaise with the outside world”, thus increasing their “bridging” social capital (Baynes et al., 2015, p. 226). Our analysis of this condition is loosely based on Driessen et al.'s (2012) archetypes of environmental governance, which envision different roles for civil society, private and government actors, as well as different styles of interaction between them. Their relations with local communities and with actors beyond the local sphere, e.g. universities, subnational governments, donors, may contribute to establishing networks of collaboration necessary for adaptive governance (Folke et al., 2005). Therefore, we hypothesise that *empowering partnerships with outsiders may contribute to community forestry*.

Thirdly, we consider the role of absentee occupants, who may have a deleterious effect on forest management, e.g., by incentivising indiscriminate logging (Medina & Shanley, 2004). Early in our fieldwork, we found that in some communes, up to 30 % of the land consisted of farms occupied by absentee occupants who raised cattle or planted single crops, including coca, in state-owned land; these occupants were often unknown to the neighbours, and the farm's caretakers did not take part in communal decisions, hampering collective action. Hence, we also hypothesise that communes with larger shares of *land occupied by absentee occupants* would find it more difficult to reduce deforestation and degradation.

Finally, communities' knowledge, values and practices in relation to the natural environment could favour or hinder sustainability and conservation. While local and Indigenous knowledge may hold invaluable insights for conservation (Mistry & Berardi, 2016), in Latin America, *campesino* colonists are often “blamed for a lack of ‘forest culture’ and an intrinsic antipathy towards nature” (Shanee, 2013, p. 413). In our analysis we focussed on the extent to which their culturally embedded knowledge and values about their natural environment favoured sustainable individual practices and behaviours, which are not necessarily mediated by communal institutions (Berkes, 2017; Folke et al., 2005; Herrmann, 2006; Posey, 1985). While ethnic and cultural diversity could influence the communities' ability for self-governance, we hypothesise that local and Indigenous *knowledge, values and practices* about the natural environment may have a direct influence on conservation outcomes, i.e. deforestation and degradation. Paraphrasing Ostrom (1990), while institutions, i.e. working rules, are common knowledge (Ostrom, 1990), not all common knowledge consists of institutions; it also includes values and beliefs about the natural environment learnt within households and communities through education, rituals, and shared experiences. This condition was relevant given the diverse ethnic and geographic origins of households in Puerto López—a patchwork of communities comprising Indigenous Zenu people, Afro-descendants, and *mestizo* peasants who, in many cases, were forcibly displaced from regions with different ecosystems. The following section provides further details about the operationalisation of these conditions.

3. Methodology

Our comparative methodology relied on primary, qualitative data on communal institutions and forestry practices, and on spatial and quantitative, secondary data on deforestation and forest degradation obtained from the Landsat Satellite and official sources (details below, Appendix B). We began by assessing if each of Puerto López's eleven communes' institutions met Ostrom's “design principles” (1990), and we then carried out a fsQCA to pin down the conditions that explain the relative success of some communities in reducing deforestation and forest degradation despite lacking robust communal institutions. Below, we describe the study area, the fieldwork, and the conditions explored in

the comparative analysis.

3.1. The San Lucas Mountains: Ecological and sociopolitical context

The San Lucas Mountains are home to several endangered species, and most of its area is located within a national forest reserve (Corantioquia, 2013; IDEAM, 2004). The ecosystem consists of humid forest formations, and its remarkable altitudinal gradient, which extends from sea level to 2,700 m, creates numerous environmental niches that provide home to 1,093 plant species, 71 genera of aquatic macro-invertebrates, 45 species of dung beetles, 185 butterfly species, 129 fish species, 69 amphibian species, 62 reptile species, 587 bird species and 191 mammal species (Bonell Rojas, 2018). The area is home to several endangered species including trees such as the *abarco* (cariniana pyriformis), the *castaño* (licania gentryi), and the *almanegra* (magnolia polyphysophylla), mammals such as the *comadreja colombiana* (marmosops handleyi), the brown spider monkey (*ateles hybridus brunneus*) and the *tapir* (*tapirus terrestris columbianus*), and birds such as the *paujil* (*crax alberti*) and the woodpecker (*melanerpes pulcher*) (BirdLife International, 2025; Corantioquia, 2013). The first humans to inhabit the San Lucas Mountains were the Guamocó and Yamesí Indigenous peoples. The region experienced a gold rush in the 16th and 17th centuries when Spanish colonisers founded the towns of Zaragoza (in 1581), Guamocó (in 1611) and El Bagre (in 1675). By the mid-17th century, production decayed, and most miners migrated to other regions (Corantioquia, 2013; Quijano Mejía & Figueroa Salamanca, 2020).

Our area of study sits along the western boundary of the Magdalena River Forest Reserve Zone (MRFRZ). Established in 1959 by the national government (Ley 2 de 1959), the Reserve originally covered 5.82 million hectares; by 2004, it had lost 63 % of its original extension and was fragmented into three patches, the largest of which includes the San Lucas Mountains and extends over an area of 1.47 million hectares (IDEAM, 2004). The Reserve still holds large primary forests with a “high degree of natural conservation” but also a “mosaic” of forests with substantial human intervention, e.g., pastures, subsistence agriculture, gold mines (both placer and underground), coca crops, and even human settlements of up to 7,000 inhabitants (Corantioquia, 2013). With some exceptions, most of its occupants are informal occupants.

Since the 1960 s, insurgencies, government forces, paramilitary death squads, and drug-trafficking organisations have competed to control the region and, in the process, terrorised the population with selective killings, child recruitment, and forced displacement, among other crimes (Defensoría del Pueblo, 2020). The demobilisation of paramilitary groups in 2006, and of FARC rebels in 2016, did little to change the landscape of fear and uncertainty, as old insurgencies (the National Liberation Army, or ELN) and new armed groups (such as the Gulf’s Clan, or AGC) scrambled to secure the clandestine cocaine routes to the coast, extort local miners and coca growers, and control the region, sometimes in battle but more often through collusion (Defensoría del Pueblo, 2020). The impact of armed conflict on deforestation in Colombia has been mixed, and the evidence suggests it is contingent on each armed group’s agenda: whereas some armed groups enforce the protection of the forest for the cover it provides, others focus on rent extraction and, thus, promote its conversion to pastures or coca fields (Álvarez, 2003; Chadid et al., 2015; Dávalos, 2001). Landholm et al. (2019) found that, from 1992 to 2015, armed conflict in Colombia was often associated with deforestation, but in some municipalities, it led to a “forest regrowth pathway,” and their maps show that the municipality of El Bagre was an example of the latter (map 5a, p. 90). Back in 2001, Dávalos warned that armed conflict produced “few, if any, incentives for long-term resource management” and reported the absence of any sort of “articulate local community in San Lucas that may oppose, enforce, refine, refute, enhance, disrupt or apply conservation programmes of any kind” (2001, p. 77).

We analysed eleven rural dispersed settlements located around the village of Puerto López, on the western slopes of the San Lucas

Mountains. By comparing contiguous cases, we controlled for confounding factors that are shared among them and, therefore, cannot explain the observed performance variation across cases, such as biophysical attributes (e.g. altitude, precipitation, topography, species), distance to urban centres and major markets, land uses (e.g. subsistence agriculture, cattle pastures, artisanal mining), and presence of primary forests and forests in different stages of succession. Their location, population and area are shown in Fig. 2 and Table 1.

3.2. Fieldwork

Building on our prior connections with the Puerto López community, we first approached their leaders to discuss the project in November 2021. Two of the authors have promoted apiculture and silviculture in Puerto López since 2012 through the Medellín-based, non-profit *Corporación Grupo Trópico Diverso*. This article’s leading author also conducted two research projects on local peacebuilding with the same communities back in 2015 and 2018. Furthermore, one of us is a local resident in Puerto López, and a member of *Colectivo Gente y Bosques*, a local organisation that promotes the protection of the forest. The research team also included master’s students from Universidad EAFIT, in Medellín, who participated as research assistants, as well as several faculty advisors who contributed to the project and to this article.

In our fieldwork, we employed a range of qualitative research techniques (see Fig. 3). We began by conducting exploratory focus groups, with open-ended questions, with leaders from all communities to understand the organisational arrangements and attitudes to conservation and environment in Puerto López and, more generally, to build mutual trust between the research team and the community. We then asked each community to select five to six of their own members to take part in the project based on their prior engagement in environmental projects, their ability to gather and share information within their communities, gender equity, and their willingness and consent to participate in the activities we planned. Using participatory techniques such as group interviews, participatory mapping exercises, and vignette-based activities, we asked participants about the factors influencing conservation in each commune. Compared to the initial focus groups, these activities were much more structured (see Appendix B). To delve deeper into sensitive topics, such as the role of non-state armed groups in local governance, or to clarify data collected before, we conducted 39 individual semi-structured interviews, and we also administered an individual questionnaire to 120 respondents. We completed most of the fieldwork by December 2022, but we returned to Puerto López afterwards to disseminate the lessons learnt in the project across all eleven communities, including practical ideas about sustainable forest management, local environmental conflicts and how to solve them, and basic concepts of sustainability. Research protocols, approved by EAFIT University’s Research Ethics Committee, as well as links to the learning materials we developed in the final year of the project to disseminate lessons, are provided in Appendix B.

3.3. Common-pool resource institutions and sustainable outcomes

In the first step of the analysis, we assessed whether the communal institutions in each commune were “fragile” or “robust” according to the “design principles” put forward by Ostrom (1990), and whether this could explain the environmental performance of each commune in reducing deforestation and forest degradation. We gathered information on common-pool resource institutions in each of the eleven communities through individual and group interviews and participatory mapping exercises; we asked participants about the rules for accessing and withdrawing resources from the forest, and the arrangements to protect water streams, marshes, and forests, paying special attention to their ability to set, monitor and enforce rules, which are essential for effective resource management (Appendix B, materials B1 to B4). Following Ostrom’s steps (1990, p. 180), we then coded this information

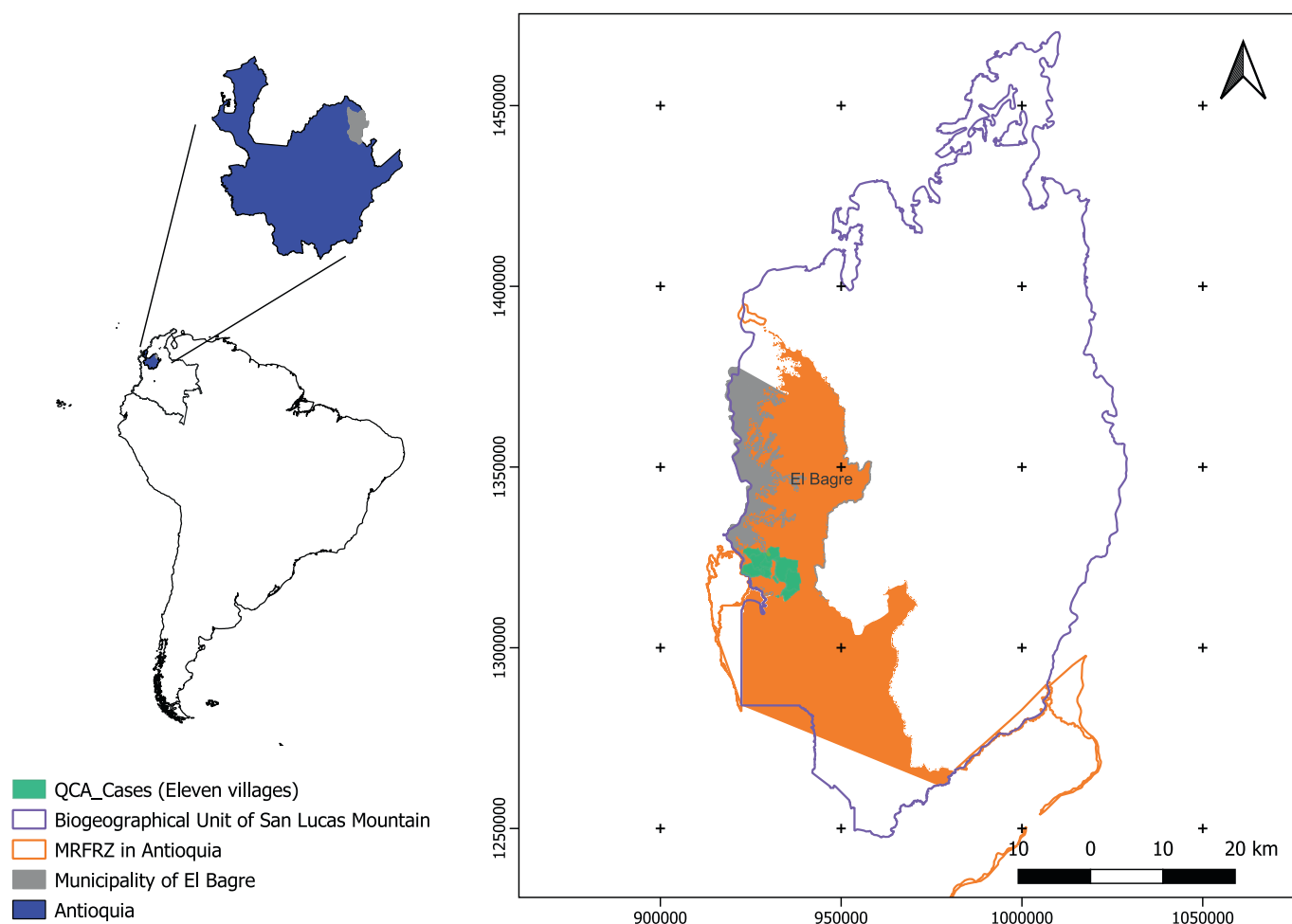


Fig. 2. Selected case studies in Puerto López, San Lucas Mountains.

Table 1
Population and area of case studies.

Cases	Population ¹	Area (ha)	Forest area (ha)
Borrachera	160 (56)	872.36	170.48
La Bonga	96 (36)	1,762.90	701.32
El Noventa ²	187 (37)	169.64	91.65
Villa Grande ²	87 (30)	1,320.31	765.11
La Capilla	159 (38)	400.48	80.83
Cimarrón	87 (28)	1,286.21	801.49
Villa Hermosa	108 (30)	2,608.56	1,436.46
Caño Claro	182 (35)	121.99	4.78
Arenas Blancas	210 (47)	2,038.59	1,164.60
San Cayetano	69 (32)	743.07	391.89
Puerto López ³	2,893 (443)	28	0

Notes:

¹Individuals (households).

² These communities have collective land titles; the remaining cases are irregular settlements within the Reserve Zone, without legal property rights.

³ This is a nucleated village; all other cases are scattered settlements.

Sources: IGAC, IDEAM and in-depth interviews with local leaders to validate the data.

employing a diagnostic rubric (see Appendix A, Table A1). Finally, we assessed the association between the strength of communal institutions and performance, i.e., conservation effectiveness.

We found that, by Ostrom's standards (1990, p. 180), most communes had fragile institutions and, even the best performers failed to meet most of the "essential elements" that explained the success of the cases she studied (p. 90). For instance, while three of the four best

performers did monitor users' behaviour, only one of them set and enforced sanctions, and only two of them had conflict resolution mechanisms in place. For reasons already explained, most communes lacked formal control rights over the forest, e.g. exclusion or monitoring rights; although this did not necessarily mean that environmental authorities or non-state armed groups challenged the informal rules they set, this weakened their capacity to enforce them. The reluctance to set and impose sanctions could also be explained by fear that armed organisations could end up interfering in their monitoring and enforcement. Most importantly, the configurations of conditions that appeared to explain the success of the best performers, such as the co-occurrence of monitoring and congruence between rules and local conditions, and the co-occurrence of collective choice arrangements and conflict resolution mechanisms, were observed in other, less effective cases, meaning they could not explain the outcome.

3.4. Fuzzy-set QCA

Based on the results of the previous step, we employed fuzzy set QCA to assess whether other conditions could explain the relatively more sustainable outcomes achieved by some communities. Qualitative Comparative Analysis yields deterministic, causal inferences on the conditions that produce an outcome of interest through the systematic comparison of cases. Whereas crisp-set QCA requires sorting the cases into dichotomous sets that represent the presence or absence of the outcome and each condition (e.g., sustainable or unsustainable), fsQCA enables researchers to sort cases into ordinal, fuzzy sets, e.g., sustainable values and practices, values and practices are more sustainable than

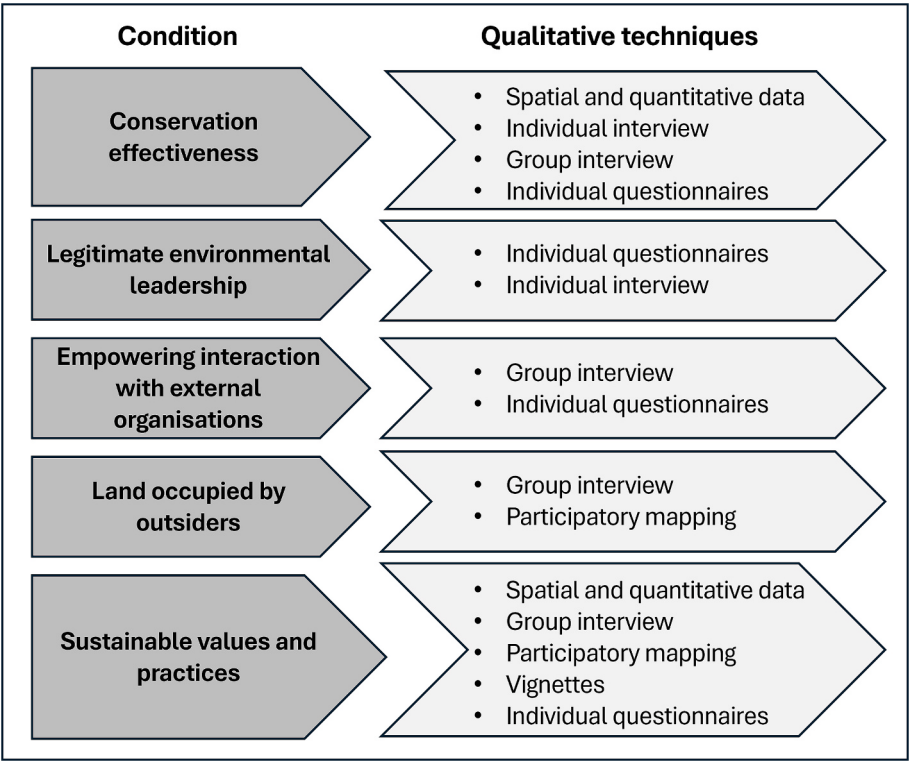


Fig. 3. Data-gathering techniques employed to collect information on conditions.

unsustainable, values and practices are more unsustainable than sustainable, and unsustainable values and practices, allowing for a more nuanced analysis (Ragin, 2008). The first step in such analysis is the

operationalisation of the outcome (analogous to the dependent variable in quantitative analyses) and the conditions of interest (similar but by no means equivalent to independent variables):

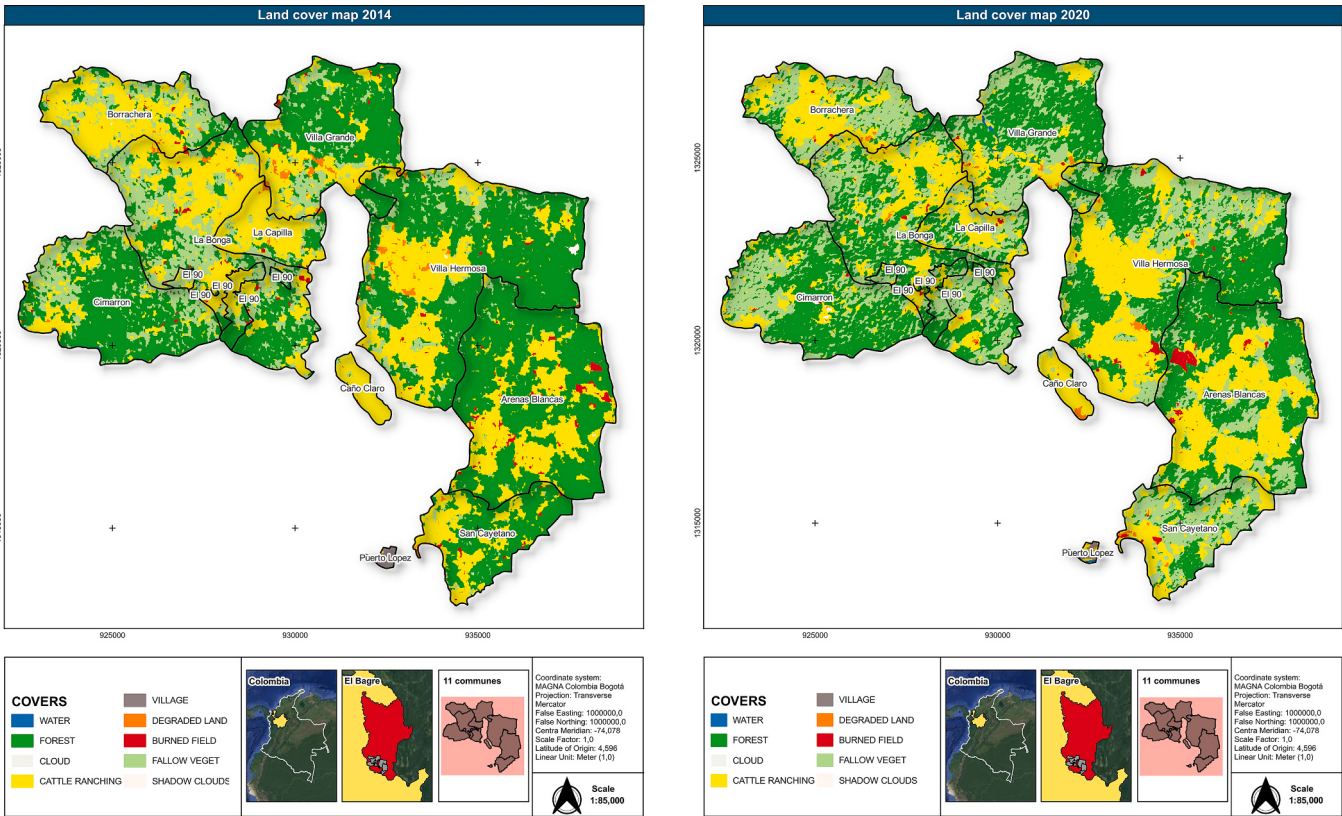


Fig. 4. Land uses in the area under study in 2014 and 2020.

- a) Conservation effectiveness in terms of reducing deforestation and promoting regeneration (outcome of interest). To code the outcome, we measured the deforestation rate, the percentage of total land area under each forest type, and the area of degraded forest restored, using spatial and quantitative data obtained from Landsat Satellite and the National Institute of Hydrology, Meteorology and Environmental Studies (see Fig. 4). In doing so, we followed the guidelines set by FAO (2011) and ITTO (2016). We also considered the participants' perceptions about their own communities' effectiveness in reducing deforestation and restoring degraded patches of forest, which we gathered using individual questionnaires, semi-structured interviews and group interviews. After collating the data, we constructed a four-level scale, with the top performers achieving low deforestation rates, conserving > 90 % of the primary forest area, and regenerating over 10 % of the forest area (See Appendix B, questionnaires B4 and B5).
- b) Legitimate environmental leadership. To assess the presence of this condition, we asked participants their opinion about the procedures to elect their leaders, the degree to which their posts were open to competition and rotation, their motivation towards environmental projects, and the roles played by Community Action Boards (*junta de acción comunal*). We collected the data through questionnaires and interviews (See Appendix B, questionnaire B5).
- c) Empowering interaction with external organisations. Using group interviews and questionnaires, we asked community members about their participation in conservation and environmental education projects implemented in partnership with external organisations such as government agencies, businesses, universities, non-governmental organisations, and international cooperation organisations. We coded in the highest rung cases where projects were frequent, involved a range of external organisations and where communities actively participated in making project-related decisions. (See Appendix B, materials B2 to B4).
- d) Land occupied by outsiders. In line with our analytical framework, we inquired about the share of land occupied by absentee occupants within each commune's territory. These individuals grab tracts of land but leave someone else in charge, avoiding contact with the community and its leaders, thus making collective decision-making difficult. We collected data using participatory mapping and group interviews and ranked cases with more than 30 % of the land occupied by outsiders in the top rung. (See Appendix B, guidelines B1 and questionnaire B4).
- e) Sustainable values and practices. To grasp this condition, we asked participants about their perceptions of the importance of nature to their livelihoods, their awareness of the vegetal species in the territory, their knowledge and skills regarding the sustainable use of the forest, the extent to which their farming practices contributed to ecological restoration and natural regeneration, and whether they were compatible with the ecosystem (Crouzeilles et al., 2017; FAO et al., 2021; Shimamoto et al., 2018). We also took into account the share of transformed land they devoted to sustainable uses, such as sustainable beekeeping or silviculture. We employed mixed methods such as satellite data from Landsat, participatory mapping, group interviews, vignettes and individual questionnaires. (See Appendix B, questionnaires B4 and B6).

Our analysis focussed on the period from 2014 to 2020 because of the availability of satellite information and statistics on the area of study and because it was recent enough to be recalled by the participants. For the operationalisation of each condition and the outcome, we established their thresholds based on the literature review. Following standard practice, we coded the cases employing an ordinal scale in which degrees represent the extent to which each case meets a given condition and, thus, belongs within a given set: 1.00, 0.67, 0.33 and 0.00 (Arts & de Koning, 2017; Ragin, 2008; Sehring et al., 2013; van der Zon et al., 2023). We defined codes to operationalise the fuzzy set levels for each

condition: 1 (membership), 0.67 (intermediate membership or more a member than a non-member), 0.33 (low membership or more a non-member than a member) and 0 (non-membership). For instance, the operationalisation of full membership (1.0) of sustainable values and practices was: "at least 40 % of the commune's territory is devoted to sustainable uses. Also, inhabitants have relevant technical and environmental knowledge about the use of forests". These codes were the main guidelines for the coding process made with ATLAS.ti. For the analysis, we used a protocol to explain why each commune was classified in the different QCA scales for each condition (Appendix B, material B7). Within this process, the authors delivered five sessions for data calibration to strengthen the research's internal validity based on the methodological recommendations made by Ragin (2008), Arts & de Koning (2017) and van der Zon et al. (2023). A step-by-step guide as well as the R Studio code scripts can be found in Appendix B, materials B8 and B9.

4. Results

Table 2 presents the fsQCA results, indicating the values for the outcome and each condition. Two cases were coded as "environmentally effective" given their achievements in reducing deforestation and regenerating degraded areas (1.0 = *El Noventa, La Capilla*) and the other two as being more effective than ineffective (0.66 = *Borrachera, La Bonga*). The remaining cases were more ineffective than effective (0.33 = *Villa Grande, Cimarrón, San Cayetano*) or fully ineffective (0.00 = *Arenas Blancas, Caño Claro, Villa Hermosa, Puerto López*).

Following Duşa (2019), we conducted a preliminary analysis to identify the necessary and sufficient conditions for effective forest conservation, as well as a logical minimisation process, to find the simplest configuration associated with the outcome. This process yielded a "conservative" solution consisting of three joint conditions: empowering interactions with external organisations, sustainable values and practices, and legitimate environmental leadership (see Table 3). This configuration shows scores in inclusion (inclS) greater than 0.80 and coverage of at least 0.70, meaning that it is both necessary and relevant, i.e., it covers most cases with environmentally effective outcomes in terms of deforestation and restoration (Dul, 2016; Fiss, 2011; Greckhamer et al., 2013; Mendel & Korjani, 2012; Pappas & Woodside, 2021; Ragin, 2008; Riboux & Ragin, 2009; Schneider & Wagemann, 2010).

The counterfactual analysis confirmed that the combination of unsustainable practices and disempowering interaction with external organisations was a necessary condition for ineffective conservation. Furthermore, the combination of those two conditions and illegitimate environmental leadership was sufficient for ineffective conservation. Following Greckhamer et al. (2013), we also carried out a sensitivity analysis to ensure that the findings were robust to minor adjustments to the fuzzy-set membership thresholds; the results showed that slight variations in data calibration or the thresholds yielded similar findings. Summing up, the fsQCA indicates that community forestry under less-than-ideal institutional conditions is more effective in reducing deforestation and promoting regeneration when three conditions are met: empowering interaction with external organisations, legitimate environmental leadership, and sustainable values and practices. Let us take a closer look at the cases to see how these conditions combined and interacted to produce the outcome.

4.1. Explaining conservation effectiveness in *El Noventa* and *La Capilla*

Compared to the other cases, *El Noventa* showed the lowest median deforestation rate (1.3 ha/year), the highest conservation of primary forest cover between 2014 and 2020 (92.42 %), and the second highest forest recovered area (10.16 %). The Indigenous *Zenu* community settled in these lands in the 1990 s and gained the legal status of *resguardo* in 2018, i.e., the right to own the land collectively. In their traditional belief system, the forest is sacred, and the headwaters within the

Table 2

Fuzzy-set values of case studies.

Case	Land occupied by outsiders (LOO)	Legitimate environmental leadership (LEL)	Sustainable values and practices (SVP)	Empowering interaction with external organisations (EIEO)	Outcome: Conservation effectiveness (CE)
El Noventa ¹	0.00	0.67	1.00	0.67	1.00
La Capilla	1.00	0.67	1.00	1.00	1.00
Borrachera	0.67	1.00	1.00	0.67	0.67
La Bonga	0.00	0.67	1.00	0.67	0.67
Villa Grande ¹	0.33	0.33	0.67	1.00	0.33
Cimarrón	0.00	0.33	0.00	0.33	0.33
San Cayetano	0.33	0.00	0.67	0.33	0.33
Arenas Blancas	0.67	0.00	0.00	0.33	0.00
Caño Claro	0.00	0.33	0.00	0.00	0.00
Villa Hermosa	0.33	0.67	0.33	0.33	0.00
Puerto López	1.00	0.33	0.00	0.00	0.00

Notes:

⁽¹⁾ These communities have collective land titles.

Source: Authors based on primary qualitative data and satellite imagery.

Table 3

Conservative solution.

	inclS	CovS	PRI	Cases
LEL * SVP * EIEO	0.901	0.695	0.860	El Noventa, La Bonga; La Capilla, Borrachera

Source: Authors' calculations using QCA for R.

resguardo must be protected because “they are the key to good health and life [as] water gives us food and quench our thirst,” as told us, Gloria Toribio (interview, March 2022). According to her, they “plant trees and cut wood following the times of the Moon, which allows the trees and the land to have a longer useful life.” They have set rules to punish the cutting of trees and the planting of certain species of trees (interview with Sergio Navarro, June 2022). Their values and knowledge are also evident in sustainable practices such as fallow enrichment (29 % of the commune’s area) and agroforestry (12 %).

The collective title granted by the government in 2018 allowed the *resguardo* to access a payment-for-environmental-services scheme funded by the department’s authorities (*Gobernación de Antioquia*) and to participate in state-funded soil restoration and apiculture training programmes that helped them to gain technical insights and learn new sustainable practices. Thanks to the title, the community has prevented the occupation of land by outsiders and has fended off attempts to purchase tracts of land within their territory, as these transactions are legally forbidden. Their legal status as an officially recognised Indigenous community allows them to give (or deny) their “free, prior and informed consent” to any project within their territory, as stated in the Indigenous and Tribal Peoples’ Convention (ILO, 1989). For instance, they recently vetoed a government-endorsed project to create a natural park within their territory (interview with Sergio Navarro, October 2022). More effective forest conservation has been possible through the combination of frequent and equitable partnerships with external organisations and the legitimacy of the *resguardo*’s chieftain, who is esteemed by the community because of his ability to collaborate with insiders and outsiders and his ability to mobilise the younger members of the community (questionnaire responses from community members, September 2022) and to promote projects and activities such as apiculture, fallow enrichment, cleaning of water streams, and protection of headwaters (interview with Gloria Toribio, March 2022).

In *La Capilla*, the landscape has changed significantly: deforestation forced jaguars, tapirs, deer, and armadillos out of the territory, and mining has polluted the water stream, reducing the fish population

(interview with Lidia Julio, March 2022). However, from 2014 to 2020, the community managed the forest more sustainably than most cases analysed, with the highest forest-recovered area (10.39 %), and one of the lowest median deforestation rates (3.15 ha/year). They maintained the forest cover at ~74.52 %, increased stubble areas by 14.24 %, and reduced pasture areas by 20.83 %. How did they achieve this? Again, we see a combination of three conditions: first, 54 % of the transformed land is managed through sustainable practices such as rubber agroforestry (32 % of transformed land), fallow enrichment (15 %), sustainable apiculture (5 %) and agroforestry (1 %). Second, although absentee occupants hold a significant share of *La Capilla*’s territory (43.7 %), the president of the Community Action Board has managed to establish a dialogue with them and has made agreements to preserve forests and water streams. He played that role for 15 years and still enjoyed the support of the community. Finally, the community has entered partnerships with external organisations that have introduced these practices through environmental projects and educational programmes: “We have learned to keep stubble fields, to plant rubber trees, to avoid cutting down all the trees to have a pasture, to let some trees grow so that the land does not degrade” (interview with Lidia Julio, March 2022). This has been possible thanks to the organisations such as *Corporación Grupo Trópico Diverso* and the Medellín-based *Instituto Popular de Capacitación*, with funding from USAID and the United Nations Development Programme. Through these projects, communities learned or improved practices such as beekeeping and fallow enrichment, and reforested degraded lands with native species with a view to making a profit on their timber in about 20 years—in effect, a “forestry pension” for many household heads. Just as important, communities learned how the forest could become a key asset in their livelihood strategies, not only as a store of value for the future but as a source of income in the present.

4.2. Environmental leadership: The missing piece in Villa Grande

At first glance, the case of *Villa Grande* is puzzling: on the one hand, they were granted a collective title in 2011, and, just as in *El Noventa*, this opened the door to environmental education projects in partnership with the government and international organisations. The title also helped them to stop newcomers who wanted to settle in their land. They also reported sustainable practices such as fallow enrichment (21 %), agriculture (21 %) and apiculture (2 %). On the other hand, *Villa Grande* did not excel in our forest conservation and restoration measures: with a forest cover loss of 7.21 %, a median deforestation rate of 17.81 ha/year, and only 39.54 % conserved forest cover between 2014 and 2020, it was

among the poor-performing cases. In an individual questionnaire, community members reported that their leaders' commitment to environmental projects reflects a desire to attract funding rather than a genuine belief in the importance of conservation. Indeed, the Community Action Board authorised gold mining in their territory, with the consequent damage to the ecosystem. This case illustrates the importance of the presence of, and interaction between, all the three conditions we identified: in *Villa Grande*, the absence of legitimate environmental leadership is the missing piece that fails to produce a more sustainable outcome. Furthermore, this case also confirms that secure property rights are not a sufficient condition for sustainable management of the forest. Indeed, in our comparative analysis, we found other rural communes that were more effective in protecting the forest (*La Bonga*, *Borrachera*, and *La Capilla*) despite lacking tenure rights.

4.3. Caño Claro: The prophecy of failure fulfilled

Finally, at the lowest end of the spectrum, in *Caño Claro*, only 4 % of the area is covered by forest, and roughly half of this area has been conserved since 2014. Median deforestation rates were low because most of the forest is gone. Nearly 80 % of the transformed land has been converted to pasture, which is now used to raise cattle; the remaining area is devoted to fallow enrichment (19 %) and rubber tree crops (1 %). Not surprisingly, community members are practically unaware of sustainable timber extraction practices (questionnaire responses from participants, April 2022). Over the last twelve years, two local leaders and their relatives have monopolised decision-making in the community; they have shown little interest in partnerships with conservation organisations or in promoting environmental education programmes. Community members interviewed by the authors reported that they rarely participated in meetings to discuss the management of the Reserve Zone, and they were unaware of a government project to establish a national park in the region, which, if implemented, could lead to their involuntary resettlement. In the responses to our questionnaires, community members questioned their leaders' qualities and skills and their failure to empower the youngest members. Overall, this case illustrates how the absence of sustainable values and practices, legitimate environmental leadership and empowering interactions with external organisations—on top of all the unfavourable conditions we described before, made conservation unfeasible.

5. Discussion

In her seminal book on common-pool resource management, Elinor Ostrom warned about the dangers of assuming that model's constraints "fixed for the purpose of analysis are taken on faith as being fixed in empirical settings, unless external authorities change them" (1990, p. 6). Applying her warning to our study, it would be mistaken to assume that, unless government authorities intervene to create the ideal institutional setting—for instance, granting forest people the right bundle of tenure rights and putting in place the right policies and regulations—communities would be "caught in an inexorable process of destroying their own resources" (1990, p. 8). The fact that communities in Puerto López achieved different degrees of success in containing deforestation and degradation—as opposed to a sweeping null outcome in all the cases analysed—was a strong indication that such an assumption was wrong and that a different set of conditions, as well as a causal mechanism, was at work in these cases.

Our empirical analysis shows that community forestry can reduce deforestation and forest degradation even when most of the institutional requirements to do so—tenure rights, enabling government policies and regulations, and robust communal institutions—are missing. Such an inhospitable institutional setting has been rarely explored in the empirical literature on community forestry, which has focussed, with good reason, on formal forestry schemes. Yet, such conditions may be

closer to the reality of many forest-dependent communities that inhabit areas where state institutions "seem suspended balloon-like over the rural localities, but state agents do not seek to exercise authority in the local arena," to borrow Caroline Boone's description of non-incorporated areas, where "localities are left to their own devices: the regime seems to abdicate authority. The centre does not seek to engage or impose" (2003, p. 33).

Our findings do not mean that such positive outcomes are probable—merely that they are possible. The causal mechanism involves the collaboration of local leaders and external organisations to promote sustainable values and practices through environmental education and training in agroforestry. For this collaboration to be effective, local leaders must be legitimate in the eyes of their communities and must have an interest in promoting environmental projects. Furthermore, external partners must consider the locals' interests and concerns and empower them to participate in decision-making processes. Rather than a mechanistic knowledge transfer, e.g. distributing printed material, such projects entail a collaborative learning process in which the participants' aspirations and prior knowledge are recognised, as already documented in the literature (Arts & de Koning, 2017; Salam et al., 2005; Wulandari & Inoue, 2018).

This causal mechanism is feasible because it does not require the government to grant formal management rights to communities, and it is effective because it leads to behavioural changes when communities learn how sustainable practices may contribute to improving their own livelihoods. Put otherwise, it works by increasing the expected benefits of sustainable practices rather than by increasing the expected costs of flouting communal rules. The empowering collaboration with external partners we observed in a handful of Puerto López's communities may put them on a virtuous path towards crafting the kind of communal institutions necessary to achieve a fair and sustainable distribution of the rewards they expect to reap, but this remains to be seen.

The causal mechanism just described includes features of adaptive governance, such as social networks, leadership, and collaborative learning (Folke et al., 2005). However, the autonomy that rural communities in this study have to manage the forests they inhabit is not the result of a decentralised institutional arrangement; paradoxically, it is a function of the virtual absence of the state and the fragmented and contentious governance that prevails in the zone which is, in itself, a source of uncertainty.

Indeed, we must not underestimate the challenges and barriers that these communities still face. In our analysis, we did not find that tenure rights were a necessary condition for reducing deforestation and degradation. Still, their lack hindered voluntary community forestry initiatives. For instance, in *La Capilla*, it frustrated the community's proposal to undertake the environmental management of a zone known as *El Catorce*, which the local authorities rejected due to the lack of a property title. Indeed, the community of *La Capilla* have formally applied for a collective land title, such as the one granted to the Zenu people in *El Noventa*. In their request, they claimed to be a multicultural territory inhabited by a mixture of *mestizo* peasants, Afro-Colombians, and Indigenous peoples. However, the application process is cumbersome and uncertain, so it may take a while before they get an official response from the national government.

Perhaps the most important source of uncertainty is armed conflict. Until now, territorial settlements between warring factions have led to a tense calm punctuated by occasional raids and skirmishes, which are often the product of disputes within the armed groups themselves. This did not change much after the demobilisation of FARC rebels in 2016, as the territories they controlled in the region were swiftly taken over by the ELN. Although these local truces substantially reduced the risks for the population, they still live in a climate of fear and uncertainty, as the area of study sits right on the boundary between the ELN's and the Gulf Clan's turfs. Fresh peace talks between the Colombian government and several armed organisations, promoted by the Petro administration, could lead to very different scenarios in the region, depending on which

armed groups demobilise, whether new armed groups enter the territory, and what steps the government authorities take to fill up the political vacuum that a comprehensive agreement and demobilisation would leave. Although unlikely, the latter outcome could accelerate deforestation, as it already happened in several national parks in FARC-controlled areas after 2016 (Clerici et al., 2020), or it may prompt environmental authorities to make decisions on the Reserve, which may or may not take into account the peasants' best interests.

Regarding the limitations of our study, first of all, it is worth stressing that our analysis focussed on specific environmental outcomes—deforestation and regeneration—leaving aside other environmental and social outcomes such as biodiversity, gender inequality, or household income, which are crucial for sustainability but went beyond the time and resources we had at hand. Likewise, in our analysis of power relations we focussed on the relation between communities and local leaders and external partners, but broader aspects of political ecology, such as power imbalances within and between communities or relations with non-state armed groups were left unexplored for being too sensitive. Indeed, participants consented to participate in the project but were often reticent about armed conflict and illegal activities in their territories, so most of the information we gathered on these matters comes from official reports (e.g. Defensoría del Pueblo, United Nations Office on Drugs and Crime), independent researchers, and the press.

Also, it is worth highlighting that our study did not aim to achieve external validity in the sense of being empirically representative of a larger population of community forestry experiences. On the contrary, the point was testing the limits of community forestry by exploring whether it was feasible under unfavourable institutional conditions which, despite not unusual, have been poorly studied. Far from being *typical*, we chose our cases precisely because they were *extreme*, in the sense of lacking most of the ideal conditions for community forestry, as well as *deviant* in the sense that a few cases in our sample performed much better than the existing theories predicted and, thus, opened an opportunity to investigate “causal processes within the deviant case[s] that will illustrate some causal factor that is applicable to other (deviant) cases” (Seawright & Gerring, 2008, p. 302). Whether the latter is true remains to be seen, and, indeed, it calls for further research on the impacts of rebel and criminal governance on natural resource management, on community forestry in particular, and for interdisciplinary collaborations involving local participants, ecologists and researchers familiar with poorly governed spaces.

6. Conclusion

Community forestry works best when tenure rights are secure, government agencies are supportive, and communal institutions are robust. However, these conditions are often missing in forest-rich tropical zones where a distant state and natural resource abundance may attract predatory, coercive organisations. In this article, we analysed eleven contiguous rural communities on the western slopes of the San Lucas Mountains, in Antioquia, Colombia, to show not only that community forestry is possible under such hostile conditions but also that it can contribute to stopping deforestation and forest degradation. By comparing the cases, we found that a combination of legitimate leadership, empowering partnership and sustainable values and practices made possible such an unlikely outcome. Our work contributes to the empirical literature on community forestry by revealing a less-trodden path to protect the forest. From a policy perspective, our work highlights the importance of promoting collaborative partnerships even when the political and institutional circumstances are unfavourable and call for actions that strengthen and empower communal organisations to protect the forest, improve their livelihoods, and develop more robust institutions.

CRediT authorship contribution statement

Sara Vélez Zapata: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Conceptualization. **Gonzalo A. Vargas:** Writing – review & editing, Validation, Methodology, Conceptualization. **Elizabeth Castaño:** Methodology, Investigation, Data curation, Conceptualization. **Carolina Muñoz:** Writing – original draft, Methodology, Investigation. **Yeison Londoño:** Software, Methodology, Investigation, Formal analysis. **María Camila Zamudio-Mir:** Investigation, Conceptualization. **Mariela Ríos:** Investigation, Conceptualization. **Alexander Palau:** Investigation, Conceptualization. **Sergio Valencia:** Investigation, Conceptualization. **Manuel Tovar:** Investigation. **Jorge Tobón:** Investigation. **Mauricio Uribe:** Conceptualization. **Adolfo Eslava:** Supervision, Funding acquisition.

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Declaration of competing interest

Elizabeth Castaño and Mariela Ríos, co-authors, work with Trópico Diverso, a non-profit that promotes sustainable development in Antioquia, Colombia. Manuel Tovar, also a co-author, is member of Colectivo y Bosques, a grassroots organisation that promotes community forestry in the municipality of El Bagre, in Antioquia, Colombia.

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Appendices

Appendix A. Institutional design principles in San Lucas Mountains

Appendix B. Qualitative techniques for analysing community forestry

Appendix C. Colombia's legal framework on forest management: A timeline

Decree 2278 of 1953 introduced a four-tier categorisation of forests and established rules for conservation or management through licenses or concessions under the supervision of the government.

Law 2 of 1959 created seven “protective” forest reserves, covering 65,3 million hectares (67 % in the Amazon basin), and restricted the titling of state-owned land (“baldíos”). By 2004, the government had “subtracted” 13.9 million hectares (27 %), mainly for agrarian reform.

Law 135 of 1961 instructed the Agrarian Reform Institute to grant land titles to Indigenous “groups or tribes.” By 1989, the Institute had created more than 200 Indigenous land reserves (“resguardos”) over 25.7 million hectares.

Decree 2811 of 1974 introduced a new classification of forests (protective, productive, mixed), and tightened restrictions on land titling on forest reserves.

Law 37 of 1989 instructed the government to issue a National Plan for Forest Development and create a National Forest Service and a Forest Police.

Article 63 of the 1991 new Colombian Constitution established that natural parks and communal lands owned by Indigenous groups are unalienable in perpetuity. Article 330 also granted Indigenous communities the right to be consulted on decisions regarding natural resource extraction from within their territories.

Law 21 of 1991 ratified the Indigenous and Tribal Peoples Convention, which includes their right to prior, informed consent.

Law 70 of 1993 granted Afro-Colombian communities the right to own land collectively; forests within communal lands must be managed sustainably through conservation and agroforestry. Afro-Colombian communities were also granted the right to prior consent on any project that may affect their territories, on the same terms as Indigenous peoples.

Law 99 of 1993 reorganised environmental agencies, created the Ministry of Environment and Sustainable Development, and decentralised decisions such as the granting of permits and concessions for forest harvesting to subnational environmental authorities (*corporaciones autónomas regionales*).

Decree 1791 of 1996 introduced a new legal framework for forest management, instructed regional environmental authorities to zone productive forests, and set the requirements for long –or short- term forest harvesting.

The 1996 Forest Policy (Conpes Document No. 2834) instructed the national authorities to promote the sustainable management of forests by communities and small-scale farmers, as well as the creation of communal enterprises.

The 2000 Forest Development Plan stated that the country's richest forests were located within lands collectively owned by Indigenous and Afro-Colombian communities, characterised by informality, marginalisation, armed conflict, and poor state presence, which limited their potential for development.

In the 2016 Peace Agreement with the FARC insurgency, the Colombian Government committed to help peasant communities settled within forest reserves to improve their livelihoods while protecting the environment, for instance, through sustainable food production systems, payments for environmental services and reforestation. However, this, as most pledges included in the Agreement's Comprehensive Rural Reform, remains unimplemented.

The 2018 Green Growth Policy instructed the Ministry of Environment to update the forest management legal framework, including rules on community forestry.

The 2018 Strategy for Deforestation Control and Forest Management promised the developed and implementation of a community forestry management programme, the promotion of associative schemes, with particular attention to the role of women.

By 2018, 46.1 % of forest land in the country was located within Indigenous-owned, communal estates and 7.3 % was within Afro-Colombian territories (Yepes Quintero et al., 2019).

The 2020 Deforestation Policy instructed the Ministry of Environment to create enabling conditions for community forestry and announced a nine-year plan to that effect.

The 2023 National Development Plan authorised the creation of 30-year "peasant forest concessions" for the restoration and sustainable management of forests within forest reserves; the Plan explicitly excludes Indigenous and Afro-Colombian collective estates.

In 2024, the national government authorised the creation of Peasant Reserve Zones, a legal figure that restricts land transactions within a given rural area to prevent land accumulation and speculation, within forest reserves.

Data availability

Supplementary data associated with this article can be found at <https://data.mendeley.com/datasets/sdxjd9ntjz/1>.

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