Decentralization without Context: Unintended Conservation Outcomes in Cameroon's Community Forests

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HIGHLIGHTS

- The success of community forests is significantly influenced by local contexts.
- Staggered difference-in-difference design with matching developed by Imai et al. (2021) is a promising venue to evaluate the impact of conservation policies.
- The study highlights that community forest reforms in Cameroon inadequately considered local institutions and led to negative impacts on forest conservation, particularly where elite interests in timber extraction prevailed.
- While the overall impact of community forests on deforestation was insignificant, a notable increase in forest degradation was observed in the Southern region, driven by economic opportunities for timber exploitation and elite corruption.
- The findings emphasize the necessity for conservation policies to be grounded in culturally adapted processes of legitimacy and accountability to effectively empower community members and enhance forest conservation outcomes.

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ABSTRACT

What is the conservation impact of forest decentralization reforms that inadequately consider local institutional settings and empower unaccountable groups? This study develops a theoretical framework explaining how the lack of consideration for local settings might adversely impact conservation outcomes during decentralization reforms. The case of the 1994 Cameroonian decentralization reform is then used to test the predictions. The study assesses its effects on deforestation and forest conservation through a staggered difference-in-differences design with matching. While no overall significant impact on deforestation or forest degradation was found, a regional heterogeneity analysis revealed increased forest degradation in the Southern region, driven by elite-driven timber exploitation. The empowerment of unaccountable elites may have contributed to the adverse conservation outcomes. This study contributes to the broader discourse on decentralized forest management by offering novel empirical insights from the Cameroonian experience.

Keywords: Forest decentralization, community forests, Forest conservation, Accountability, impact evaluation

INTRODUCTION

Since the late 20th century, forest decentralization or devolution has emerged as a leading model of forest management, with Agrawal and Ribot (1999) documenting 60 instances by the end of the 1990s. These reforms typically transferred forest management responsibilities to local governments or community leaders, leading to the establishment of community forests. By the early 2000s, it was estimated that community-owned and managed forests covered at least 377 million hectares in developing countries, representing about 22% of all forested areas (White and Martin 2002).

The efficacy of community forests is influenced by numerous contextual factors, including intra-group dynamics, institutional objectives, and geographical conditions (Agrawal et al. 2018; Hajjar et al. 2021). These reforms are expected to yield greater efficiency, equity, and stronger conservation outcomes when local authorities are accountable to community members (Agrawal and Ribot 1999; Larson and Ribot 2004). The prevailing approach has developed a set of universal instruments, such as local elections and community participation, recommended across different contexts to enhance accountability (Ostrom 2007).

However, this mainstream conceptualization has two major flaws. First, communities are not homogeneous; they consist of multiple social groups with diverse preferences regarding forest management and conservation. Second, the effectiveness of fostering community member participation varies depending on local institutional settings. Consequently, community forests that employ these universal instruments without considering local contexts are unlikely to succeed (Ostrom, Janssen and Anderies 2007). Their success hinges on whether the new institutions are grounded in culturally adapted processes of legitimacy and accountability (Brown and Lassoie 2010), empowering groups committed to forest conservation. Nonetheless, many reforms failed to include local institutions because they were not recognized by the state, often empowering groups with minimal community ties, leading to conflicts at the local level (Brown and Lassoie 2010; Komalawati et al. 2023).

What are the conservation impacts of such reforms that inadequately consider local institutional settings and empower groups unaccountable to other community members?

First, the paper develops a theoretical argument explaining why integrated local and culturally adapted processes of legitimacy and accountability is essential for the success of conservation policies. Then, it aims to determine the causal effects of Cameroonian community forests, a typical decentralized reform that overlooked local institutions, on forest cover change. This paper hypothesizes that reforms are likely to yield negative forest conservation impacts when empowered groups have an interest in wood extraction, the capability to extract and appropriate economic rents from forests, and find it economically viable to do so. The study examines the potential adverse effects of such reforms through the lens of the Cameroonian forest decentralization reforms, notorious for their poor integration of the local context (Oyono 2003).

The 1994 reforms permitted local communities to manage up to 5000 hectares under community forests, facilitating the commercialization of timber and non-timber forest products and transitioning the property rights regime from formally state-owned to collectively owned land. The official objective was to reduce deforestation and enhance local welfare. As depicted in Figure 1, Cameroon experienced medium deforestation rates between 1994 and 2015, approximately 2% of the total forests deforested, compared to regions like Brazil, where over 4 to 5% of their forested area was deforested (Global Forest Watch, 2024). Despite numerous case studies examining the implementation of community forests (Bruggeman, Meyfroidt and Lambin 2015), no research has specifically assessed the impact of community forests on forest conservation at a national scale and on a long period. Such an assessment is crucial and strategic, considering that community forests in Cameroon make up 9% of the national forest estate and are generally located in areas of high biodiversity, including both natural and secondary forests in zones at high risk of conversion to other land uses (Bernard and Minang 2019).

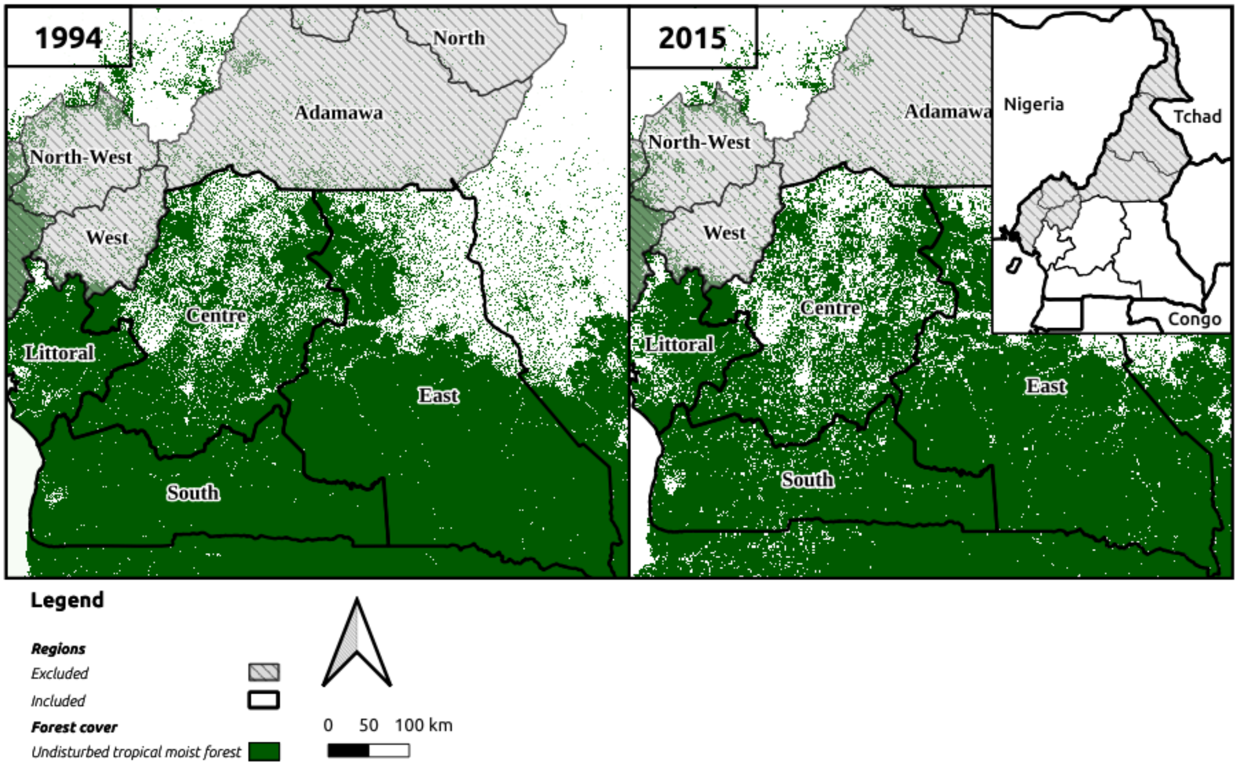

Figure 1. Evolution of forest cover between 1994 in the main forested regions in Cameroon.

Notes: The maps display primary forest cover in 1994, the year of the decentralization reforms, and in 2015, in the main forested regions of Cameroon. Data come from the tropical forest moisture dataset (Vancutsem et al. 2021). Regions highlighted in grey have been excluded from the analysis due to their lack of forest cover.

This study employs a staggered difference-in-difference design with matching, based on the methodology developed by Imai, Kim and Wang (2021). The findings reveal that community forests have had no significant overall effect on deforestation or forest degradation, with no spatial spillover to its buffer zone. Heterogeneity analysis highlights that the organisation nature of community forests and their proximity to protected areas do not affect significantly deforestation and forest degradation patterns. However, a heterogeneity analysis indicates a significant increase in forest degradation in the Southern region, attributed to the implementation of community forests. The exacerbation of forest damage in this region is likely driven by the presence of elites interested in extracting forest revenues and heightened economic opportunities for timber exploitation. In the Southern region, I find a higher proportion of commercial community forests and a higher proportion of citizens who consider the political and economic elites to be corrupt. Additionally, there is no history of timber extraction in the South compared to other regions, suggesting that high-value timber is still present. Case studies in the academic literature also supports this narrative.

Despite the extensive body of literature, studies employing quasi-experimental methods in sub-Saharan Africa are still rare. This research contributes to the discourse on community forests and collective titling by providing empirical evidence of the relatively negative impacts of reforms that fail to adequately incorporate contextual knowledge.

MATERIALS AND METHODS

Literature review

The theoretical expectation that democratic decentralization reduces deforestation is based on several arguments. Firstly, local elections are expected to increase political participation and restructure local officials' incentives (Agrawal and Ribot 1999; Faguet 2014). This would strengthen the accountability loop between providers and consumers of public goods. Secondly, it is believed that decentralization distributes resources and governance functions across multiple levels, reducing national power abuses and increasing political competition, which correlates with positive economic performance and reduced corruption (Albornoz and Cabrales 2013; Faguet 2014). Thirdly, decentralization may enhance efficiency by reducing transaction costs and leveraging local authorities' knowledge of local conditions (Tacconi 2007; Wright et al. 2016).

Despite these theoretical benefits, practical implementations often fall short, leading to recentralization and the empowerment of national state agents (Agrawal and Ribot 1999). Failures are due to inadequate powers granted to local institutions and an overreliance on elections for accountability, risking elite domination (Komalawati et al. 2023; Ribot 2003; Tacconi 2007). Communities might favor logging and agricultural expansion for revenue, increasing deforestation (Burgess et al. 2012; Tacconi 2007). The outcomes depend on local political incentives, with varying effects on deforestation (Harstad and Mideksa 2017). A recent literature suggests multiple alternative approaches to address those issues (Komalawati et al. 2023).

Empirical evidence on the impact of community forests, particularly in sub-Saharan Africa, is limited and mixed, highlighting the complexity of socio-ecological systems and the need for context-specific approaches (Ferraro and Agrawal 2021; Samii et al. 2014).

Community institutions typically involve collective titling, securing lands to local communities for either commercial or non-commercial forest resource use, depending on legal frameworks and community preferences. A recent meta-analysis conducted a global analysis of community forest management using data from 643 cases across 51 countries (Hajjar et al. 2021). Authors found that while most cases reported positive environmental or income outcomes, forest access and resource rights of local communities were frequently negatively affected (Hajjar et al. 2021).

Although numerous studies have explored the impact of these institutional arrangements on forest outcomes —such as forest cover, carbon stocks, forest tree density, or regeneration (Loke, Baul and Nath 2024)— relatively few have employed robust causal inference methods that enable the identification of unbiased and precisely estimated causal effects (Di Girolami, Kampen and Arts 2023). Taking only into consideration those studies, results are mixed. For example, Rasolofoson et al. (2015) assessed the impact of community forests in Madagascar on forest cover and found no statistically significant results. Similarly, community forests in Nepal were not more effective at carbon storage than non-community forests (Luintel, Bluffstone and Scheller 2018), though another study reported a significant reduction in deforestation (Oldekop et al. 2016). In contrast, similar institutional setups in Indonesia reduced deforestation between 2012 and 2016 (Santika et al. 2017), mirroring findings from Peru where legal titling was granted to communities in the Amazon (Blackman et al. 2017). In Easter Cameroon, a study found no effect of community forests on reducing deforestation rates (Bruggeman, Meyfroidt and Lambin 2015). Some suggest a potential negative effect, but these claims lack robust methodological support (Lescuyer, Cerutti and Tsanga 2016).

The efficacy of community forests is influenced by numerous contextual factors, including intra-group dynamics, institutional objectives, and geographical conditions (Agrawal et al. 2018; Hajjar et al. 2021). The type of community forests intervention is critical for its success. Agrawal et al. (2018) emphasized the importance of supportive policies, capacity building, collaborative stakeholder processes, and monitoring mechanisms. The motivations underpinning the creation of community forests are also critical. In Colombia, collective titling proved effective in reducing deforestation when local communities decided to expel private logging companies and large palm oil operators (Vélez et al. 2020). Conversely, in Madagascar, when community forests were established for commercial purposes, deforestation rates increased in subsequent years. Evidence from Nepal suggests that legal designation is less important than social cohesion and collective action mechanisms in achieving positive ecological outcomes (Bluffstone et al. 2018). When forest user groups maintain good relations with local politicians and actively engage them on forest issues, better forest outcomes are observed (Wright et al. 2016), highlighting the significance of multilevel governance in forest management (Andersson and Ostrom 2008).

I aim to contribute to this literature by providing evidence of the importance of looking at the interaction between the incentive structures of the groups being empowered by the reform and the economic benefits of land clearing and timber extraction. I also provide another robust empirical evidence of the conservation impact of decentralization reforms in Cameroon, extending previous research geographically and temporally.

Study area

Before colonization, the Bantu forest peoples of Cameroon's humid forest zone managed the forest primarily through lineage ownership, utilizing productive use to assert collective rights. The forests, along with associated agricultural lands, were managed as common property by lineages, with decision-making centralized within lineages encompassing multiple generations (Etoungou 2003). During colonization, some traditional practices were maintained, allowing local use rights.

Post-independence legislation perpetuated state control, marginalizing local populations and nationalizing lands except those registered as public or private, or under cultivation (Oyono 2005). Despite the state ownership of the forests, the lineage ownership regime was still in place. Forest management was a collective endeavor with decisions typically made collaboratively rather than through formal permissions, especially within the clan and lineage systems (Diaw 1998, 1997). While the chief and lineages heads theoretically dictate land use within primary forests, in practice, villagers followed an informal consensus on land usage, rarely requiring explicit authorization except for outsiders (Brown and Lassoie 2010). In areas dominated by secondary growth and customary tenure, decisions about land use were generally made at the lineage or household level, with the village council resolving disputes over forest resources (Brown and Lassoie 2010).

The reform in 1994, which aimed to increase popular participation in forest management, foster sustainable management, and fight against poverty, introduced a new zoning with two zones. The permanent forest estate, owned by the state and managed by the forest ministry, aimed to foster logging and conservation activities. The non-permanent forest estate, where most of the degraded and secondary forests are, is managed by the agriculture ministry for agriculture development. Concretely, the law allowed the transfer of power and forest management responsibilities to communities to create community forests in the non-permanent forest estate. Under certain conditions, since 1994, local communities can manage patches of forested lands up to 5000 hectares and for a period of 25 years.

The reform created a shift in the de-facto property right regime. It was widely criticized for its lack of integration of the local context and institutions (Brown and Lassoie 2010). The legislation did not adequately define 'community' in a way that aligns with the cultural realities of the region, a widespread phenomenon also found in the academic literature (Schusser et al. 2016). As per the legal definition, a community is a local population or village near a forest with recognized forest access and use rights (Vabi 1999). This definition, however, often excludes many key users whose usage does not conform to the proximity criteria (Brown and Lassoie 2010). The legislation also creates a new institutional layer that overlooks the traditional systems of natural resource management in Cameroon, which rely on the authority of elders, lineage leaders, and village chiefs (Diaw 1997; Vabi 1999).

The creation follows three key steps: 1) a consultation meeting with the population; 2) a provisional agreement with the forestry ministry that covers the location of the community forests, the type of exploitation, and the legal structure; and 3) a final convention in which the nature of the exploitation is defined, the ways economic benefits will be shared within the community, and how the governance structure is set-up. Community forests can be legally registered as an Association, Cooperative, Common Initiative Group (CIG), or Economic Interest Group (EIG), which handle all government correspondence related to the establishment and management of the community forest. As of 2013, most community forests were registered as either a common initiative groups (63.47%) or under associations (36%) (Alemagi et al. 2022). Communities often choose those legal structures for their advantages. Associations are simple to establish and manage, tax-exempt, and eligible for subsidies, donations, and bequests if recognized as a public utility by the President (Alemagi et al. 2022). Similarly, CIGs are manageable, convertible into cooperatives, can distribute benefits among members, and are also eligible for subsidies and donations (Alemagi et al. 2022).

The legal entity is governed by the president of the community forests (Mbairamadji 2009). By law, the president must be elected by community members and held participatory meetings with communities to decide on the objectives of the community forests, the set of economic activities to develop, and the benefice sharing mechanisms (Mbairamadji 2009). In practice, the reforms are not implemented as intended on the ground with most of community forests leaders who are not downwardly accountable to community members. Oyono and Efoua (2006) examined the composition and appointment methods of community forestry management committees in the southern region. Their findings indicated that only 10% of committee members were elected through democratic means, while 20% were appointed by consensus. Furthermore, they pointed out that nearly half (43%) of the committee members assumed their positions through self-appointment.

The shift in community rights to forests and resources led to the transfer of management powers from village chiefs to management committees (Oyono, Biyong and Samba 2012), who may be more educated but lack traditional legitimacy (Brown and Lassoie 2010). The committees are frequently comprised of retired civil servants or educated young men unable to find urban employment (Etoungou 2003; Oyono 2005). They tend to dominate the process and exclude other local stakeholders from the benefits of community forests. Community meetings are rarely held and participation rates, especially among women, is relatively low, engendering low information flow, no transparency, which is fertile ground for no-accountable leadership (Piabuo, Foundjem-Tita and Minang 2018). As Etoungou (2003) documented, these committees have become a kind of forestry elite, self-interested and detached from the village communities they serve. This shift towards elite control has resulted in disorganized management and exploitation of many community forests (Assembe 2006; Mbairamadji 2009; Oyono, Biyong and Samba 2012), with funds being often misappropriated by community forests managers (Piabuo, Foundjem-Tita and Minang 2018). This has led to significant conflict between community forests committee members and traditional authorities (Oyono 2005). Such exclusion has escalated into conflicts, some of which have turned violent, suggesting that the approach to decentralization may have disrupted established social regulatory mechanisms, paving the way for social distortion and increased conflict (Brown and Lassoie 2010).

Most community forests engage in logging activities as an income generating process. To legally engage in logging activities, community forests need to develop a management plan and make it approved by the forest ministry. Because the development of such management plan is technically, procedurally and financially demanding, and the need of high initial investment to start logging activities, community forests generally seek to partner with a logging company to exploit the forests (Kimengsi and Bhusal 2021). There are multiple factors that have limited the timber exploitation of community forests (Mbarga 2013). First, they are located in the non-permanent forest domains where forests richness is more limited (Mbarga 2013). Second, the size of community forests are small from 1000ha up to 5000ha. In comparison, private concessions are generally 10 times bigger to achieve economic scalability. Third, the limited timber potential is also explained by an history of timber exploitation where the more monetary valuable woods were already logged (Mbarga 2013). Finally, they are poorly geographically connected to the timber market, generating high transportation costs (Lescuyer 2013).

Where timber logging remains economically viable, I posit that the creation of community forests will likely increase forest degradation due to intensified logging activities. This effect is likely to be exacerbated by the presence of local elites with short-term interests, empowered by the shift in property rights regimes.

Sample characteristic

In 1997, the first community forests received a final convention, but the first wave of community forests emerged in the early 2000 with the acceleration of the rate of community forests creation from 2005 onwards. In 2020, there were 687 community forests, among which 604 were in the five regions of interest (Center, East, Littoral, South), and 345 received a final convention (MINFOR 2021). Community forests in Cameroon have been concentrated in the forested regions: Centre, East, Littoral, and South. As of 2010, these regions implemented 187 community forests (considering only those with finalized administrative agreements). The Anglophone regions (Southwest and Northwest) exhibited a different pattern, with only 6 and 3 community forests established, respectively. These regions have distinct institutional arrangements, characterized by strong traditional leadership structures with a degree of autonomy from the central government. This often mitigates conflicts with newly empowered elites, leading to a smoother transition in property rights regimes. Furthermore, historical marginalization of the Anglophone regions by the Central government culminated in the 2016 civil war located in the Anglophone regions, which displaced hundreds of thousands of civilians. Consequently, the theoretical framework outlined earlier may not be directly applicable in these regions. To ensure a focused analysis, I excluded them from the study. Additionally, non-forested regions, irrelevant to forest conservation and deforestation research (comprising four community forests), were also excluded. Including these regions did not affect the consistency of the results presented in this paper.

Difficulties arose in assessing forest changes before and after 2013 due to changes in satellite data during that period (2013-2015). To address this challenge, the study focused on community forests established up to 2010. This timeframe allows for the observation of at least three years of deforestation data preceding the introduction of the new Landsat satellites.

Data on community forests were obtained from the Cameroonian Ministry of Forestry's online portal. A critical variable for this study is the community forest's implementation date, which coincides with the signing of the official convention with the state. This convention grants the community forest the right to exploit forest resources. Of the 604 community forests identified within the four regions of interest, only 398 possessed sufficient information regarding implementation dates. Appendix A1.2 depicts the geographical distribution of all 604 community forests across the four regions. The excluded units, lacking implementation date information, appear to be well distributed throughout the study area. This suggests that the phenomena under investigation might not differ significantly within those excluded forests.

The staggered difference-in-difference with matching design

Treatment and outcome variables

I consider the year of the creation of the community forests as the year when the treatment starts. The treatment is staggered between 1996 and 2010. Among the 398 community forests included in the analysis, 187 were created before 2010 and constitute the treated sample of units. Figure 2 shows the distribution of the creation of community forests among the community forests created before 2010. There are 211 community that were created after 2013. Those community forests are used in the control pool of never treated unit in the empirical design.

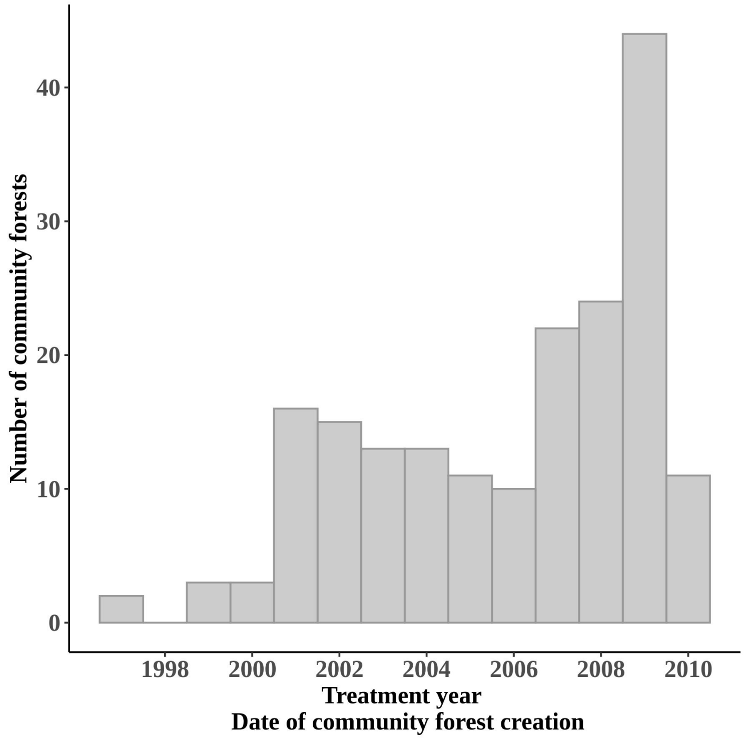

Figure 2. Temporal distribution of community forests implementation, the treatment under consideration.

Notes: The graphic illustrates the temporal distribution of community forests implementation. The implementation date which corresponds to the administrative date when the permit is deliver, corresponds to the treatment under consideration. The data come from the forestry ministry (MINFOR 2021).

The unit of analysis is the community forest. I am interested in the impact of community forests on deforestation and forest degradation. Deforestation refers to the permanent change in forest cover from forested land to unforested land, typically representing a shift in land use from forest to agriculture. Forest degradation, on the other hand, is a non-permanent change in forest cover. After the forest has been cleared, it regrows, indicating that logging has occurred but without a permanent change in land use. Forest clearing is typically classified as forest degradation when the forest regrows within the next three years; otherwise, it is considered deforestation (Vancutsem et al. 2021). Both phenomena are significant because they negatively impact forest ecosystems, particularly biodiversity and carbon stock. Nevertheless, they indicate different human-nature interactions, suggesting different political economies at play. In cases where elites are short-sighted and it is economically viable to cut trees, I expect the creation of community forests to increase forest degradation as the elites are interested in selling timber. Patterns of deforestation, however, could be related to either investments by the newly arisen elites in new land uses or actions by excluded families who prefer to log and farm the land to secure a share of the economic benefits.

Empirical strategy

A simple comparison of the deforestation rates before and after the implementation of community forests would lead to bias in estimating the Average Treatment Effects on the Treated (ATT) (Blackman 2013). In a case in which climate and economic factors drive deforestation and forest degradation. If such factors disappear at the exact moment of community forests' implementation, the reduction of deforestation and/or forest degradation would be misallocated to the implementation of community forests. Hence, the estimate will be biased.

The process of assigning community forest implementation may largely depend on access to financial resources, networks within the forestry ministry, and access to information. Community forests established in the early 2000s may, on average, differ from those implemented later. Appendix A1.3 presents descriptive statistics for community forests established before 2005, between 2005 and 2010, and after 2010. On average, community forests implemented in the late 1990s and early 2000s are closer to main roads and cities, more densely populated, and located farther from protected areas. Regions with stronger connections to areas of higher socio-economic activity and the capital city where the forest ministry is located, may have greater access to resources and information for implementing community forests. Consequently, a simple difference-in-difference analysis between implemented and yet-to-be-implemented community forests could lead to biased results due to differences in socio-economic connectivity.

Consequently, the conservation literature advises using matching methods combined with panel data to cope with that issue (Andam et al. 2008; Jones and Lewis 2015). Therefore, I used a staggered difference-in-difference with a matching strategy to construct the control group (Imai, Kim and Wang 2021), in which, for each year, each newly created community forests is compared with not yet implemented community forests.

For the matching strategy, I follow the practical guide given by Blackman (2013) to choose the best-observed covariates to match on and use: distance to main cities, capital, and port, elevation average, and variation, four lags of temperature, precipitation, population and four lags of deforestation rates. I use a broad set of matching techniques to constitute the matched control group. These techniques vary according to the treatment-to-control ratio, the replacement of control units, weighting, setting capillaries, and the order of selecting matches (Schleicher et al. 2020). Then, I assess the quality of the matching strategy according to three main criteria: covariate balances (using a criterion of 0.25 standard mean differences), the number of treated and control units retained (100% of treated units and a maximum of control units are considered as a good approach), and the consistency of the parallel trend assumption. Appendix A1.3 provides the list of the matching approaches and their assessment. The best technique is the so-called *1 to 1 Mahalanobis matching*, the technique does not exclude any treated unit but 50% of the control units are discarded.

Community forests can generate spatial spillover effects on deforestation and forest degradation in areas around the community forests. Community forests could decrease deforestation and forest degradation inside the border but increase it outside the borders. I assess such effect using the same strategy (matching method combined with difference-in-difference) but using the areas around 500m, 1km, and 3km from community forests.

Data

I match geographical, socio-economic data, and political variables to each community forest. Table 1 presents the averages and standard deviations of those characteristics for all community forests in Cameroon and the one included in the analysis. I use a variety of controls known to be essential factors explaining deforestation outcomes: demographic, geographic, socio-economic, and political controls. Appendix A1.1 displays the main sources for each of these variables, the units and transformation used in the analysis. I use three main outcome variables, forest degradation and deforestation from Vancutsem et al. (2021) and a measure of forest loss combining both forest degradation and deforestation from Hansen et al. (2013).

As a demographic control, I measure population density from the grid population data to determine the population density in each subdivision. The following years are available: 1990, 1995, 2000, 2005, 2010, 2015, and 2020. Taking advantage of the monotonous and slow change of population density, I compute the value for the missing years, fitting a polynomial model of degree three (maximum degree available).

Table 1. Descriptive statistics of community forests

	All CF	CF with creation date
General information		
N	604	398
Cumulated surface (in 1000ha)	1615	1041
In % of the national forest surface	*8.2*	*5.3*
Matching variables		
Population density (in hab/km)	14.0	11.1
	(72.4)	*(9.4)*
Temperature (maximum, in K)	347.6	347.9
	(7.6)	*(7.5)*
Temperature (minimum, in K)	234.0	233.5
	(12.7)	*(12.9)*
Precipitation (mm)	1693.9	1681.5
	(264.6)	*(248.3)*
Elevation (m)	589.2	595.6
	(163.4)	*(159.9)*
Slope	16.6	16.6
	(18.1)	*(19.0)*
Distance to main city (km)	117.1	119.9
	(65.7)	*(63.6)*
Distance to national road (km)	33.1	33.8
	(36.5)	*(35.8)*
Distance to departmental road (km)	38.1	39.6
	(37.1)	*(38.1)*
Distance to provincial road (km)	37.5	36.7
	(36.3)	*(36.0)*
Distance to protected area (km)	67.5	78.5
	(67.3)	*(74.5)*
Latitude	3.9	3.9
	(1)	*(1)*
Longitude	12.9	12.9
	(1.4)	*(1.4)*
High proportion of State-owned lands	0.5	0.5
	(0.3)	*(0.3)*

Notes:
The table presents descriptive statistics for the full sample of community forests (all CF column) and the subset for which implementation dates are available (CF with creation date). For the general information, N is the number of community forests. The cumulated surface represents the total area the community forests cover in thousands of hectares and as a proportion of the national forest surface. Average values are displayed for all variables, with standard deviations in parentheses. The national territory is divided into the permanent and non-permanent forest estate. The proportion of State-owned lands represents the proportion of community forests located in subdivisions (equivalent to cantons) with at least 50% of the area covered by the permanent forest estate.

I use the annual precipitation average, annual minimum, and maximum temperature average (Hijmans et al. 2005), and elevation measures (average altitude and the variation of this altitude in each subdivision) for geographic controls (Farr et al. 2007).

I also control for socio-economic and political variables. As administrative data are not available, I use the distance between the main cities and the capital as proxies of political connectedness. I use the distance to the main port, the main national, provincial, and departmental roads to proxy economic connectedness. Requests for community forests might be more straightforward in places close to the political hubs. Also, as the wood is sold in the international market, the cost of the activity depends widely on transportation costs. Therefore the farthest from the port, the highest the cost of logging activities.

The matching quality

The covariate balance measures the quality of the matching strategy. Figure 3 displays covariate balances before and after matching using the one-to-one Mahalanobis distance measure. Before matching, not yet treated units (used as the control group) are, on average, more distant to protected areas and closer to national roads. Community forests used as treated units are also located on lands with higher temperatures and precipitation. After matching, most of the sources of imbalance are removed with an exception for the distance to protected areas where a standardized mean difference of 0.275 exists between treated and not yet treated units. I describe the potential effect of this difference in the discussion.

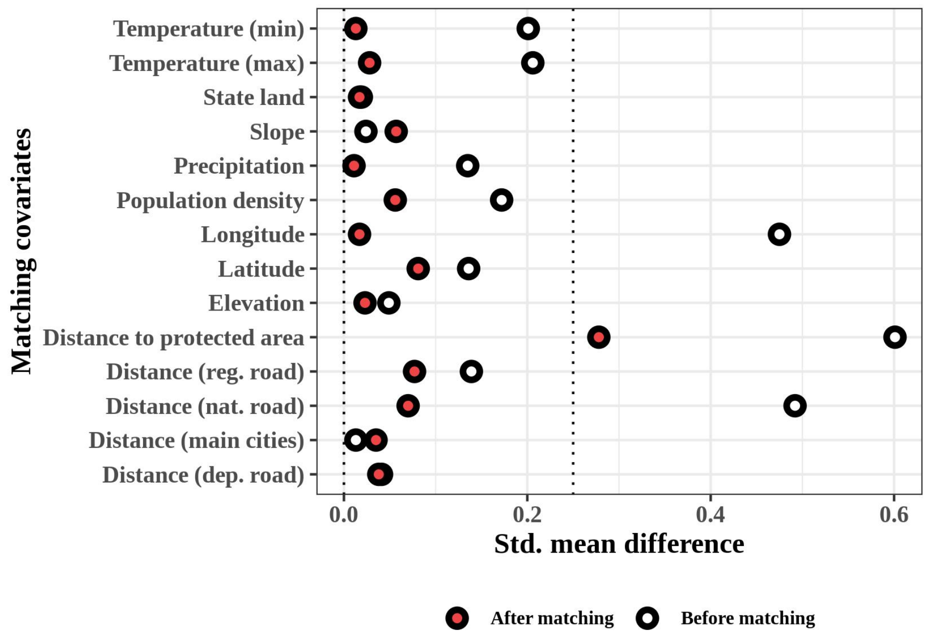

Figure 3. Covariate balances for the main matching strategy: 1 to 1 mahalanobis.

Notes: The graphic displays the covariate balances for the 1 to 1 mahalanobis strategy. The matching is done on the 5-year preceding the creation of community forests. Empty dots represent differences in covariates before matching while full dots represent differences after matching.

To assess the plausibility of the parallel trend assumption, I display the lagged standard difference of the outcome variable and conduct placebo tests. Overall, the tests are consistent with the parallel trend assumption, as depicted in the result section.

RESULTS

Main results

I test whether the implementation of community forests affects two main ecological outcomes: forest degradation and deforestation rates. Panel A and B in figure 4 display the average treatment effect on the treated of the creation of community forests on deforestation rates from 4 years before the implementation to 5 years after the implementation. Overall, the results using tropical forest moisture datasets (Vancutsem et al. 2021) show no differences in deforestation after the implementation of community forests. Appendix A2.1 display the results of a pooled estimate from those years and results are not statistically different from 0 with an estimate of 0.01% higher deforestation rates. When using the Hansen data (Hansen et al. 2013), a dataset commonly used to assess deforestation rates in tropical countries (Larcom, van Gevelt and Zabala 2016; Mihaylova 2023), the patterns are slightly different. The analysis shows a small statistically significant increase in deforestation rates of 0.05% in treated units compared to not-yet treated units after 2 years of implementation, with the other effect sizes being positive but not statistically significant from 0. The differences can be explained by three reasons. First, Hansen data uses deforestation threshold of 30% at baseline. Second, deforestation rates from Hansen data is provided relative to the baseline year 2000. Finally, Hansen data uses additional assumptions to calculate annual deforestation rates, (i.e. a pixel deforested a given year is considered as deforested even if there is forest regrowth afterwards).

The analysis focusing on forest degradation depicted in the panel C in figure 4 reveals similar findings. After 3 to 5 years the creation of community forests, forest degradation rates increase up to 0.2%. However, none of the point estimate are statistically different from 0. Appendix A2.1 displays the pooled estimation and reveals an increase of 0.12% forest degradation rates after the creation of community forests but the result remains statistically insignificant from 0.

I test whether the results are robust when accounting for treatment anticipation. To do so, I test the robustness of the results using two alternative specifications displayed in Appendix A2.2. The first specification assesses whether there is any anticipation of the treatment which could explain the null finding in the main specification. To do so, I used another treatment variable, the year in which communities send the administrative request for the implementation of the community forest. The results underline an increasing trend in forest degradation among treated units although none of those results are statistically significant.

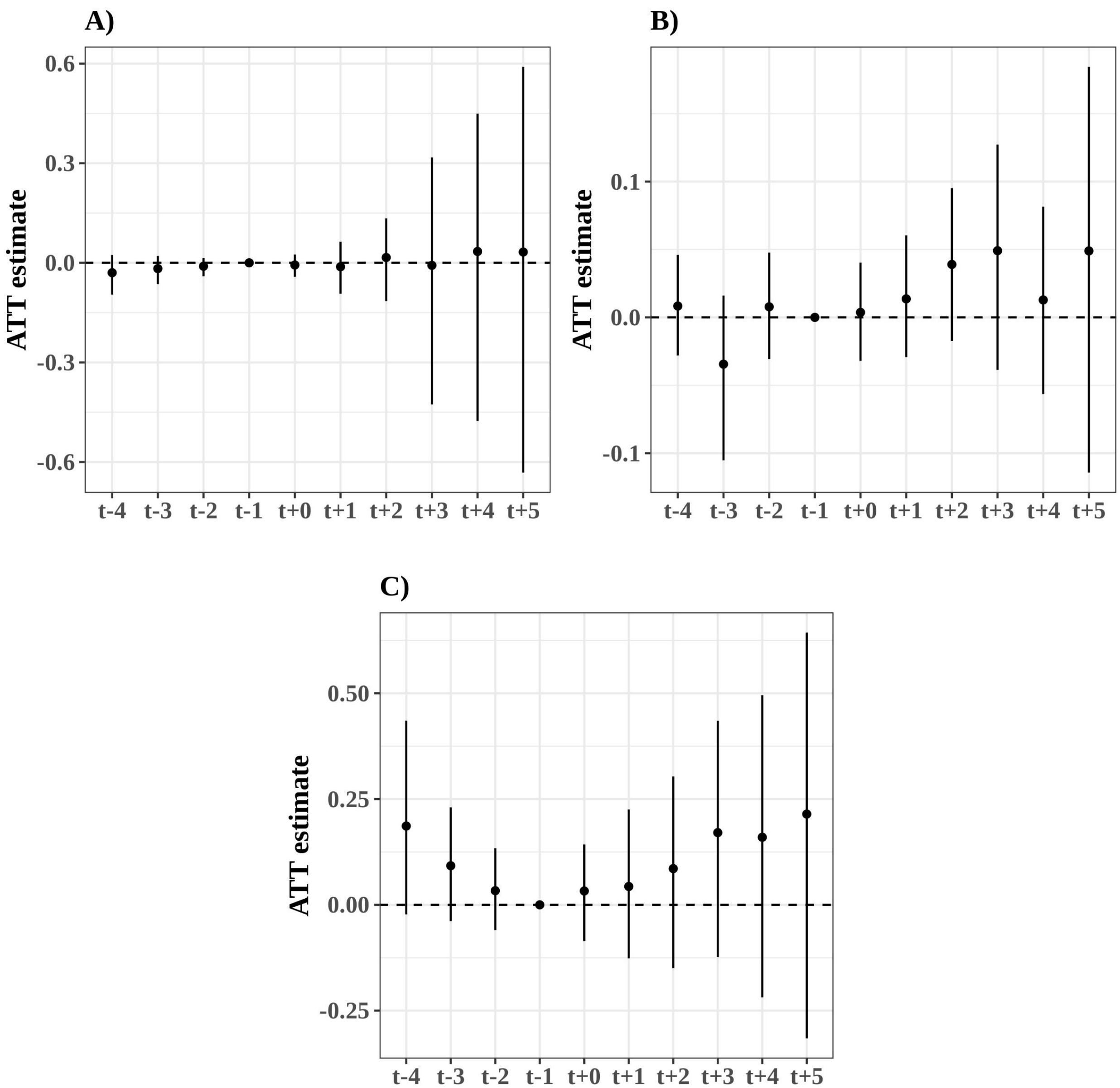

Figure 4. **(A)** ATT of the impact of the creation of community forests on **deforestation rates** (vancutsem data) from 4 years before implementation to 5 years after, **(B)** ATT of the impact of the creation of community forests on **deforestation rates** (hansen data) from 4 years before implementation to 5 years after, **(C)** ATT of the impact of the creation of community forests on **forest degradation** from 4 years before implementation to 5 years after

Placebo test

The validity of the identification strategy depends on the fact that observations with the same treatment status have similar outcome variables trends, the so-called parallel trend assumption. If communities that receive treatment early on present a declining deforestation trend compared to of that communities that receive treatment later on, one could expect that the treatment effect would capture this even in the absence of a titling effect. I test whether such trends are similar for deforestation and forest degradation, illustrated by figure 4. The test is undertaken between community forests implemented early on and the ones implemented later for four years before the implementation of the community forests. As figure 4 suggests, there is no evidence of the presence of statistically significant differences between deforestation trends in treated and not yet treated units. When using forest degradation, the standardized mean differences between control and treated units decrease from 0.2 four years before implementation to 0.03 2 years before the implementation. However, none of these differences are statistically significant at the 5% level. For the robustness strategy, I display the placebo test in the appendix A2.2.

Spillover effects

The impact of community forests on deforestation is difficult to assess because of the spatial spillover. The creation of a community forests could potentially affect how forests users interact with the forest at the buffer. Forests users could choose to stop cutting trees at the buffer to cut trees inside the community forests where it has been legalized. On the other hand, forest users that did not access to the management of the community forests could choose to deport the extraction of timber to the zone at the buffer of the community forests. I assess the potential for spatial spillover using a two ways fixed effects models and comparing the trends of deforestation rates at the buffer compared to the trends inside the community forests at the creation of the community forests. Table 2 presents the results. The implementation of community forests did not affect deforestation rates within 500m, 1km, or 3km buffers around these areas. These findings are consistent with the absence of spatial spillover effects.

Table 2. Spatial spillover analysis. Two ways fixed effects models of the impact of a creation of community forests (CF) on the differences in deforestation rates between the zone inside CF and the buffer.

	Deforestation: CF vs. buffer		
	500m	1km	3km
Community forests implementation	−0.001	−0.003	−0.005
	(0.010)	(0.010)	(0.010)
Adj. R^2	0.323	0.329	0.332
Num. obs.	11976	11964	11928

Notes:
The table assesses the potential for spatial spillover. It presents two ways fixed effects models of the relationships between the creation of community forests on the differences in deforestation rates between the zone inside community forests and the buffer: 500m, 1km and 3km. It uses the Hansen data. Positive values implies that the creation of community forests increases deforestation inside the community forests zone compare to the deforestation trends in the buffer. Robust standard errors in parenthesis. $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$; $^{+}p < 0.1$

DISCUSSION

Regional differences in the effect of community forests

The literature emphasizes critical moderating factors of the effect of community forests on deforestation and forest degradation such as the geographical locations (regions), the legal status of community forests (commercial vs. non commercial community forests) (Rasolofoson et al. 2015), and proximity to protected areas (Loveridge et al. 2021). I explore whether there is any heterogeneity in the effect of community forests based on those factors. Figure 5 in the analysis display the main result for geographical locations and the other heterogeneous results are displayed in Appendix A3. When focusing on deforestation, the results suggest no discernible pattern in the East and in the Center. In the Littoral, the effect sizes are high with a point estimate of 0.2% after two years of implementation to 0.7% after 5 years of implementation. The low number of community forests (less than 10) renders the estimate noisy and therefore it does not reach statistically significant level. In the South, deforestation rates increased slightly reaching statistically significant levels of 10% and 5% for the first and second year after the creation of community forests. The effect sizes remain small compared to the trends in the Littoral. When looking at forest degradation, it is noticeable that in the South region, community forests seem to lead to a significant increase in forest degradation from 2 to 5 years after implementation with an effect size of around 1% increase when comparing to not-yet treated units reaching statistical significance level of 5 to 1%. On the other hand, in the other regions included in the analysis, I do not find any impact of the creation of community forests on forest cover. As already discussed previously, forest degradation means that the cutting of the forests was followed by forests regrowth. It suggests that such forest degradation was not induced by agriculture practices but rather by logging activities. I further dig into the mechanisms in the following subsection.

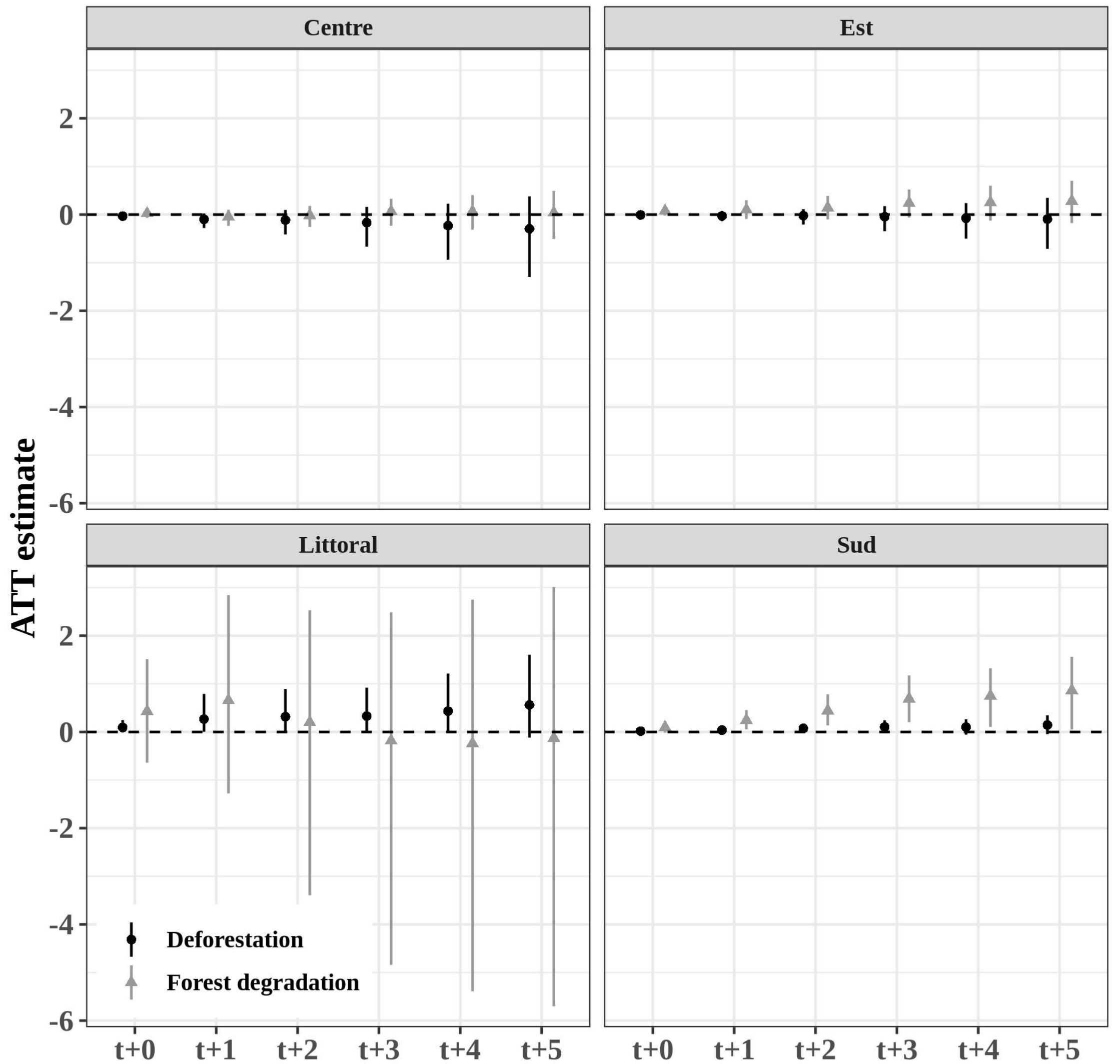

Figure 5. Average treatment effect on the treated of the implementation of community forests on primary forest loss, deforestation, and forest degradation

Notes: The figures displays the average treatment effect on the treated of the implementation of community forests on deforestation and forest degradation from 0 to 5 years after implementation in the four regions where the analysis takes place. Dots represent average estimate and bars bootstrap 95% confidence interval. Black colour represents the effect for deforestation and grey colour for forest degradation.

When looking at the moderated impact of commercial community forests compared to non-commercial community forests, I find that effect sizes are close to 0 and not statistically significant results unlike previous studies (Rasolofoson et al. 2015). Finally, community forests in proximity to protected areas have often been targeted by NGOs as conservation priorities to create buffer zones around biodiversity hotpot (the protected area). If those community forests concentrate conservation and NGOs efforts, they might experience a different treatment effect. However, in this paper, I don't find any evidence suggesting that community forests have different ecological outcomes around protected areas compared to community forests further away.

The profitability of forests logging as a potential driver

In this section, I explore why community forests lead to increased forest degradation in the Southern region but not in others, excluding the Littoral region due to its low number (8) of community forests. The Central region is unlikely to have experienced increased forest degradation or deforestation due to its geographic characteristics. The forests in this region have lower timber values and it is more densely populated than the South and East (Piabuo 2022). Additionally, less than 70% of the Central region is covered by forest, compared to 80% to 90% in the South and East. This, combined with high population density and low enforcement capacity, makes the new institutional arrangements around community forests less effective. Consequently, pressure on forest resources under both community and non-community forest regimes might have led to similar levels of forest degradation and deforestation.

The differences in forest degradation rates between the East and South are more intriguing. I propose three complementary explanations for these differences, with the results detailed in Appendix D.

Firstly, increased forest degradation in the Southern region may be attributed to higher industrial logging activities. I proxy the phenomena with the extent of unusual high rates of forest degradation in a given year and descriptive statistics are reported in Appendix A4.2. In the South, community forests are significantly more likely to experience high rates of forest degradation, with a nearly 10% difference. This contrast is only observed in the South. In the East, community forests are less likely to experience such phenomena compared to areas where community forests have not yet been created, also by about 10%. This quantitative evidence is supported by case studies from the southern region of Cameroon, which document prevalent industrial logging activities (Ezzine de Blas et al. 2009; Piabuo, Foundjem-Tita and Minang 2018).

Secondly, leaders of community forests may be more inclined to pursue private gains, successfully arranging with logging companies for the exploitation of community forests, as documented in multiple comparative case studies in the area (Oyono, Biyong and Samba 2012). To evaluate this potential explanation, I analyze corruption perception in the South and in the East region using Afrobarometer data, and the rates of commercial versus non-commercial community forest creation with descriptive statistics reported in Appendix A4.3. As Table 3 shows, in the South, most professions related to the forest sector are perceived as significantly more corrupt than in the East. For instance, 50% of respondents in the South considered most businessmen to be corrupt, compared to 27% in the East. It is also the case for bureaucrats and NGOs, although to a lesser extent. Regarding status, in commercial community forests, locally known as common initiative groups, members can directly benefit from exploitation, which facilitates the use of forest revenues for private gains. In the South, there was only one community forest until 2004. From 2004 to 2010, the number of commercial community forests consistently exceeded non-commercial ones, peaking in 2007 when approximately 70% of community forests were commercial. After 2010, the proportion of commercial and non-commercial community forests was similar. In contrast, in the East, non-commercial community forests consistently outnumbered commercial ones, with proportions around 55% to 60%.

Table 3. Attitudes towards different professions in the South and the East region of Cammeroon using Afrobarometer wave 9 (2022)

	East	South	Diff.
Number of observations	56	40	-
Most or all of the following figures are corrupt (in %)			
Business men	27	52	+25%
MPs	38	50	+12%
Judges	55	62	+7%
Bureaucrats	57	62	+5%
NGOs	30	35	+5%
Municipal councilors	38	40	+2%
Chiefs	27	22	−5%

Notes:
This table presents the average perception of multiple professions by residents from the East and the South of Cameroon using Afrobarometer Wave 9 (2022). The question was, 'How many *of the following profession* do you think are involved in corruption?' I averaged the proportion of respondents answering 'most of them' or 'all of them.'

Finally, the commercial benefits from community forests are likely higher in the South than in the East. To investigate this pattern, I examine two characteristics associated with lower profitability. The first characteristic is the size of community forests, with results reported in appendix A4.6. Smaller community forests are less viable for effective logging and sourcing sufficient timber resources for scalable operations. In 2010, community forests in the South averaged 2400 hectares, compared to 3200 hectares in the East, which does not provide a substantial explanation. However, the second characteristic—the history of logging activity within community forests—is more telling. I assess this by examining industrial logging permits in the area years before the creation of community forests. Interestingly, community forests in the East had experienced heavy logging in the years prior to their creation, suggesting that the most valuable trees had already been extracted. This is corroborated by the creation of new logging roads prior to the establishment of community forests, with results displayed in appendix A4.5. No new roads were found in the South, whereas numerous roads were created in the East before the creation of community forests.

Overall, the increased forest degradation in the South may have been driven by higher industrial logging activities, fueled by the short-term gain preferences of rising local elites (Ezzine de Blas et al. 2009; Oyono, Kouna and Mala 2005) and a context of higher economic profitability of the community forests (Nuesiri 2015).

CONCLUSION

In 1994, the Cameroonian government initiated in a forest decentralization reform allowing communities to govern small patches of forests and legalize logging activities. Such a reform did not take into account the local institutions and induce an abrupt shift in the property right regimes leading to higher tenure insecurity. This paper contributes to the literature on collective property right regime by highlighting the potential negative effect when local institutions are not taken into account. The reform induces the rise of new institutions where a forestry elites, not accountable to the local population, could extract private revenues from the forests, especially when strong ties with logging companies were developed. In this paper, I tested formally such an argument by determining the effect of the creation of community forests on forest conservation in the main forested regions. Using a staggered difference-in-difference using matching method, I found that the reform did not induce higher forest conservation benefits. If anything, it has led to higher forest degradation, especially in the Southern region where industrial logging activities were found to be unusually high.

The empirical strategy identifies the Average Treatment Effect on the Treated (ATT) for community forests with known implementation dates prior to 2010. However, the external validity of these results remains uncertain. Table 1 presents the characteristics of community forests with and without available information, showing overall similarity. Nevertheless, forests established after 2010 are, on average, more remote and less connected to markets and political centers. Consequently, the results likely represent general deforestation trends for community forests implemented in Cameroon before 2010 but may not accurately reflect the impact on forests established after that date.

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Appendix

A Details on the main empirical strategy

A.1 Data sources

Table 4. Data, sources and units

Variables	Source	Units	Transformation
Outcome variables			
Community forests requests	MINFOR and WRI (2020)	%	
Deforestation rates	Hansen et al. (2013)	%	
Forest degradation	Vancutsem et al. (2021)	%	
Control variables			
Forest cover	Hansen et al. (2013)	%	
Population density	(CIESIN)	N/km^2	
Precipitation	Hijmans et al. (2005)	mm	
Temperature (min)	Hijmans et al. (2005)	K	
Temperature (max)	Hijmans et al. (2005)	K	
Public/private owned forests	Hansen et al. (2013)	m	log
Land pressure	Author	0/1	
Subdivisional area	Hansen et al. (2013)	m	log
Elevation	Farr et al. (2007)	m	log
Distance to capital	Author	m	log
Distance to main cities	Author	m	log
Distance to roads	Author	m	log

Notes:
The table presents the main variables used in the main empirical strategy (column 1), where they have been downloaded (column 2), the measurement unit (column 3), and whether any additional transformation was used.

791 A.2 Map of community forests location

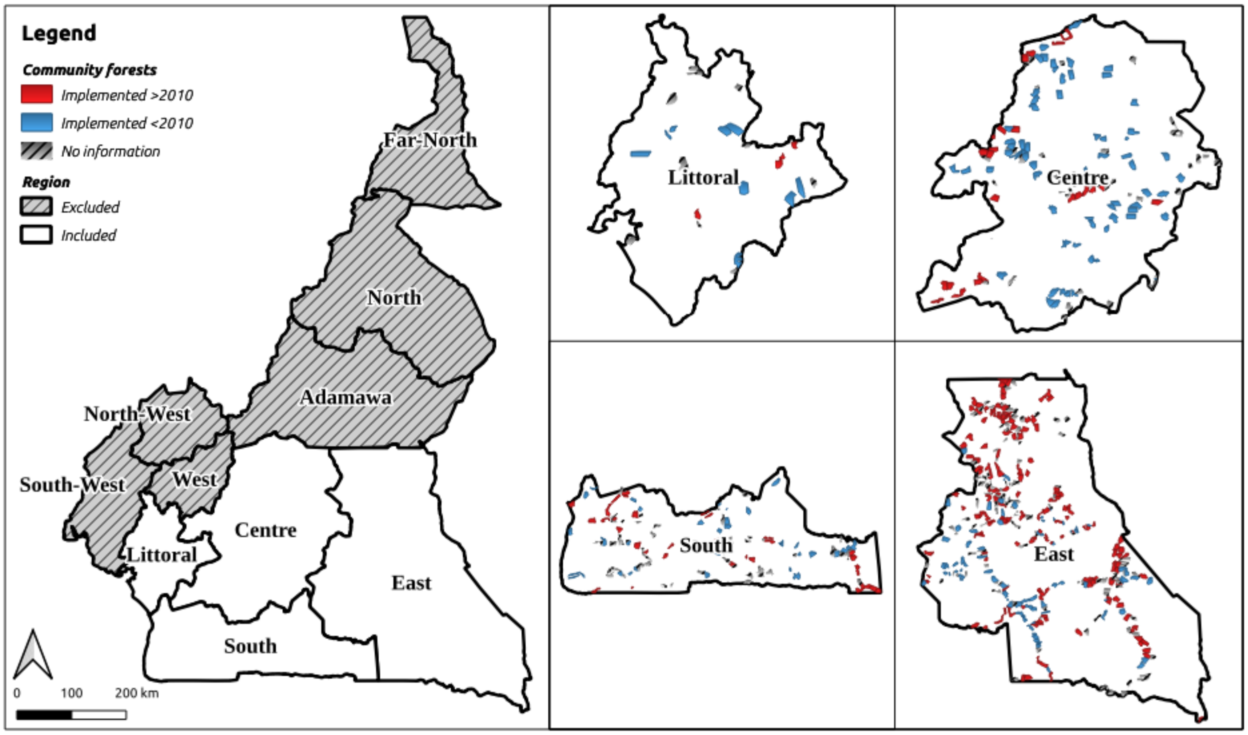

Figure 6. Map of the regions included and excluded from the analysis and location of community forests.

Notes: The maps shows the region included in the analysis. For each region, it also displays the community forests included in the analysis (implemented before 2010) and the community forests whose implementation happens after 2010 included in the control group.

A.3 Descriptive statistics of the community forests by the implementation period

Table 5. Descriptive statistics of the community forests included in the analysis by period of implementation.

	Implementation date		
	1994-2004	2005-2010	After 2010
Observation	65	122	211
Population density (in hab/km^2)	12.0	10.6	8.8
	(13.5)	(10.7)	(5.1)
Temperature (maximum, in K)	346.2	345	347
	(8.5)	(7.7)	(6.7)
Temperature (minimum, in K)	235.9	231	230
	(15.2)	(11.4)	(13.4)
Precipitation (mm)	1733.1	1695	1719
	(309.7)	(201)	(200)
Elevation (m)	567.6	604	599
	(192.3)	(150)	(154)
Slope	19.2	15.7	16.4
	(20.6)	(20.1)	(17.9)
Distance to the main city (km)	120.5	120	120
	(45.6)	(60.8)	(69.8)
Distance to national road (km)	27.7	33.6	35.8
	(29.1)	(32)	(39.4)
Distance to departmental road (km)	39.6	38.2	40.4
	(34.6)	(41.5)	(37.2)
Distance to provincial road (km)	28.5	29.5	43.3
	(28.2)	(25.3)	(41.7)
Distance to protected areas (km)	165.2	78.2	52
	(101.9)	(68.9)	(39.5)
Latitude	4.1	3.8	4
	(0.9)	(0.9)	(1.1)
Longitude	12.2	12.8	13.3
	(1.3)	(1.4)	(1.4)
High proportion of State owned lands	0.2	0.2	0.2
	(0.4)	(0.4)	(0.4)

Notes:
Values represent the average for the community forests implemented between 1994 and 2004 (column 1), 2005 and 2010 (column 2), and after 2010 (column 3). In parenthesis, the standard deviation is displayed. For the time variants variable (population, temperature, precipitation, and high proportion of State owned lands), values for the year 2000 are used.

A.4 Matching strategies

Matching technique		Parallel trends				Covariate balances						Control units used					
Refinement	**N match**	**T – 4**	**T – 3**	**T – 2**	**T – 1**	**min_covbal**	**Q1_covbal**	**Q2_covbal**	**mean_covbal**	**Q3_covbal**	**max_covbal**	**min_w**	**Q1_w**	**Q2_w**	**Q3_w**	**max_w**	**mean_w**
No matching	-	0.306	0.301	0.3	0.299	-0.492	-0.139	-0.011	-0.007	0.171	0.601	0.006	0.127	0.813	0.813	0.813	0.521
Mahalanobis	1	0.023	0.016	0.012	0.013	-0.041	0.011	0.035	0.047	0.07	0.278	0	0	0	1	10	0.521
Mahalanobis	5	0.059	0.05	0.046	0.044	-0.236	0.003	0.03	0.038	0.092	0.359	0	0	0.2	0.8	4.8	0.521
Mahalanobis	10	0.045	0.038	0.035	0.032	-0.428	-0.088	0.032	0.034	0.188	0.382	0	0.1	0.3	0.8	4.4	0.521
Mahalanobis	15	0.04	0.033	0.03	0.028	-0.55	-0.107	0.035	0.029	0.212	0.388	0	0.067	0.333	0.867	3.267	0.521
Mahalanobis	20	0.04	0.033	0.03	0.028	-0.618	-0.127	0.032	0.024	0.223	0.391	0	0.1	0.3	0.8	2.8	0.521
Propensity score	1	0.125	0.129	0.13	0.13	-0.166	-0.099	-0.01	-0.024	0.064	0.13	0	0	0	1	16	0.521
Propensity score	5	0.13	0.135	0.133	0.129	-0.207	-0.058	-0.02	0.001	0.072	0.284	0	0	0.2	0.6	7.4	0.521
Propensity score	10	0.137	0.139	0.139	0.136	-0.212	-0.086	-0.051	-0.005	0.064	0.347	0	0	0.2	0.7	4.9	0.521
Propensity score	15	0.091	0.091	0.091	0.087	-0.215	-0.067	-0.035	-0.004	0.068	0.379	0	0.067	0.267	0.667	3.867	0.521
Propensity score	20	0.044	0.044	0.043	0.039	-0.232	-0.073	-0.035	-0.007	0.04	0.413	0	0.05	0.3	0.675	3.55	0.521
Covariate balance propensity score	1	0.176	0.177	0.181	0.183	-0.239	-0.107	-0.059	-0.028	0.045	0.183	0	0	0	1	20	0.521
Covariate balance propensity score	5	0.252	0.251	0.25	0.248	-0.194	-0.109	-0.039	-0.011	0.034	0.296	0	0	0.2	0.6	6	0.521
Covariate balance propensity score	10	0.173	0.176	0.175	0.172	-0.205	-0.06	-0.022	0.001	0.031	0.352	0	0	0.3	0.6	5.3	0.521
Covariate balance propensity score	15	0.136	0.136	0.135	0.132	-0.213	-0.06	-0.04	-0.006	0.056	0.396	0	0.067	0.267	0.6	4.267	0.521
Covariate balance propensity score	20	0.095	0.094	0.094	0.091	-0.215	-0.077	-0.033	-0.01	0.043	0.427	0	0.05	0.3	0.65	3.95	0.521
Propensity score weighting	-	0.25	0.251	0.25	0.247	-0.243	-0.091	0.002	0.003	0.074	0.303	0	0.095	0.258	0.566	9.485	0.521
Covariate balance propensity score weighting	-	0.213	0.213	0.211	0.208	-0.195	-0.054	-0.018	0.01	0.097	0.311	0	0.082	0.21	0.633	9.44	0.521

Figure 7. Quality of the matching strategies.

Notes: The table summarises the main matching strategies developed. The first two columns show the matching technique used: the refinement methods and the match set size. All match set between 1 and 20 were used. For simplicity, the table displays only match sets of size 1, 5, 10, 15, and 20. The parallel trends column display placebo tests of the different-in-means at t-4, t-3, t-2, and t-1 between treated units and not yet treated units using primary forests loss as outcome variable. The covariates balances columns represent the summary statistics of the difference-in-means for all covariates used in the empirical strategy between treated and not-yet treated units. The last columns show the proportion of control units used for the analysis. Based on the three set of indicators - parallel trends, covariates balances, and proportion of control units kept - the matching technique was chosen. 1 to 1 Mahalanobis optimises those criteria.

A.5 Main results

Table 6. Average treatment effect on the treated of the creation of community forests on forest degradation and deforestation.

	Degradation	Deforestation (1)	Deforestation (2)
t+0	0.033	−0.007	0.004
	(0.061)	(0.018)	(0.018)
t+1	0.043	−0.012	0.014
	(0.090)	(0.042)	(0.022)
t+2	0.086	0.016	0.039
	(0.115)	(0.068)	(0.029)
t+3	0.171	−0.008	0.049
	(0.141)	(0.198)	(0.042)
t+4	0.160	0.034	0.013
	(0.188)	(0.240)	(0.036)
t+5	0.215	0.032	0.049
	(0.255)	(0.321)	(0.079)

Notes:
The table displays the average treatment effect on the treated of the creation of community forests on forest degradation and deforestation using Vancutsem data (Vancutsem et al. 2021) in column 1 and 2 and Hansen data (Hansen et al. 2013) in column 3. Estimation includes 0 to 5 years after the implementation of community forests. Bootstrap standard errors in parenthesis. $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$; $^{+}p < 0.1$

A.6 Heterogeneous analysis by region

A.6.1 Forest degradation

Table 7. Average treatment effect on the treated of the creation of community forests on forest degradation by region.

	Center	East	Littoral	South
t+0	0.024	0.078	0.430	0.098^{+}
	(0.043)	(0.052)	(0.594)	(0.057)
t+1	−0.046	0.098	0.656	0.244^{*}
	(0.086)	(0.101)	(1.102)	(0.100)
t+2	−0.016	0.144	0.199	0.444^{**}
	(0.111)	(0.129)	(1.528)	(0.164)
t+3	0.064	0.240	−0.183	0.690^{**}
	(0.134)	(0.152)	(1.934)	(0.242)
t+4	0.063	0.254	−0.239	0.748^{*}
	(0.176)	(0.188)	(2.105)	(0.301)
t+5	0.038	0.283	−0.129	0.865^{*}
	(0.246)	(0.241)	(2.285)	(0.377)

Notes:
The table displays the average treatment effect on the treated of the creation of community forests on forest degradation for each region in the analysis. Estimation includes 0 to 5 years after the implementation of community forests. Bootstrap standard errors in parenthesis. $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$; $^{+}p < 0.1$

797 A.6.2 Deforestation

Table 8. Average treatment effect on the treated of the creation of community forests on deforestation by region.

	Center	East	Littoral	South
t+0	−0.031	−0.007	0.093	0.017
	(0.035)	(0.022)	(0.064)	(0.013)
t+1	−0.101	−0.029	0.268	0.039^{+}
	(0.078)	(0.051)	(0.225)	(0.022)
t+2	−0.114	−0.023	0.317	0.075^{*}
	(0.132)	(0.083)	(0.250)	(0.035)
t+3	−0.168	−0.046	0.330	0.104
	(0.213)	(0.134)	(0.255)	(0.065)
t+4	−0.230	−0.077	0.432	0.101
	(0.304)	(0.189)	(0.342)	(0.077)
t+5	−0.296	−0.094	0.560	0.145
	(0.432)	(0.270)	(0.457)	(0.098)

Notes:
The table displays the average treatment effect on the treated of the creation of community forests on deforestation for each region in the analysis. Estimation includes 0 to 5 years after the implementation of community forests. Bootstrap standard errors in parenthesis. $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$; $^{+}p < 0.1$

B Robustness check

B.1 Pooled estimate

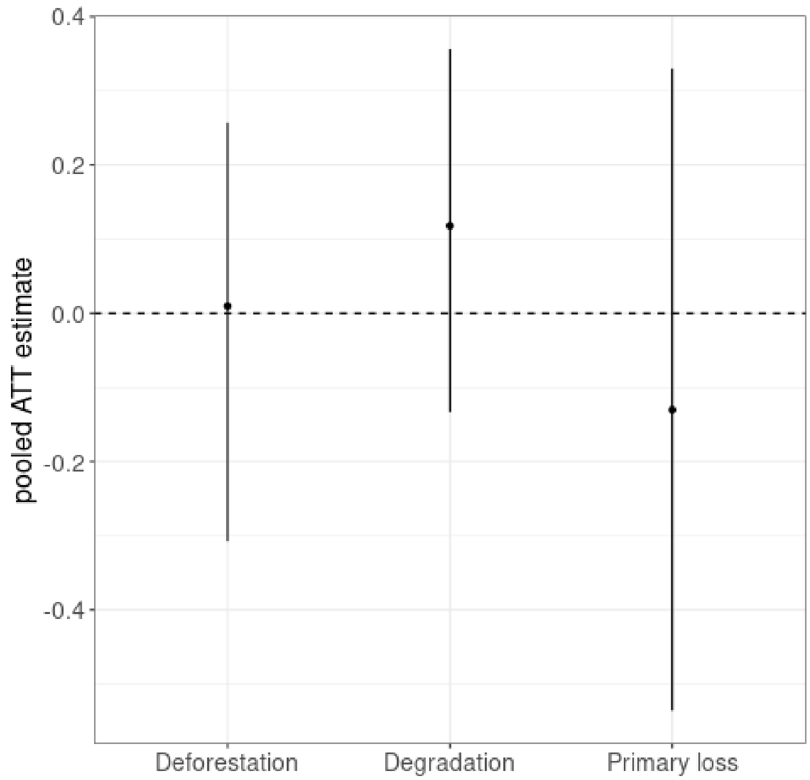

Figure 8. Pooled results of the community forests implementation on deforestation, forest degradation and primary forest loss from 0 to 5 years after implementation

B.2 Alternative treatment variable

B.2.1 Pooled results

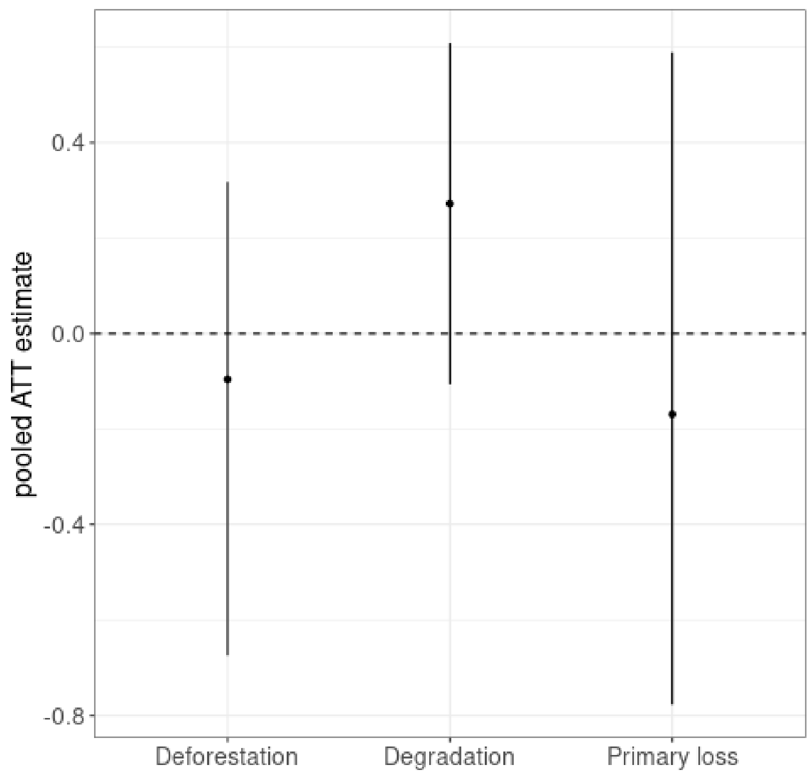

Figure 9. Average treatment on the treated of the implementation of community forests on primary forest loss, deforestation, and forest degradation from 0 to 5 years after implementation using an alternative treatment variable.

Notes: The figure shows the average treatment on the treated of the implementation of community forests on primary forest loss, deforestation, and forest degradation from 0 to 5 years after implementation using an alternative treatment variable. The alternative treatment variable is the administrative request. Propensity score weighting is the matching technique. Dots represent average estimate and bars bootstrap 95% confidence interval.

802 B.2.2 Event study results

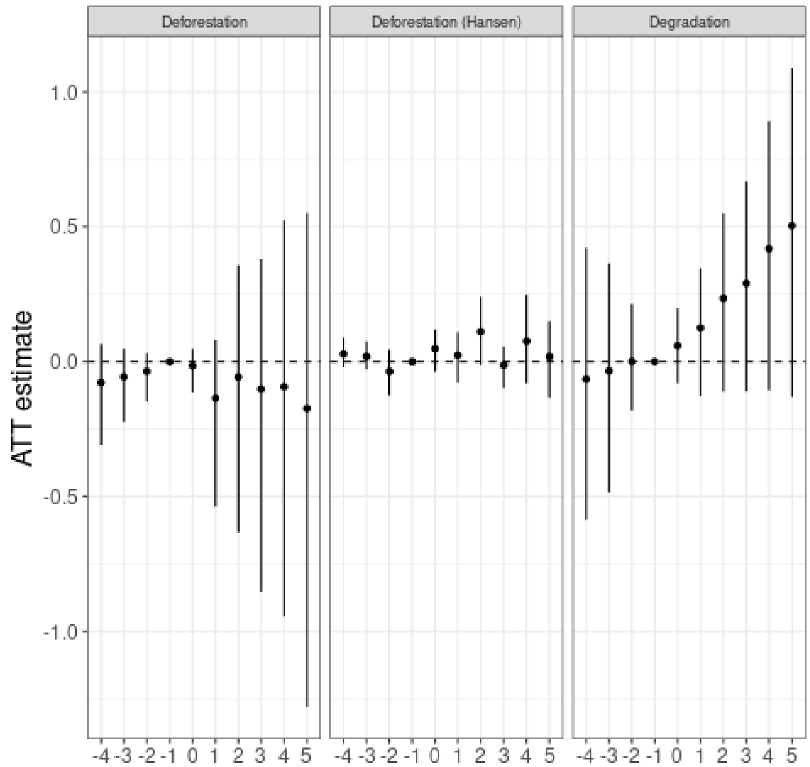

Figure 10. Average treatment on the treated of the implementation of community forests on forest degradation, and deforestation using Vancutsem data and Hansen data, from 4 years before to 5 years after the first administrative request.

Notes: The figure shows theaverage treatment on the treated of the implementation of community forests on forest degradation, and deforestation using Vancutsem data and Hansen data, from 4 years before the first administrative request to 5 years after the first administrative request as the treatment variable and propensity score weighting as the matching technique. Dots represent average estimate and bars bootstrap 95% confidence interval.

C Heterogeneous effect

C.1 Protected area

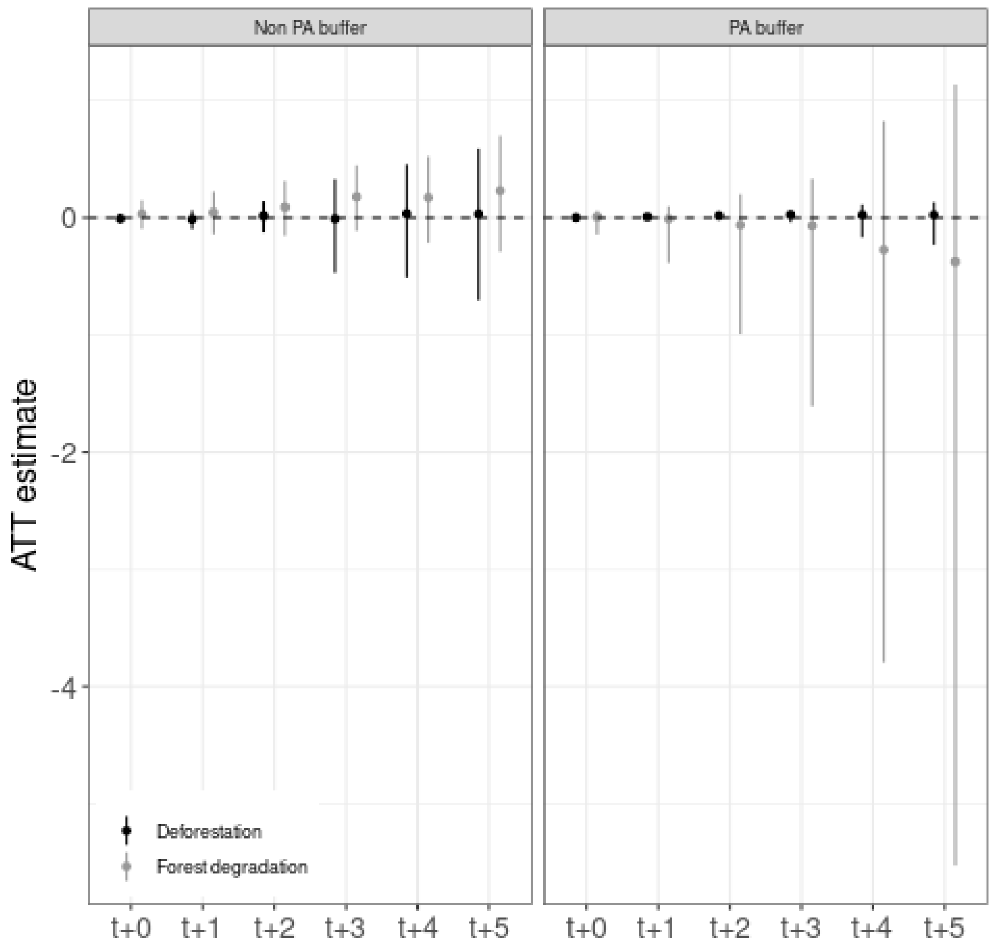

Figure 11. Average treatment on the treated of the implementation of community forests on Primary forest loss, deforestation, and forest degradation from 0 to 5 years after implementation in units at a 5-km buffer of protected areas and units further away. Dots represent average estimates and bars bootstrap 95% confidence interval.

805 C.2 Type of community forests

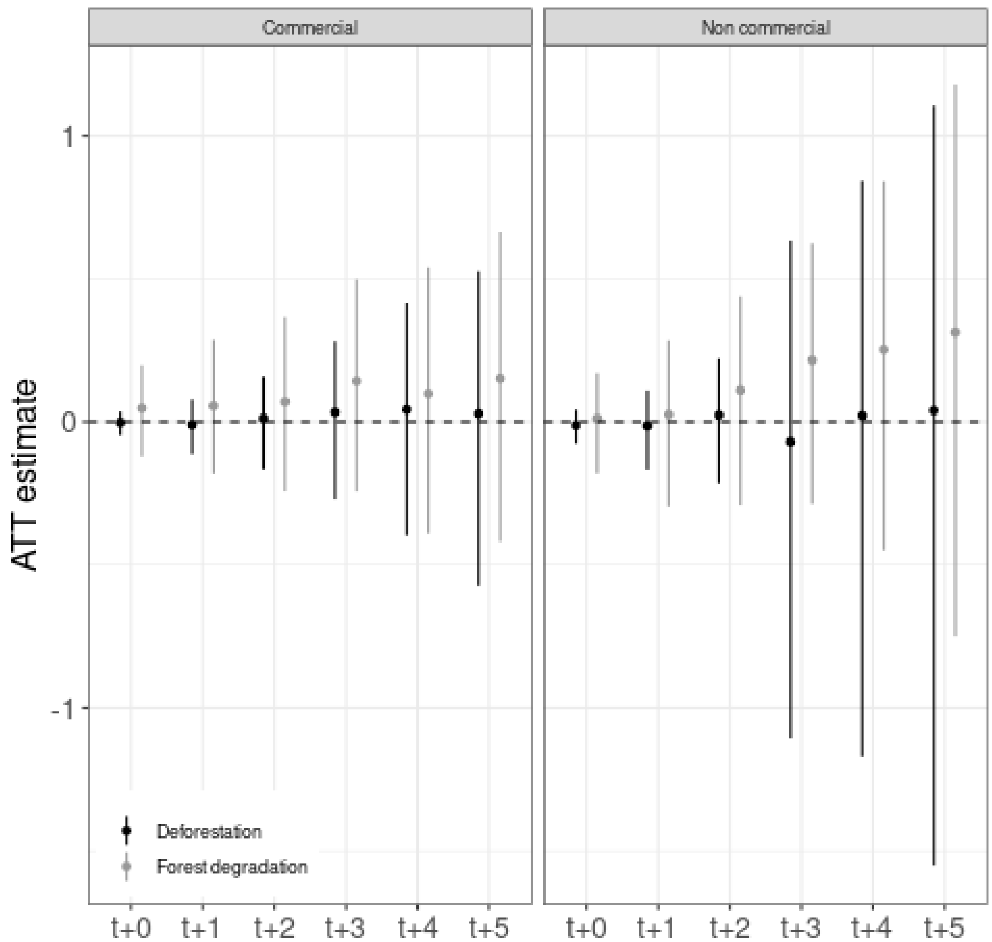

Figure 12. Average treatment on the treated of the implementation of community forests on Primary forest loss, deforestation, and forest degradation from 0 to 5 years after implementation in commercial and non-commercial legal types. Dots represent average estimates and bars bootstrap 95% confidence interval.

806 D Mechanisms explaining higher forest degradation in the South

807 D.1 Number of community forests in each region by year

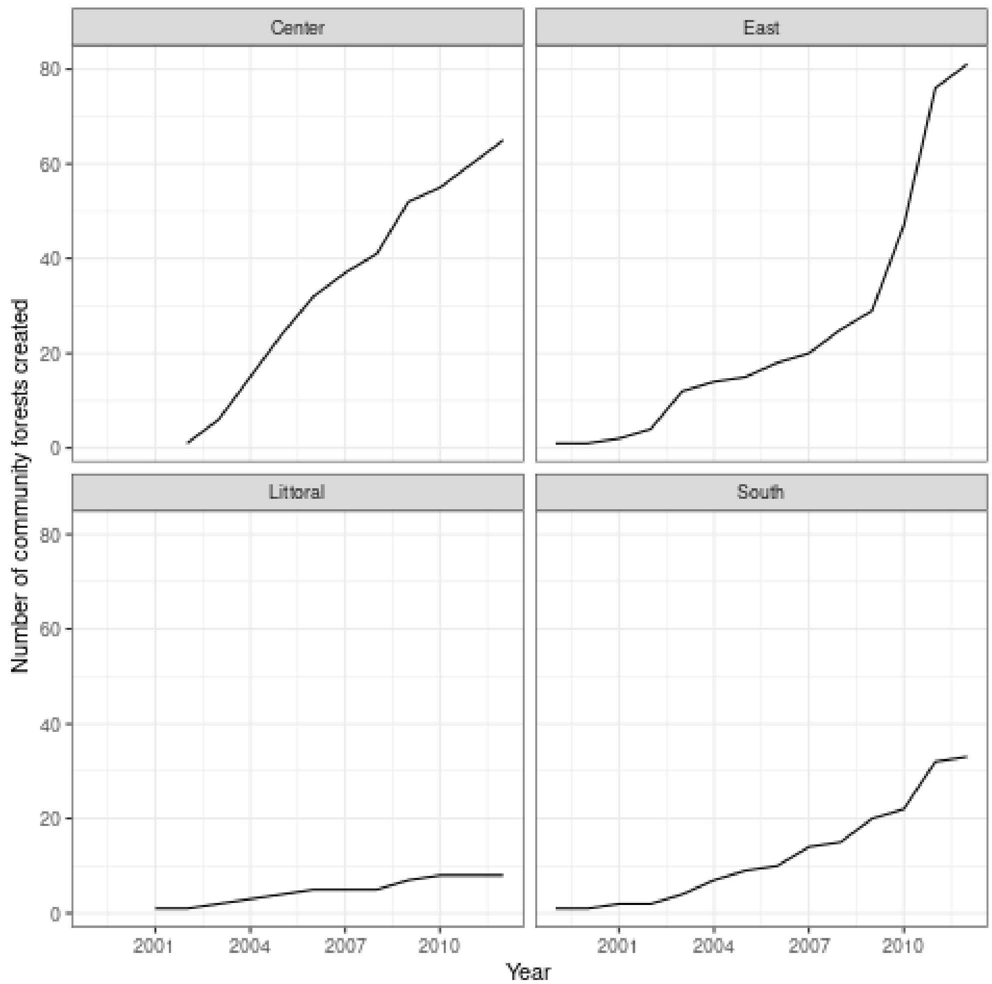

Figure 13. Number of community forests created by region

808 D.2 Rates of unusual high annual forest degradation

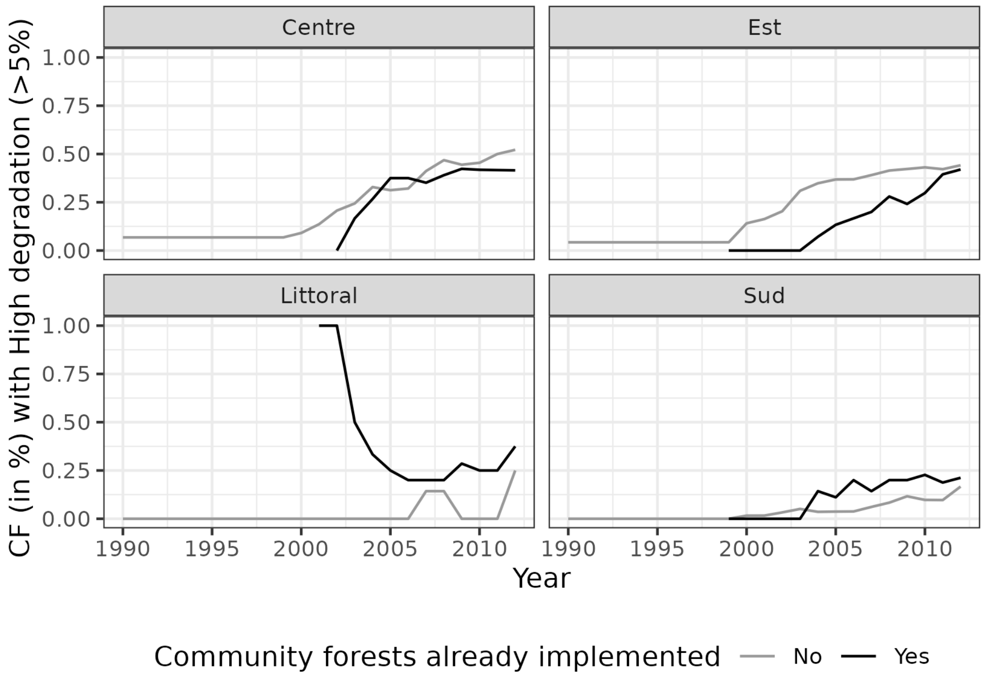

Figure 14. Proportion of community forests and not yet created community forests (used as control) with unusually high level of forest degradation for each year and region. Threshold is put at 5%, the third quartile in the dataset. CF in the Y-axis refers to community forests.

809 D.3 Number of commercial and non-commercial community forests created

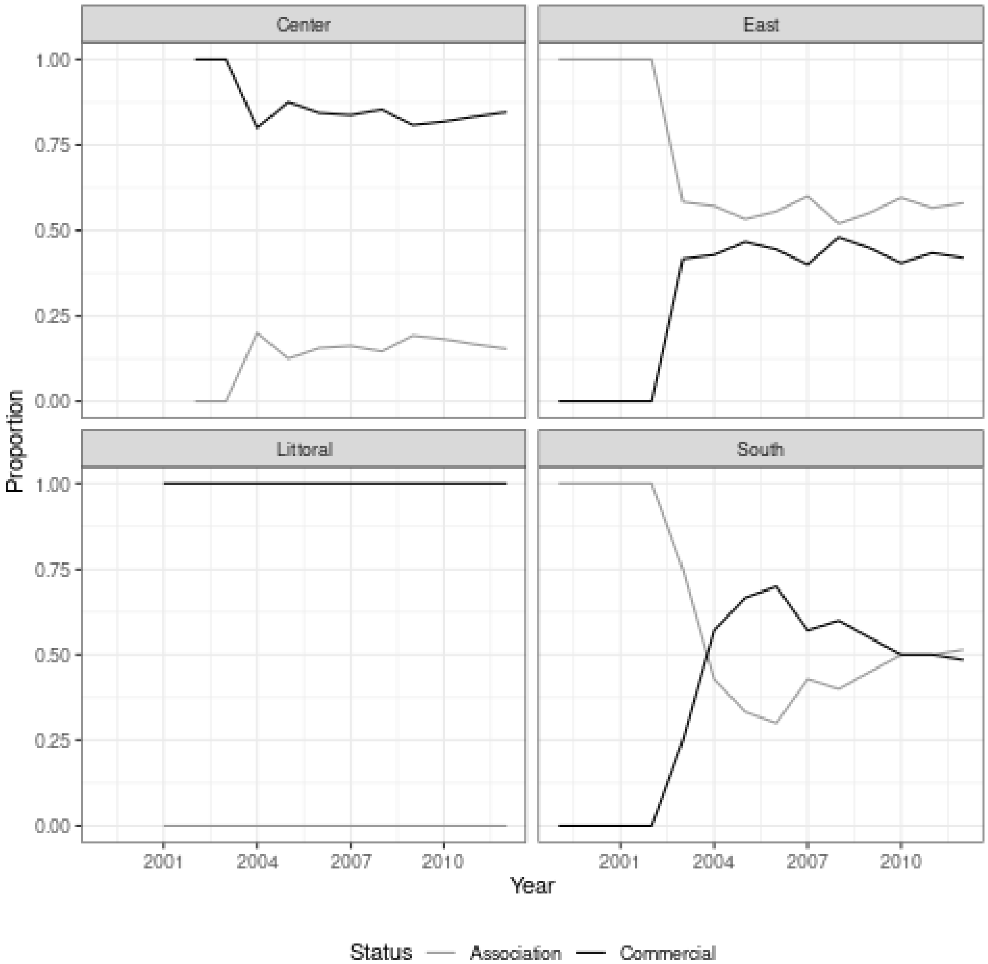

Figure 15. Proportion of commercial community forests and association created by year in each of the four regions.

D.4 History of industrial logging activities

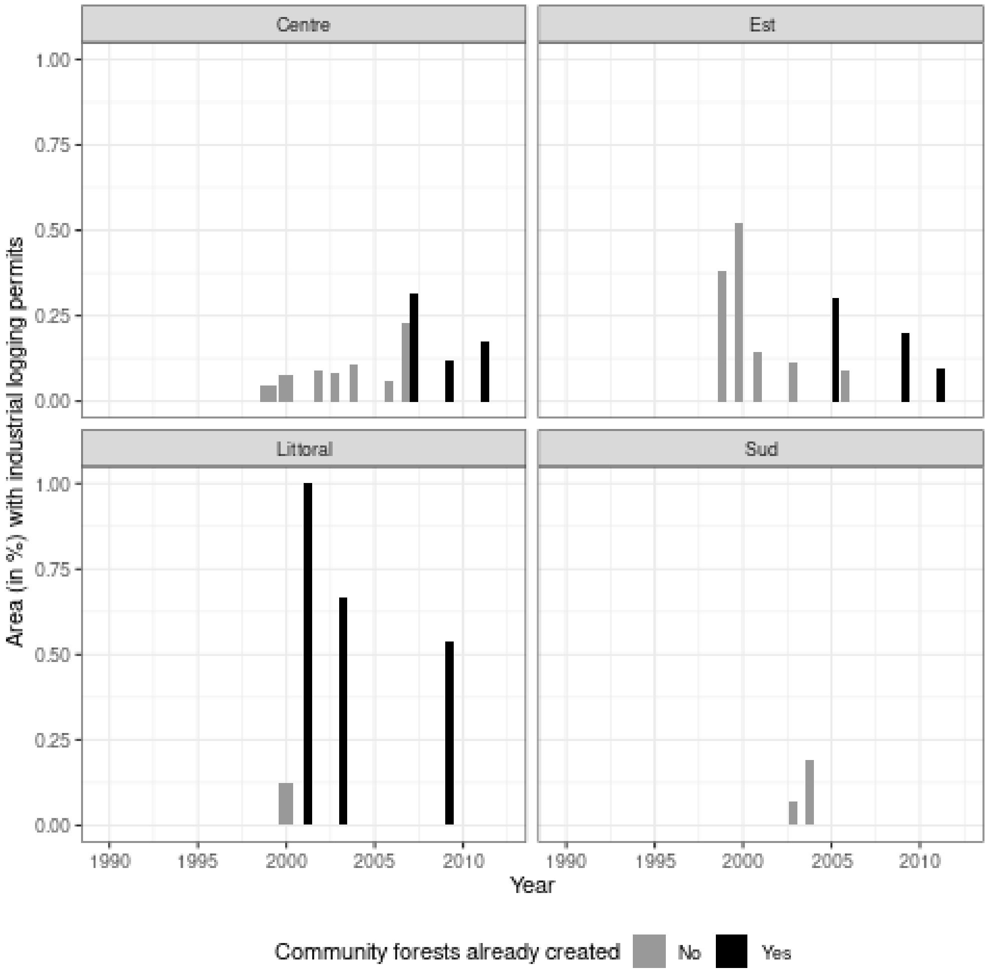

Figure 16. Logging permits given in area where future community forests will be created or are already created. Logging permits are generally given in a given year and expire after two to three years. They allowed only a certain volume of wood exploitation.

811 D.5 Length of logging roads

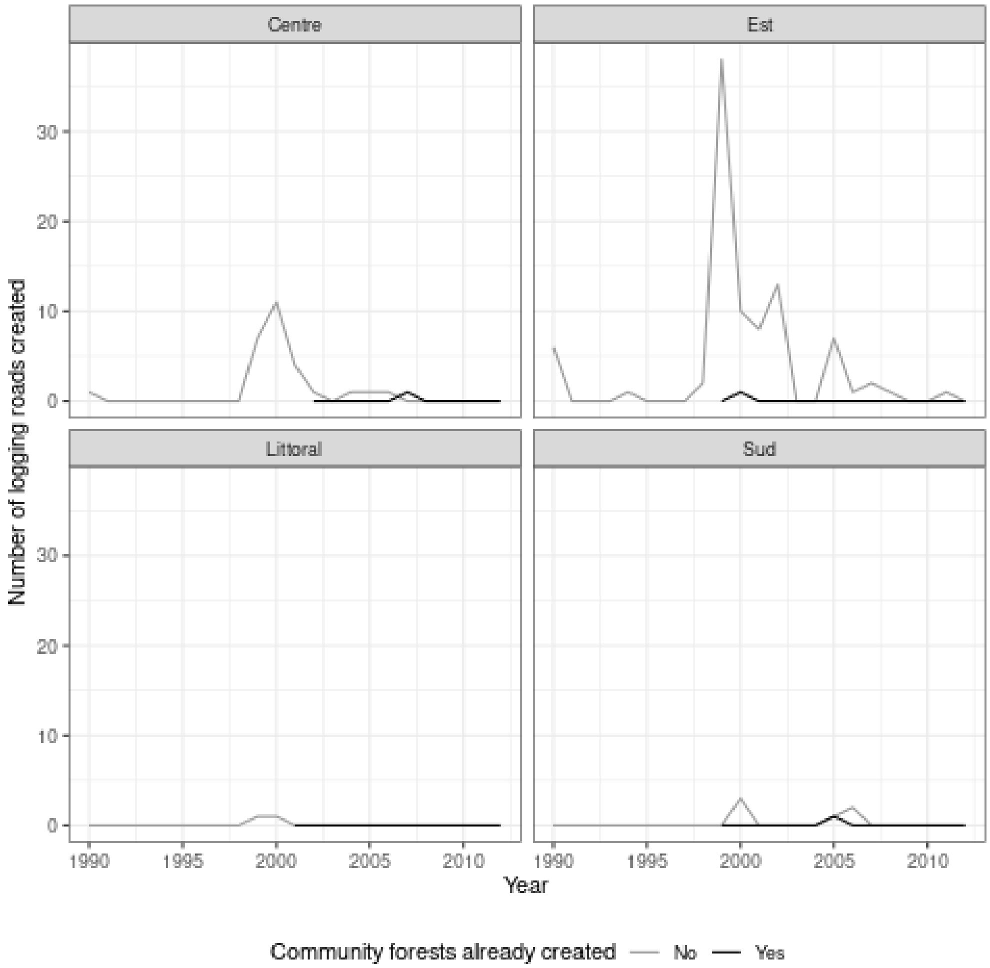

Figure 17. Number of logging roads created in each region

D.6 Size of community forests

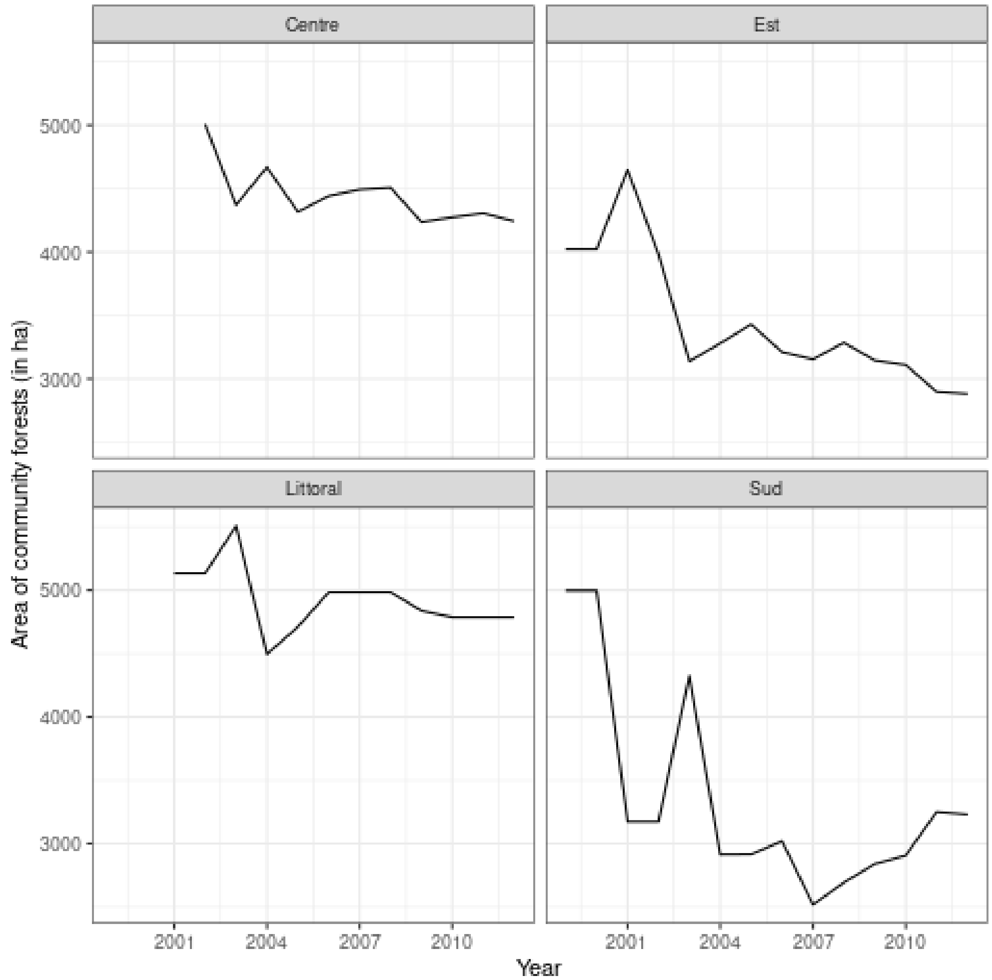

Figure 18. Average surface of community forests in each region measured in hectares (ha). The downward trends signify that community forests created at the beginning of the reform are on average larger than more recently created once.