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Common Resources Management and the "Dark Side" of Collective Action: an Impact Evaluation for Madagascar's Forests *

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Abstract

A sufficient level of collective action between community members is often presented as a strong pre-requisite to sustainably governing local common property resources (CPR). What if in some contexts instead, strong collective action led to short-term depletion of CPR instead of their sustainable use?

This paper brings to light causal evidence on the environmental impact of establishing community-managed forests in Madagascar and highlights the complexities underlying collective action in their sustainable management. I compile fine-scale deforestation data over 15 years, use a unique spatial census of locally managed CPR and mobilize firsthand field data from four case studies to show that transferring management rights to local communities has failed to decrease deforestation. Instead, the policy has led to an increase in deforestation in some areas, often when collective action was strong, not when it was weak. This is what I call the possible "dark side" of collective action.

JEL Codes: Q15, Q23, D02

Keywords: Commons, Collective Action, Impact Evaluation, Experimental Economics, Forests, Madagascar

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1 Introduction

From a theoretical standpoint, forests or fisheries can be analyzed as common goods, that are goods for which consumption rivalry exists (as opposed to public goods) but for which there is no perfect exclusion of potential consumers (as opposed to private goods). Today, hundreds of millions of poor rural households across the world still depend on the access to commons for their livelihoods (WRI 2005).

The economic theory has for long predicted a systematic over extraction of common resources (Gordon 1954) leading to their inevitable exhaustion. This situation is known as the *tragedy of the commons* (Hardin 1968). Following the seminal work of Ostrom (1990), a large body of literature has reframed the problem of common pool resource (CPR) management as a collective action question, and has explained how and when collective agreements can emerge to sustainably manage CPR. Meanwhile, sustaining these cooperative agreements is particularly challenging and the success of CPR management is uncertain. Long term sustainable management necessitates the existence of sufficient economic incentives to overcome the temptation to overuse the resource in the short term, and the existence of sound collective action structures to enforce collaborative strategies. Many case studies have documented the environmental impact of community management but only few studies allow to statistically determine a causal impact on large areas (Samii et al. 2014).

In this paper, I determine the environmental impact of the decentralization of natural resources management in Madagascar at a national scale by focusing on forest CPR, and I statistically explore how collective action affects the impact. I additionally use first hand data from a survey and from two *lab in the field* games in four case studies to refine the understanding of collective action patterns. I show that CPR management has currently failed to slow down deforestation. A pure economic reasoning of profit maximization with low financial incentives for sustainable use explains part of this failure. In this context, I do not find however solid evidence that stronger social capital have helped to attain better environmental impact. If deforestation tends to be a bit lower in areas where collective action is better (the well-known "green side" of social capital), my results suggest that the environmental impact of delegating management to communities may have been worse within well organized areas, that is within areas with high trust between inhabitants as compared to areas with low collective action. Instead of favoring the emergence of environmentally friendly behaviors as generally stated in the literature ("green side"), social capital seems to have favored the depletion of the resource in many cases. This is what I call a possible "dark side" of collective action. I explain this possible phenomena within a principal-agent framework and discuss how the limited presence of "intrinsic motivations" (Ryan and Deci 2000) for nature conservation may have exacerbated the problem.

Madagascar is one of the top three countries in the world in terms of mega diversity (Goodman and Benstead 2003). It is also currently among the five countries with the highest deforestation rate.[1] The IUCN (2014) Red List warns us of the possible extinction of 927 animals and plants, with about 90% of them being endemic to the island (Goodman and Benstead 2003). This combination of importance and threat makes of Madagascar one of the a *hottest spot* for global conservation (Myers et al. 2000). Small scale agriculture is the principal activity of 90% of the active population and slash-and-burn agriculture, the dominant technique used in the country, is the principal driver of deforestation.[2]

On the legal side, forests belong to the State. The extraction of timber and non-timber forest products is regulated, and the cleaning of natural forest is forbidden. Meanwhile, roughly one to three millions inhabitants live inside or just by forested areas within communities according to my estimates, and depend on forest clearing for their livings.[3] Their legal rights over the resource ownership were unrecognized until 1996. Small scale fisheries also support the livelihoods of more than a million coastal inhabitants. They are of crucial importance for local economies and for local food security (Le Manach et al. 2012; Mayol 2013).

In 1996 the Government of Madagascar passed the *GELOSE* law to start recognizing locals' right of using (without owning) natural resources as forests, pastures or fisheries. Beyond a fairness logic, the recognition of locals' rights constitutes a direct strategy to halt resources depletion (Ostrom 1990). By securing locals' rights over the resources, the State allows the users to project themselves into a long term planning of the resource management and reinforces their ability to exclude squatters from its use. Until 2013, 1,248 locally managed commons known as *Vondron'Olona Ifotony* (*VOI*) have been recognized (Figure 1).[4] The vast majority of *VOI* has been established in a top-down approach with the intervention of multiple actors: the State and associated public agencies, NGOs, ranging from local development

[1]See Global Forest Watch figures for the year 2014.

[2]The role played by slash and burn agriculture in deforestation (and deforestation itself), tended to be nuanced and discussed by some scholars in the 1990s. With the development of satellite images, a consensus seems to have emerged, both on the role of slash and burn agriculture, and the pregnancy of deforestation even if estimates diverge of total forest losses as it is difficult to estimate what was the actual extent of initial forest cover. See Harper et al. (2007) and McConnell and Kull (2014).

[3]Estimates of the number of inhabitants living in forested areas has to be taken with extreme prudence as census data in Madagascar are not of perfect precision. Yet, there is no other estimates of the number of people living in forested areas to the best of my knowledge (See Section 3 for more details).

[4]VOI designates the representatives of the local community in Malagasy. Often, the transferred commons itself is referred as a VOI. *GELOSE* stands for *Gestion Locale Sécurisée* - secure local management.

to international conservation NGOs, private companies as part of their environmental and social responsibility strategies. They now cover approximately 30% of total remaining natural forests of the country.

In addition to *GELOSE-GCF*, a large expansion of the network of Protected Areas (PA) has started in 2003. These new PAs have currently failed to decrease deforestation (Desbureaux, Aubert, et al. 2015). New PAs are *de jure* managed in collaboration between official authorities (backed up by NGOs) and communities, and they combine strict conservation areas with sustainable use areas. The two logics underlying new PAs and *VOI* are thus very similar. As well, the sustainable use area has often been implemented as a *VOI* so that about 20% of *VOI* are located inside PAs.

I begin my analysis by quantifying the environmental impact of CPR management for forested commons. My focus on forests is justified by the availability of precise satellites data which allow me to construct objective measures of land cover changes at the national scale. I construct a rich dataset of 15 years of fine scale deforestation data between 1990 and 2014 to track land cover changes that I have combined with an exhaustive spatial census of all *VOI* in Madagascar, socio-economic census data and other spatial covariates. I use the rolling of the program, a fixed effects panel approach and a multi-levels regression framework to show that *VOI* have not allowed to decrease deforestation, whatever the region, whatever the period. Instead, deforestation might have slightly increased following the recognition of *VOI*. Combining *VOI* and PAs or implementing *VOI* alone has not lead to important different impacts.

Second, I show that the political and economic conditions for a sustainable management of forest resources were not met over the period. In Madagascar, general law enforcement is weak and property rights are not fully respected. The country has experienced two major political upsurges in 2001 and 2009. The later has lead to a five years "transition period" and law enforcement has become even more complicated during the crisis. In this context, recognizing locals' rights over CPR management should have helped increasing the respect of property rights. I find that in localities where the general capacity to enforce property rights was low, deforestation was higher. The creation of *VOI* has helped to slow down deforestation only when general law enforcement was not too bad. During the crisis as well, the State human and financial capacities were extremely limited. With the freeze of international aid after the 2009 coup, actors who worked at the implementation of CPR have experienced important financial constraints. I find that seemingly better funded organizations have achieved slightly better impact.

Third, I analyze the collective action mechanisms. Difficulties in collective action have said to be at the heart of many failures of community-based approaches across Africa, for natural resources management (Roe, Nelson, and Sandbrook 2009) and beyond (Baland, Guirkinger, and Mali 2011). In Cameroon, CPR management has been undermined by external conflicts and internal conflicts (De Blas, Ruiz-Pérez, and Vermeulen 2011). Ribot, Agrawal, and Larson (2006) highlight the important lack of accountability of local leaders regarding resource management in Senegal and Uganda, and the conflict that arose from this non-accountability. Such concerns about dysfunctional collective action is also present in Madagascar. The country is doing poorly in international surveys such as the Afrobarometer. Some anthropologists have even characterized collective action for CPR managament in Madagascar simply as an "illusion" (Blanc-Pamard and Fauroux 2004). I use proxies of collective action from a 2007 commune census to explore the links between collective action and deforestation, and to explore the heterogeneity of the environmental impact of *VOI*. I find ambivalent results on the links between collective action, deforestation and the impact of *VOI*. Globally, deforestation appears to be lower in areas with sound collective action. In addition, within the very few *VOI* that have emerged from a local initiative (suggesting some existing collective action and a motive for nature conservation in the community), the environmental impact of delegating the management was positive. These two results are consistent with the idea of a "green side" of collective action often presented in the literature. However, for the vast majority of *VOI* created in a top-down approach, the environmental impact of management delegation is not better in areas with strong collective action as compared to areas with low collective action. Actually, the environmental impact of *VOI* often appears as null in areas with low collective action, and as negative (i.e., increase in deforestation) in areas with high collective action suggesting that collective action mechanisms may have accelerating deforestation rather than limiting it. This is what I call a possible "dark side" of collective action.

Fourth, I use data from two "lab in the field" games I have organized with about 200 villagers in two study sites to understand better this possible "dark side" of collective action. Vohibola and Vohimana (Figure 2) are two rainforests that are co-managed between local communities gathered within local associations, and a NGO. A trust game allows me to put into perspective the idea of an "illusion of collective action". I have then organized a contextualized Voluntary Contribution Mechanism game to quantify participants' motivations for nature conservation. Results obtained in my trust game are similar to the ones found elsewhere in the world with the same protocol (Cardenas and Carpenter 2008). The problem in Madagascar might not be a generalized impossibility of collective action. The results of the Voluntary Contribution Mechanism highlight the lack of priority of nature conservation issues given by communities members. Within a general context which has not favored sustainable management of natural resources, the absence of strong "intrisc motivation" for nature conservation has not allow to engage communities within a sustainable management process.

On top of these two games, I use survey data I collected during the years 2014-15 in Vohibola and Vohimana and from two other study sites - Ankarea and Ankivonjy (Figure 3), to illustrate collective action patterns within a CPR context all along my analysis. Ankarea and Ankivonjy are not forests but two co-managed Marine PAs located in northern Madagascar. The choice of these four study sites does not pretend to be representative of national dynamics. Instead, they reflect the opportunities of the author to collaborate with local partners. The situation in the four study sites clearly illustrates the soundness of social ties within communities but the deep lack of accountability and representativeness of designated leaders.

Relation to Existing Literature

This study mainly relates to two streams of literature. First, it relates to the institutional literature and more particularly, to the Common Pool Resource Management literature. This group of studies explains how local governance arrangements affect the level of extraction from CPR and highlights how overexploitation can be averted by local collective action (Ostrom 1990). The literature finds its theoretical foundations within game theory results: efficiency in resource extraction is obtained by cooperation. However, because not cooperating is often a Nash-equilibrium strategy, sustaining a collaborative equilibrium requires decisions from the community to define rules and to set up mechanisms to monitor and enforce them (McCarthy, Sadoulet, and Janvry 2001). The success of cooperation at the end will depend on the gain from the collaborative payoff net of the cost of defining, monitoring and enforcing the mechanism.

Comparisons of case studies have allowed the authors to isolate a set of eight principles which favor in practice the success of collective agreements: clearly defined boundaries of the resource, rules, arrangements that allow most appropriators to participate, monitoring by accountable participants, graduated sanctions, mechanisms for conflict resolution, self determination rules recognized by the authorities and when large resources are at stake, a polycentric organization (Ostrom 1990; Gibson, McKean, and Ostrom 2000). Human factors have also to be integrated with ecological dynamics which are peculiar to each ecosystem (Anderies, Janssen, and Ostrom 2004).

In the CPR approach, motivation or social orientation as altruism, moral identity, reciprocity, reputation or trust play a central role to favor cooperation and to overcome social dilemmas (Bénabou and Tirole 2011; Ostrom 1998). Following these social norms might be motivated by cold rational expectations of future higher profits (an extrinsic motivation, Ryan and Deci (2000)). It might also been driven by more intrinsic motivations (i.e., respecting the rule because it is inherently a motive of satisfaction , Ryan and Deci (2000)). Particularly, social norms for environmental actions exist in many societies (Sheil and Wunder 2002; Chan, Satterfield, and Goldstein 2012). The presence of intrinsic motivations will facilitate cooperation for CPR management. Nonetheless, intrinsic motivations alone might be insufficient to ensure sustainable management if other economic, political or social factors push too hard in the direction of overexploitation. In the later case, policy reforms to strengthen CPR institutions might be an appropriate step to restore balance towards more incentives to protect the resource instead of overexploiting it. In some sense, changing institutions can in this case crowd-in motivations for sustainable management (Cardenas 2000).[5]

The CPR principles have been quantitatively tested only in a few studies. Gibson, Williams, and Ostrom (2005) find better forest conditions when rule enforcement is more effective. Alix-Garcia, De Janvry, and Sadoulet (2005) and Alix-Garcia (2007) find lower deforestation in smaller communities - a setting that theoretically favors cooperation within groups (Olson 1965). Andersson and Gibson (2007) find lower deforestation within better governed municipalities in Bolivia, i.e. in municipalities which have issued important property rights to communities between 1993 and 2000, in municipalities that have provided larger field assistance to communities and in municipalities that have professional foresters within their staffs. Most of these studies have however tested the CPR principles within already established CPR. Yet, the 1990s have seen an important wave of legal recognition of management rights over commons as in Madagascar. These reforms have transformed commons from an open-access or unregulated CPR to a regulated CPR (Baland and Platteau 1996). Few studies have however tested the impact of the creation of these new CPR institutions. Beyond CPR, this paper is thus among the first to empirically study the impact of the creation of new institutions in the tropics (Humphreys, Sierra, and Van der Windt 2014).

Second, my work is related to a stream of literature that has focused on evaluating the impact of conservation policies. Since the original call "Money for Nothing" by Ferraro and

[5] At the opposite, it has been extensively shown that imposing external regulation might crowd-out pro-social motivations (Cardenas, Stranlund, and Willis 2000). Similar questions of pro-environment motivation crowding-in and crowding-out are also extensively debated when payments are set up. See Rode, Gómez-Baggethun, and Krause (2014) for a recent review.

Pattanayak (2006), the lack of studies measuring rigorously the impact of conservation policies has been often pointed out (Miteva, Pattanayak, and Ferraro 2012; Baylis et al. 2015; Ferraro and Hanauer 2014a). These authors highlight the shortcomings of early impact evaluation studies which have failed to take into account the non-randomness of policy interventions. Instruments like PAs are placed in more remote areas that are less susceptible to be subject to important land use modifications (Joppa and Pfaff 2009; Sánchez-Azofeifa et al. 2003; Green, Sussman, et al. 1990). Community approaches or Payment for Environmental Services on the other hand tend to be implemented at the forest frontier, i.e. in areas more subject to land use changes than non targeted sites (Ferraro and Pattanayak 2006). It the two cases, not dealing with the problem of non-randomness leads to the use of poor counterfactual scenarios of what would have happened without the policy. The majority of the studies in the literature on community forest management is subject to these shortcomings (Baland, Bardhan, et al. 2010).

These issues have started to be tackled in a burgeoning literature of "Conservation Evaluation 2.0" (Miteva, Pattanayak, and Ferraro 2012) by relying on quasi-experimental approaches. Most of these papers focus on the impact of conservation policies in the case of forests as it is now convenient to track large scale land use changes with satellite datas. Many of these studies have analyzed the impact of PAs on deforestation (e.g., Andam et al. 2008; Gaveau et al. 2009; Nelson and Chomitz 2011; Nolte et al. 2013), the impact of PAs on poverty alleviation (Sims 2010; Canavire-Bacarreza and Hanauer 2013) or the impact of PAs on the provision of ecosystem services (Ferraro, Hanauer, et al. 2015). At the opposite, few studies only focus on CPR (Samii et al. 2014) because of the lack of spatial datas on locally managed commons (Agrawal 2014). CPR management has allowed to decrease forest degradation in the Himalayan forests from the 1930s. Baland, Bardhan, et al. (2010) find that lopping is 20% to 30% lower within CPR forests as compared to similar yet State owned forests in Nepal. However, delegating management to the communities has not allowed to increase the quality of the canopy, of forest biomass or of regeneration. Somanathan, Prabhakar, and Mehta (2009) find similar environmental impact in India. They also demonstrate that CPR managament has been more cost-effective than State-owned forests. In Bolivia, Andersson and Gibson (2007) find a larger impact of deforestation of forest decentralization within better governed municipalities. The authors however fail to construct an untreated control group. Instead, their study only provide information on the impact of an increase of local governance quality on deforestation. Finally, Rasolofoson et al. (2015) find that *VOI* have not allowed to decrease deforestation in Madagascar. Yet, the authors rely for their analysis on a preliminary and incomplete non-random census of CPR in Madagascar. Additionally as explained by the authors themselves, the study suffers from possible biases due to mis-measurement of the outcome variable.[6]

Furthermore, so as to to design and implement better future policies and programs, it is crucial to understand under which social, economic, political and environmental conditions the interventions operate, and understand better how the context shape the results. In other words, we have to study the mechanisms underlying the impact (Ravallion 2009). Attention has started to be given to statistically understanding the mediators and moderators (Imai et al. 2011) of conservation interventions for PAs (Ferraro and Hanauer 2014b; Ferraro and Hanauer 2015). To the best of my knowledge, such an approach has currently not been followed for CPR management.

The remaining of the paper is organized as follow: Section 2 theoretically motivates my analysis. Section 3 presents the context of Madagascar and Section 4 the data. In Section 5, I introduce the empirical strategy I implement to determine a causal impact of the legal recognition of forest CPR. I present the results of the impact evaluation and of the mechanisms of the impact in Section 6. Section 7 presents the results of two "lab in the field" games to understand better the "dark side" of collective action presented above. I discuss the results in Section 8.

2 An Illustrative Model: Collective Action and the Sustainable Management of a Common Resources

I start by theoretically highlighting the economic and collective action problems arising from the extraction of timber and non-timber forest products from a forest common resource. The model is developed for the context of Madagascar for which the empirical analysis is conducted. I highlight under which circumstances institutions can endogenously emerge to enforce Pareto-optimal extraction levels by taking into consideration possible intrinsic motivations for cooperation. Then, I discuss some potential pros and cons of an external regulation mechanism in an asymetric information framework.

[6] The authors study the impact of *VOI* created between 2000 and 2005 on deforestation between 2000 and 2010. For that, they use forest cover data for 2000 and 2010. It follows that whether the VOI has been created in 2000, 2001 or lets say 2004, then it is considered as protected from 2000 in their analysis even if they have not been treated for the whole period. In doing that, the authors mechanically lower the chance of finding an impact of VOI on deforestation

2.1 Primitives

A group of n individuals is depending on the extraction of an homogeneous good from a forest CPR for their livings. I call n_i the extraction effort of agent i, with $0 < n_i < \bar{n}$. The return of extraction from the CPR depends on the agent's individual effort n_i and on the total harvesting effort $N = \sum_{i=1}^{n} n_i$. I model the per-unit benefit of extraction with a standard linear form $\Phi(N) = a - bN$, $(a, b) > 0$. The profit function for player i considering the actions of other players n_{-i} is given by :

$$\pi_i(n_i, n_{-i}) = pn_i\Phi(N) - \bar{c}n_i = pn_i\left[a - bN_i\right] - \bar{c}n_i$$

where p is the given price of the output, a is the productivity coefficient of the forest, b is the sensitivity of the productivity to extraction and $\bar{c}$ represents a fix production cost by unit of extraction. For simplicity, I consider the case of $n = 2$:

$$\pi_{i=1,2}(n_1, n_2) = pn_i\left[a - b(n_1 + n_2)\right] - \bar{c}n_i \tag{1}$$

A central feature in the CPR analysis is that for a given harvesting effort n_i, the agent only receives a share $\frac{n_i}{N}$ of its investment. In this setting, a profit maximizing agent will choose its harvesting level n_i so that:

$$n_i^{\star} = argmax_{n_i}\, \pi_i(n_i, n_j) = \frac{a - \frac{\bar{c}}{p}}{2b} - \frac{n_j}{2}\ ;\ i \neq j \tag{2}$$

The extraction from the CPR by j of n_j represents a negative externality for agent i of $\frac{n_j}{2}$. The two player can decide to collaborate so as to internalize this joint negative externality of production by playing the first best (FB) Pareto-optimal strategy $n_1 = n_2 = n^{FB}$. Yet, the best response for any agent i to an extraction level n_j^{FB} by agent j is different from n_i^{FB} so that as in a standard prisoner dilemma, the *laissez-faire* (LF) equilibrium will be Pareto-inefficient. Following McCarthy, Sadoulet, and Janvry (2001), I denote by I_i^C the incentive the agents have to cooperate and by I_i^{Ch} the incentive the agents have to cheat:

$$\begin{cases} I_i^C = \pi_i(n^{FB}, n^{FB}) - \pi_i(n^{LF}, n^{LF}) > 0 \\ I_i^{Ch} = \pi_i(n^{LF}, n^{FB}) - \pi_i(n^{FB}, n^{FB}) > 0 \end{cases}$$

2.2 The Endogenous Emergence of Institutions

To overcomme the dilemma, the CPR literature has highlighted that institutions can endogeneously emerge within the community. In order to enfore the first best equilibrium, community members can for example agree on a punishment mechanism that aims at sanctioning individuals who would not respect the collaborative solution. McCarthy, Sadoulet, and Janvry (2001) model this strategy as couple $\{K, M\}$ that combines a fine K that is imposed to an agent if she or he is not respecting the cooperative strategy, and a costly monitoring system M that aims at detecting cheaters.

These monitoring mechanisms often take the form of patrols by members. I assume that each agent contributes individually to a fully observable level of monitoring m_i and enjoys the benefit of the global effort, which corresponds to a probability $\mathcal{P}(m_1 + m_2)$ that cheaters get caught. With such a monitoring mechanism, a risk-neutral agent will decide to play the cooperative strategy if the expected cost of cheating is positive:

$$P(m_1 + m_2)K - [1 - \mathcal{P}(m_1 + m_2)]I_i^{Ch} > 0$$

By assuming $\mathcal{P}(m_1 + m_2)$ as linearly increasing with M and denoting α the efficiency of the monitoring mechanism, i.e. :

$$\begin{aligned} \mathcal{P} \quad &: \quad [0, \bar{n}]^2 \longrightarrow [0, 1] \\ \mathcal{P}(m_1 + m_2) \quad &= \quad \frac{\alpha(m_1 + m_2)}{1 + \alpha(m_1 + m_2)} \end{aligned}$$

Then, the agents will prefer to collaborate if:

$$M = m_1 + m_2 > \frac{I_i^{Ch}}{\alpha K} \tag{3}$$

Otherwise, the agents will prefer to play the non-cooperative agreement.

Even if this model is particularly simple, it already brings several insights. First, it appears that for given $\{K, \alpha\}$, the economic incentive to cheat has to be small enough if we want a cooperative agreement to be feasible. It means that the economic gains from deviating from the optimal strategy have to remain limited. If the economic gains from deviating are high, the probability of reaching a collaborative agreement look more limited.[7]

Second, the model highlights that setting a monitoring mechanism might be time costly whereas the agents are time constrained ($n_i + m_i < \bar{n}$). It means that when n^{FB} is already close from $\bar{n}$, then it is harder to find room to implement the monitoring mechanism. These first two remarks underlines that reaching a collaborative agreement is subject to the satisfaction of some purely economic constraints.

[7]For convenience, I have assumed here a simple one period model. Meanwhile in a repeated game, the importance of this difference in profits might become even more crucial.

Third, Eq 4 underlines that the probability of reaching an agreement increases with K. To better enforce the collaborative equilibrium, there is the temptation to put K as high as possible. It is especially true as the alternative (increasing M) would be costly. In reality, this punishment strategy has to be credible (Ostrom 1990) so that K^{max}, the maximum fine that can be extracted from individuals, has to be finite and will be specific to the characteristics of the community. In this context, it is expected that better collective action will decrease the cost of the monitoring system, will allow to fix smaller K and thus will favor the probability of success of a collective agreement.

Fourth, the benefits derived from monitoring efforts are themselves a public good: no one within the group can be excluded from its result. Hence, it comes with this the temptation of free-riding in the individual provision of monitoring efforts m_i. It is particularly true as m_i is in reality not perfectly observable so that agents might prefer to devote part of their time to n_i rather than to m_i. CPR management is thus not a single cooperation dilemma but rather is the imbrication of several ones.

Intrinsic Motivations and Institutions

This simple model also underlines the potential role of "intrinsic motivation" for a green collective action: people can collaborate for extrinsic motives (securing a higher profit $\pi_i(n^{FB}, n^{FB})$) but also because they intrinsically value the cooperative agreement (Bénabou and Tirole 2011). Following this stream of literature, we assume that agent might intrinsically value the realization of the first best profit by a factor $\theta_i \sim \mathcal{P}\left[\theta_i^l, \theta_i^h\right]$, $\theta_i^h > \theta_i^l$ *and* $\theta_i^h > 1$. In this setting, I_i^{Ch} would be such that:

$$I_i^{Ch} = \pi_i(n^{LF}, n^{FB}) - \theta_i \pi_i(n^{FB}, n^{FB})$$

It would directly follow that a higher proportion of θ^h type agents in the community increases the probability of the emergence of institutions to manage CPR.

2.3 External Impulsion for a Sustainable Management

Let's now assume that the conditions for the endogenous emergence of institutions are not met within the community. We examine in this subsection the potential role for an external actor to come to provide the community assistance to establish institutions. In practice, this nudge might take the form of an environmental awareness campaign, a technical or financial assistance to community members to make them collaborating.

I model this intervention as an (individual) transfer τ from a project developer (the NGO) to community members in order to provide them the sufficient economic incentives to collaborate. τ is conditional to the respect of the Pareto optimal strategy by the agent. If the NGO perfectly observes n_i, then the incentive to cheat is altered so that:

$$I_{i\ bis}^{Ch} = \pi_i(n^{LF}, n^{FB}) - \pi_i(n^{FB}, n^{FB}) + \tau < I_i^{Ch}$$

In other words, thanks to the conditional transfer, it becomes more likely that an institution emerges.

Asymmetric Information

Yet, in the context of developing countries where the public sector is facing important budget and man-power constraints, the NGO might have difficulties to perfectly observe n_i. When dealing with deforestation, a moral-hazard situation can even occurs as community members have the possibility to hide part of their actions to the NGO by for example choosing to clear forests in more remote areas or behind ridge lines, by hiding the identity of who has clear a parcel and so on. Thus, the NGO might only imperfectly observe n_i.

I assume here that the regulator as a probability q to observe agents' extraction efforts correctly and a probability $1-q$ of not being able to observe them:

$$\mathcal{Q} = \begin{cases} 1 \text{ with probability } q_i \text{ (observing)} \\ 0 \text{ with probability } 1-q_i \text{ (being blind)} \end{cases}$$

The distribution of $\mathcal{Q}$ is common knowledge for the agents and community members' profit functions become:

$$\pi_{i=1,2}(n_1, n_2) = pn_i\left[a - b(n_1+n_2)\right] - \bar{c}n_i + \tau\left(1 - \mathbb{1}_{(n_1,n_2)\neq(n_1^{FB},n_2^{FB})\,\cap\,\mathcal{Q}=1}\right)$$

$\mathcal{Q}$ depends both on the NGO own characteristics (e.g., its financial constraints) and on the time spent by community members to hide deforestation to the NGO. I denote by r_i the time invested by agent i to pretend to cooperate (ndlr, to hide deforestation from the NGO). For a given NGO, it follows that:

$$1 - q(r_1 + r_2) = \frac{\beta r_1 + r_2}{1 + \beta r_1 + r_2}$$

where β represents the efficiency of the agents to fool the regulator. It can therefore become interesting for the agents only to pretend to collaborate in order to pocket τ with a probability q while not having to bear the cost of true cooperation (m_i). If doing that, they will however loose I^C, the extra profit arising from cooperation. It becomes optimal for community members to cooperate if:

$$q(r_1 + r_2)\tau - I^C > 0 \iff r_1 + r_2 > \frac{1}{\beta} \frac{I^C}{\tau - I^C}$$

Hence, as long as $\tau > I^C$, pretending to cooperate can be a rational strategy. If social capital was "green" up to now, it appears here that the higher β is (i.e., the more efficient agents are to collaborate to hide they are cheating, the more likely pretending to cooperate becomes the rational strategy. Social capital would not be "green" anymore but rather "dark". In addition, if agents are way more efficient to pretend to collaborate rather than to actually collaborate, one might observe a shift of behavior with the introduction of an external regulation from a first best strategy to a fake-cooperation strategy. It would thus corresponds to a situation of institution crowding-out (Cardenas, Stranlund, and Willis 2000) where green institutions are replaced by dark ones.

Similarly as pointed earlier for m_i, the realization of q depends on the action of everyone and free riding is hence an issue. The possibility of fake cooperation still requires a minimal level of collective action in the community. On a community perspective, if one has to cooperate, it might be easier to do so again the interest of an external NGO through r_i rather than trying to act against other community members (m_i).

At the end, this illustrative models underlines that the endogenous emergence of local institutions for CPR sustainable management is far from automatic. It depends on the presence of sufficient economic incentives to cooperate and sufficient collective action to overcome the dilemma. This collective action might be purely self-interested (extrinsic motivation) or for more moral reasons (intrinsic motivations). In this standard approach, social capital is "green" in the sense that it helps to reduce the consumption of CPR resources. One might thus expec lower deforestation within areas where collective action is stronger. The impact on an external intervention to provide incentives for cooperation may have ambiguous results. As NGOs have the capacity to help cooperation without being able to sanction non-cooperative strategies, as moral-hazard can occur in a situation of asymmetric information, community members are in a situation where they can only pocket the transfer from the NGO without changing behavior. Worse, community which has initially set costly mechanisms to cooperate might now find more profitable to extract more from the CPR not to bear cooperation costs anymore if their capacity to hide deforestation from the NGO is high while the net return of cooperation is limited. I now empirically explore this story for Malagasy forest CPR.

3 Madagascar, Deforestation and the Decentralization of the Management of Natural Resources: Background and Descriptive Evidence

Madagascar is divided in three ecoregions, each one having its own vegetation type and ecological dynamics. In the eastern part, vegetation is dominated by rainforests. The south hosts a unique ecosystem of spiny forest while the west is the home of dry forests. The country is inhabited by 25 millions people belonging to 18 ethnic groups. With 82% of them living with less than $1.90 a day (2011 PPP) - about two times more than the rest of sub-saharian Africa, the island is now the 4^{th} poorest country in the world. A large share of the population relies on various degrees on ecosystem services for agriculture, energy provision, or wildlife consumption (3.1). The willingness to regulate the access to CPR so as to ensure their sustainability is answering a crucial (yet challenging) question (3.2) in a context of limited trust and low accountability of local leaders (3.3).

3.1 Dependence on Ecosystem Services

How many are they in Madagascar to depend on ecosystem services for their living? Generally speaking, Agriculture, livestock and fisheries secure 95% of the country's food supply (Medeiros et al. 2011). 80% of the population is living in rural areas and 80% of the population has agriculture as their principal activity.[8] These figures are among the highest in Sub-Saharan Africa according to the World Bank Indicators.

Family agriculture is predominant in Madagascar. More than 70% of the households farm less than 1,5ha of lands a year, 93% farm less than 4ha a year mainly with swidden agriculture (*tavy*) as the principal agricultural technique. 87% of agricultural households primarily grow rice and have an average production of around 1ton per household per year of paddy rice.

Biomass energy from firewood and charcoal provides the daily energy demand of at least 90 % of the population (Montagne et al. 2009; Minten, Sander, and Stifel 2013). It is estimated that only half of this biomass comes from planted forests. The other 50% comes from natural forests directly (Verhaegen et al. 2014), and because the demand grows faster than the size of production forests, the share of biomass coming from natural habitats is currently increasing (Meyers et al. 2006).

Moreover, bushmeat consumption offers important sources of nutrition for households

[8] If no additional reference is provided, figures in this subsection come from the *Enquêtes Périodiques auprès des Ménages 2010 - EPM* conducted by the national office of statistics (INSTAT)

in many areas of the island particularly during the lean season (Golden et al. 2011). Estimated harvesting rates of many species, including endangered ones, are again considered as unsustainable (Golden 2009).

To the best of my knowledge, there is no estimation of the number of inhabitants who depend on the access to CPR in their daily-lives in Madagascar. A rapid spatial analysis can provide first insights. To estimate the population living directly by forest CPRs, I overlap the population census at the finest geographical scale available (the 2008 INSTAT census at the *fokontany* level, the smallest administrative division in Madagascar) and the 2000 forest map provided by the BioSceneMada project (Figure 2). When doing that, I estimate that about 2.5 millions inhabitants live in *fokontany* covered by at least 20% of natural forest cover and about 1 million live in *fokontany* covered by 50% or more by natural forests. (Table 1). As for fisheries, I count 990 coastal *fokontany*. They represented over 1.5 million inhabitants in 2008. In total, there would be probably about 2.5 to 4 millions inhabitants in Madagascar who rely in their daily lives on forest and fisheries CPR.[9]

As a result of these pressures, Madagascar is experiencing an important problem of deforestation and defaunation. Deforestation in Madagascar is on the rise again after having known a decrease in the early 2000s. The most recent figures indicate that 115,000ha (1.17% of total remaining forests) and 177,000ha (1.8%) of natural forests have been lost in 2013 and 2014 [10]. Among all the pressures, *tavy* is the principal driver of deforestation. In a context of rapid population growth, the needs of additional fallows to realize the rotation has increased and forests offer the most fertile lands to satisfy the need despite clearing forests for agriculture being banned from the XIX^{th} century.

3.2 The Decentralization of CPR Management in Madagascar: the GELOSE Law

Nature conservation in its early days in Madagascar has aimed to preserve ecologically rich and iconic areas through strict PAs for forests. These early conserved areas have often been chosen in remote and hilly places with a low demographic pressure (Desbureaux, Aubert, et al. 2015). By essence, deforestation in these areas was already low so that PAs have only slightly reduced deforestation in Madagascar (Desbureaux, Aubert, et al. 2015; Gimenez 2012).

From the end of the 1990s, a new dynamic of environmental policies has been adopted this time by targeting more areas where deforestation was actually happening and hence, in

[9] To them, we should add people relying on pastures. However, the satellite images I use for my analysis do not allow them to map them.

[10] My calculation based on the data presented in Section 4.

areas where communities are living. Two instruments have been used for that: an important extension of the network of PAs for forests and coral reefs, and the decentralization of natural resources to local communities with the GELOSE law in 1996 followed by the GCF decree in 2001. In the two approaches, locals are *de jure* involved in nature conservation. New PAs are co-managed PAs and elected locals participate in the management decisions along with NGOs and State representatives. There is currently 88 new PAs. Desbureaux, Aubert, et al. (2015) have shown that today, new PAs have not yet succeed to decrease deforestation when forest conservation was the objective.

The decentralization of natural resources through the GELOSE-GCF process has also been consequent. A census of all contracts conducted in 2013 by the Agronomic School of Antananarivo (ESSA - Agro Management), CIRAD and the Ministry of the Environment and Forests within the 22 regions of the island has allowed to quantify the extent of the policy for the first time (Lohanivo 2013). 1,248 contracts of delegation have been established in Madagascar between 1996 and 2014. Most of them concern forests (95%), mangroves (3%) and fisheries (2%). In total, they now cover more than 5% of the territory and about 30% of remaining forests. 20% of them have been created within new PAs.

The GELOSE Law (95-025 ; September, 30 1996) has been designed in a clear heritage of the CPR literature. Community members are brought together within local associations, called *VOI*. A sustainable commercial exploitation of forests is possible after the establishment of approved management plans. An environmental mediator is *de jure* designated to help *VOI* in their environmental management. In this sense, the GELOSE law is ambitious and several actors considered it as too complex to be rightly implemented. The 2001 GCF decree aimed at simplifying the implementation of the law. Meanwhile, by weakening the possibility of commercial use of forest products and suppressing the environmental mediator, the GCF decree has also modified the philosophy of the original CPR approach. Lohanivo (2013) identifies 51% of GCF *VOI* and 34% of GELOSE *VOI* (15% are not identified in the census). *VOI* have been established continuously from 1999 to 2013 (Figure 5) and GELOSE *VOI* have continued to be established after the signature of the GCF decree.

The establishment of new PAs and *VOI* has been helped by the intervention of 37 actors, mostly NGOs. *VOI* have generally been delimited around lineages, around existing community structures reinforcing the power of traditional leaders. As a direct consequence in my study sites, leaders of environmental associations are well identified within the community. In Vohibola and Vohimana for example, 72% of the households have relatives in the environmental associations. 59% even got relatives at the decision positions within these associations.

In Ankarea and Ankivonjy, they are 77% to have relatives at the decision positions. A few key central individuals are at the center of this network (Figure 3).

In my four study sites, there is also clear evidence that leaders involved in CPR management are not representative of the general population. Leaders are generally men, older than the average, who have lived in the area for longer time, who are richer than the average and who already have other local functions before the establishment of the CPR (Table 2). They generally belong to higher castes and their lack of accountability has often been pointed out (Blanc-Pamard and Fauroux 2004).

3.3 Patterns of Collective Action in Madagascar

CPR management is by essence a collective action issue (Ostrom 1990). Yet, if we believe data coming from international surveys, a salient point in Madagascar is the limited trust people accord to each others as well as the lack of accountability of leaders (Table 3).

Indeed, they are 50% less people who fully trust their relatives in Madagascar compared to the average of other African countries. They even are 100% less and 200% less Malagasy to fully trust their neighbors and other people they know. Instead, Malagasy tend to answer in majority that people can be just a little bit or somewhat trusted.

At the opposite, it is surprising to see that despite recurrent political crises and generalized mistrust between citizens, Malagasy distrust two times less local or traditional leaders than in the rest of Africa. They also are more than 50% to at least somehow trust local and traditional leaders compared to other African countries, so that Malagasy declare to trust local and traditional leaders almost as much as their relatives and more than their neighbors. Maybe even more surprising, the level of trust accorded to local governments is even two times higher in Madagascar than in the European Union as measured by the Eurobarometer (ndlr, 43% in the August 2014 Eurobarometer for EU28 countries). Consistent with that, people' perception of corruption of local governments or traditional leaders is the smallest in Africa and the perceived level of performance is the highest in the continent.

The later positive figures are obtained despite the recognition of a generalized lack of accountability of leaders, and of limited participation of locals in collective decision making. They are a majority in Madagascar to answer they are never listened by local governments when decisions are taken (52%). This represents the second highest figure for African countries included in the Afobarometer. They also answer they are treated more unequally than the average. As well, people participate in community meetings in Madagascar and are less likely to join other members of the community to raise potential policy issues, testifying of a certain passivity of locals in local politics.

This lack of accountability is a salient feature in my study sites. In Ankarea and Ankivonjy, an elected management committee represents the interests of locals in the establishment of management rules for the CPR. This management committee meets the partner environmental NGO regularly to define rules. When I asked locals if they know how many meetings happened over the last 6 months, they were 40% not to know. 90% have also answered they have never been consulted before the meetings and 70% have never received a report on the decisions taken during the meetings (Table 4). In a caste society as Madagascar, people who are consulted and who are aware about taken decisions tend to be pre-existing local leaders, more educated and richer individuals (Table 5).[11] Uneducated and poorer individuals are them not associated and mostly unaware of taken decisions.

At the end, the global picture of trust and local collective action appears as complex and somehow paradoxical in Madagascar: Malagasy do not trust each others much while they trust significantly more than the average their local leaders even if these local leaders are not accountable towards locals, treat them unequally and do not involve them when taking decisions. In this context, the outcome of CPR management might appear uncertain. I now turn to the evaluation of the environmental impact of forested CPR and analyze how economic incentives and collective action shape this impact.

4 Data

I focus my empirical work on the 95 % of forested community managed CPR for which I can follow an objective measure of their environmental impact: annual deforestation rates for 15 years ranging from 1990 to 2014. I combine fine scale satellite data, an exhaustive spatial census of decentralized CPR and census data at a municipal level containing economic and social information on living conditions.

Policy Treatment: Spatial Census of Community Forest Resources

To delimit CPR, I use the spatial census collected by Lohanivo (2013) in a research collaboration between CIRAD and the Ministère de l'Environnement et des Forêts introduced in Section 3. On top of the geographic delimitation of each CPR, the census provides infor-

[11] Old yet poor local leaders tend to be excluded from the definition of management rules over the CPR, as attested by the first component of Principal Component Analysis in Panel A to C from Table5. Only the richer and educated ones seem to be included within this two sites. Yet, I would be careful in saying that this finding is representative of Madagascar, particularly when forests instead of fisheries are at stake.

mation on the date of creation of the *VOI*, on if whether or not the recognition process has been fully completed or not, on the entity which has helped the community through the legal process and on the type of contract (GELOSE or GCF).

Outcome variable: Forest Cover and Deforestation (1990-2014)

I track deforestation with publicly available Landsat 7 and Landsat 8 fine scale vegetation and deforestation data that have a definition of about 30m x 30m.

First, I use two forest maps from 1990 and 2000 elaborated by the BioSceneMada project to define and delimit initial natural forests. The two maps are based on Harper et al. (2007) widely used map from which 200,000ha of clouds have been removed thanks to Hansen et al. (2013) global tree cover data. Second, I calculate deforestation over natural forests annually between 2000 and 2014 thanks to Hansen et al. (2013) v.1.2 vegetation loss data. It results in a panel of 15 years of deforestation between 1990 and 2014 at a fine scale definition.

In addition to vegetation losses, Hansen et al. (2013) data allow to take into consideration the overall forest regrowth over the total period. Forest regrowth data have nevertheless to be taken into account with extreme caution. It is complicated to know to what corresponds these regrowths: old fallows that will be clear again for agricultural purposes (and thus, not to forest), actual standing secondary forest & ... Additionally, these secondary forests present lower interest regarding biodiversity conservation and carbon sequestration, even after 30 years without anthropic pressures (Grouzis et al. 2001). It thus makes sense to base out the present analysis on raw forest losses only and not to take into consideration forest regrowth.

Collective Action Mediators

I use municipal census data from 2005 to obtain socio-economic information, particularly to gain first insights on general pattern on collective action. The 2005 census has been conducted by INSTAT within all the 1,392 communes (municipalities) in Madagascar. The data have been obtained by interviewing a panel of key informants within the municipalities. I spatialized the census using official communes' boundaries and matched them to community forests and deforestation data.

Of particular interest for me, the census informs on several variables that can be used to measure collective action: the level of trust given to local traditional authorities, the level of trust given to local official authorities, the level of locals' participation to rural organizations, the level of property rights enforcement through a subjective measure of the risk of theft in the municipality.

Other Socio-Economic and Biophysical Conditions

I finally complete my set of covariates by spatial measures of population density and of biogeographic characteristics. I use population density data from NASA's Earth Observatory for 1990, 2000, 2005 and 2010. I then redetermine annual population densities by using the official INSTAT population census data at the district level (ndlr, the administrative district above municipalities).

In addition, I construct indexes of spatial proximity of each pixel to roads, river and major towns by using the heat map package from QGIS. Likewise, I incorporate standard biophysical data on slope and elevation.

The list of covariates, the origins of data and summary statistics are presented in Table 6. Heat maps are provided in Appendix.

5 The Empirical Strategy

I seek to quantify the effect of *VOI* in terms of avoided deforestation and to study the collective-action channel of the impact. The key challenge consists in constructing the most credible counterfactual scenario of what would have happened without the delegation of the CPR to local communities.

Identification Strategy

Most impact evaluations of conservation policies rely on matching to establish a control group among untreated observations. Based upon a set of observable covariates that are sought to explain deforestation, the researcher selects untreated observations that are the most similar to the treated sample regarding a chosen metric of similarity (e.g., Mahalanobis distance). The assumption behind this approach is that once controlled for observable differences, there is no more unobservable variables that influence the potential effect of the treatment. Most of these studies control for spatial covariates only (slope, elevation, distance to forest edge and so on). Rare are the studies using contextual socio-economic data in additional to spatial covariates. Yet, recent studies have shown the importance of using contextual socio-economic data in deforestation studies (Kere et al. 2016). These recent findings hence underline the potential issue of remaining unobservables.

I argue that this question of unobservables is a key problem in the case of CPR. Indeed, CPR are established in areas where people have a traditional use of the resource, where the access to the resource is already framed by existing local rules despite if the later where not recognized by the legal authority. These local arrangements are often unobservable for the researcher. By selecting control observations among a random sample of all untreated units as Rasolofoson et al. (2015), I would take the risk to choose areas where these local arrangements are absent.

To overcome this challenge, Baland et al. (2010) rely on a geographically explicit approach to control for unobserved local characteristics. The authors implements a kind of geographic regression discontinuity design, with spatial contours being the exogeneous threshold. They compare forest conditions in different forest patches around the same village. Some of these patches are under local management agreements and other are not. This approach is difficult to implement in the Malagasy context. NGOs have often implemented CPR by knots (Figure 4) so that within a village all traditionally appropriated resources have likely been delegated to the communities, letting no possibility to construct a control group. Focusing on boarders effects would hence not be convincing here.

Thanks to the panel dataset I have constructed, I exploit the panel dimension and the timing of the program as my identification strategy. Having data before and after the legal recognition for each observation, I can implement a full fixed-effects panel regression and track within-observations changes of the deforestation outcome with the apparition of the treatment. Doing so allows me to control for all unobserved differences. Also, as VOI have been created every year from 1996 to 2014, I am able to control for time fixed effects.

Construction of the Outcome of Interest and Estimation Procedure

The 1,248 *VOI* are of extremely heterogeneous sizes, ranging from 2.5ha to 67,200ha. To avoid size effects (i.e., larger deforestation in larger *VOI*), I construct a 1km x 1km grid to obtain observations of homogeneous sizes. I overlap this grid with the geographical limits of CPR to only keep areas effectively covered by *VOI* (homogeneity in terms of land titling for each observation). It results in a grid of 44,788 cells among which 32,620 cells were at least partially covered with forest in 1990. Among them, I randomly select 15,000 cells. This sample size guarantees representativity of the results within each ecoregion and within each type of implementer. Within each cell, I define my outcome variable $Def_{i,t}$ as the number of forested 30m x 30m pixels lost in cell i during year t.

With an annual deforestation rate between 1% and 2% distributed unevenly within the territory, the loss of forested pixels within a cell constitutes a rare event. The distribution of the outcome is then importantly left skewed (Figure 8). I account for the non-normality of the data by estimating a Poisson Pseudo Maximum Likelihood (PPML) fixed-effects model. As a pseudo-maximum likelihood model, PPML requires only assumptions of the specification of the conditional mean and not on the complete distribution of the data. I estimate:

$$Def_{i,t} = \alpha + \beta_1 TrVOI + x'_{i,t}\gamma + \zeta_i + v_{i,t} \; ; \; v_{i,t} = u_{i,t} + c_i \tag{4}$$

$TrVOI$ is my treatment variable, $x'_{i,t}$ is a vector of two time varying covariates (extent of tree cover and population density at date t), and ζ_i a cell fixed effect. As it is standard in the literature, I first consider $TrVOI$ as a dummy variable with $TrVOI_{bin} = 1$ if the cell i is treated at date t and $TrVOI_{bin} = 0$ if it not:

$$\begin{cases} TrVOI_{bin} = 1 \; if \; Year > Year \; of \; Creation \\ TrVOI_{bin} = 0 \; if \; Year < Year \; of \; Creation \end{cases}$$

In addition, as the establishment of CPR might be more a process and as learning effects might be necessary before obtaining first impacts, I also consider $TrVOI$ as a continuous variable to measure the impact of the duration of the treatment with fixed effects at the VOI level to allow for identification:

$$\begin{cases} TrVOI_{cont} = Year - Year \; of \; Creation \; if \; Year > Year \; of \; Creation \\ TrVOI_{cont} = 0 \; if \; Year < Year \; of \; Creation \end{cases}$$

In the two cases, I exclude observations from the year the treatment happens ($Year = Year \; of \; Creation$). I account for spatial auto-correlation in my data by clustering the errors within *VOI* so that common shocks are assumed for cells belonging to the same *VOI*. Additionally, as each ecoregion has its own vegetation type with its own ecological dynamic, leading to drastically different socio-ecological systems, I estimate the impact both nationally and separately for each of the three ecoregions.

Heterogeneity of the Impact

I explore the heterogeneity of the impact by using interaction terms between the treatment $TrVOI$ and the different mediators M considered (economic conditions, management issues, collective action proxies). In my dataset, these mediators are time invariant. In addition, they are defined at different geographical scales from the one of my outcome variable. My unit of observation is the cell level. The mediators M can be defined at the cell level (whether or not the cell overlaps with a Protected Area), at the *VOI* level (identity of the implementer, type of contract) or at the municipality level (property rights enforcement, collective action). Assigning the values of higher level observations (*VOI* and municipalities) to cells directly would leads to over-confidence in significance levels and would threaten the findings with potential Type I error (Overmars and Verburg 2006).

Multilevel-regression models provide a framework to explicitly take into account this nested structure of the data and to properly model the inter-groups correlations and shared variance within each levels (Snijders 2011), and to account for the spatial correlation of the error term (Anselin 2002). To account for the non-normal distribution of my data, I fit a generalized linear mixed model via maximum likelihood, assuming a poisson distribution as my link function. The three-levels panel model has the following specification:

$$\begin{aligned} Def_{i,j,k,t} &= \alpha + \beta_1 TrVOI_i + \beta_2 M_{j,k} + \beta_3 TrVOI_i \times M_{j,k} \\ &+ \left(w_{i,j,k,t} - \overline{w_{i,j,k,t}} \right) \gamma_1 + \overline{w_{i,j,k,t}} \gamma_2 + x_{j,k,t} \delta + z_{k,t} \zeta + \eta_t + R_{j,k,t} + U_{k,t} \end{aligned} \quad (5)$$

Index i refers to the cell, index j to the VOI, index k to the municipality and index t to the year. β_3 is the coefficient of interest when exploring the heterogeneity of the impact of $TrVOI$ for different mediators M. α represents the general intercept, $w_{i,j,k,t}$ are explanatory variables at the cell level, $x_{j,k,t}$ are explanatory variables at the VOI level, $z_{k,t}$ are explanatory variables at the municipality level.

Multilevel models assume that the explanatory variables and random effects are independent. If this assumption is violated the estimation results may be biased. This problem of correlation can be dealt with by a within (-group) transformation of the explanatory variables. $R_{j,k,t}$ and $U_{k,t}$ are respectively the *VOI* level and the municipality level random effects.

Additionally, for the interaction term to identify properly the collective-action mechanism, M has to be exogenous. Yet, one might expect trust levels or participation to rural organizations to be partly explained by local economic conditions (Knack and Keefer 1997). The inclusion of economic control variables in the regressions allows us to control for endogeneity.

6 Results: The Environmental Impact of Community Forest Management in Madagascar

I now turn to the empirical results. I first present the results of the impact of CPR recognition on deforestation (6.1) and then turn to the mechanisms. I will successively present political (6.2), economic (6.3) and collective action (6.4) mechanisms.

6.1 The Impact

Table 7 presents the results of the environmental impact of the official legal recognition of locals' right over CPR management in Madagascar, at a national scale (Panel A) and for each of the three ecoregions (Panel B to D). For each panel, I successively present the standard fixed effect binary treatment, the fixed effect continuous treatment and the binary treatment only for VOI that completed the official recognition process. Table 8 displays the three-levels estimation without interaction term to allow for random effects between observations. Overall, the estimations suggest that official locals' rights securing over CPR has not currently allowed to decrease deforestation at a national scale, whatever the treatment considered, and almost whatever the ecoregion.

In the fixed-effects estimates, the coefficient associated with the treatment variable is not significant: on average, the strengthening of legal rights was not followed nationnaly by a decrease in deforestation within the polygons. This results is consistent with Rasolofoson et al. (2015) early estimates on a subsample of *VOI* in Madagascar and in line with our results of an absence of an impact of new co-managed PAs established at the same period (Desbureaux, Aubert, et al. 2015). When considering a continuous treatment, my estimates suggest that the impact globally shows no sign of improvement over time (Panel A).

More surprisingly, while expected to be negative, estimated coefficients generally are positive. In the fixed effect regression, the binary coefficient for the southern ecoregion even is positive and significant: on average, deforestation in the southern spiny forests has increased by about 10% following the establishment of *VOI*. In the eastern ecoregion, the continuous treatment suggests that deforestation has significantly increased during the first years then slowly stabilized over time. When taking the estimations from the multilevel model, this slight 10% increase in deforestation is even significant nationally. It is driven by an increased in deforestation within the southern spiny forests and the eastern rainforests, while it may have decrease within the western dry forests of the island.

6.2 Endogenous or Exogenous institutions and Limitations in Policy Implementation

Why the establishment of *VOI* has currently failed to reduce deforestation in Madagascar or worse, why *VOI* may have pushed for a slight increase of deforestation?

A salient feature of the CPR literature is that institutions can emerge to secure First-Best equilibrium. The census used here indicates that for only 7% of forest CPR in Madagascar, locals have embraced themselves the possibility to make recognize their management rights over the CPR after the passing of the GELOSE law in such a bottom-up approach. For them, this dynamic testifies of a stronger collective action, of a lower passivity in policy decisions and probably of existing collective institutions related to CPR management. They hence typically correspond to the "Ostromian" case of CPR management. In line with our theoretical predictions from Section 2, these CPR where among the places where initial deforestation was the lowest. They also are the area where the impact of the official creation of *VOI* has been the more positive, i.e. where deforestation has decrease the most despite it was already originally lower (Table 9).

For the other 93% *VOI*, the approach has been top-down: an external actor has initiated and supported the creation of *VOI*. Theoretically, it is for them that there exists some uncertainty regarding their potential impact. Particularly, if the provided assistance or transfer (ndlr, the τ from Section 2) was limited, it is unsure that the incentive to cooperate became positive. Yet, two elements suggest that it might has been the case in Madagascar.

First, let recall that only half the contracts have been officially registered with the municipalities. This fact appears as a first evidence of a poor implementation of the policy. Indeed, it is hard to know what the current situation is within the unregistered contracts. My personal fieldwork suggest that at least some *VOI* have already fall into abeyance. By focusing the analysis only on officially registered contracts, I find that the general environmental impact of their creation remains insignificant but hides two opposite dynamics: a significant 10% decrease in deforestation in the eastern rainforests, a comparable increase in the south and the absence of an impact in the west (Table 7).

Second, the management of the policy has been delegated by the State to a multitude of actors (Table 9) who drastically differ regarding their human and financial capacities. They range from,on the one hand, the Malagasy State which has particularly suffered from the political crisis in terms of budget or Malagasy NGOs, to on the other hand, better funded international NGOs. When conditioning the impact on the manager type, I do find that better funded actors have performed globally better than Malagasy State or actors, particularly in the east. Indeed, despite being located in areas with lower pressures (i.e., with smaller margin of deforestation reduction), international conservation and international development NGOs have succeed to obtain better results that local actors. Even for them, the total impact on deforestation remains somehow limited: deforestation has not increased as opposed to other actors but does not seem to have increase. Interestingly again in the south, with similar level of initial deforestation, the increase in deforestation has been more important when these better funded actors have implemented the policy. In addition, the environmental impact appears better when GELOSE type contracts (i.e., sustainable use approach) has been implemented compared to GCF contracts (conservation approach) (Table 10). Again, this overall result masks two different dynamics: a decrease in deforestation within the eastern ecoregion but a reverse phenomenon in the west.

So that at the end, even when the policy has been fully implemented, the environmental additionality of the securing of rights over CPR has remained limited in Madagascar.

6.3 On the Limited Pure Economic Incentives to Sustainably Manage CPR

When playing a cooperative strategy, community members are asked to give up some short term profits to increase their long terms profits. For long terms profits to be credible, a satisfying level of property rights enforcement has to be guaranteed. Meanwhile, Madagascar distinguishes itself by the weakness of its law enforcement, reinforced by recurrent political crises. In this context, the respect of property rights is often dubious. Locals face difficulties to protect the CPR from outsiders when no police is present to verbalize squatters. At the same time, this lack of law enforcement let the possibility to locals to possibly clear new lands outstide the current territory of the common and then extend it in the future when needed.

Table 11 highlights a non-linear links between the quality of law enforcement, deforestation and the impact of the policy. It appears clearly that areas with a lower enforcement of property rights (i.e., where the risk of theft of goods is higher) experience higher deforestation. The problem is particularly pronounced in the southern and the western parts of the country. In this context, the recognition of CPR - that aims at reinforcing property rights enforcement - has allow to slightly reduce deforestation in the most insecure areas. However, for areas in the middle in which the risk of theft was initially moderate, the impact is at best null but or even reversed: the recognition of locals' right over the resource does not seem to have reversed behaviors towards more long term planning but maybe reaffirm a short term dynamic of over-extraction within a still unsecured environment.

To this result, it is worth recalling that local economies are oriented toward agriculture through slash and burn. Yet, what is proposed to locals with the establishment of CPR is a major change in their livings, by diminishing their agriculture activities and replace it by forest product sustainable exploitation. Desbureaux, Kéré, and Combes-Motel (2016) has shown that locals face major difficulties to even slightly change their practices when increasing law enforcement over natural forests. It is then not surprising to see that a major shift is even more not likely to happen.

So that, locals' rights recognition over CPR does not seem to have redirected behaviors towards sustainable use of common resources. The absence of strong economic incentives for this change appears as a valid argument to explain this result.

6.4 The Green and the Dark Sides of Collective Action

The second part of the CPR story deals with the necessity of sound collective action to overcome the cooperation dilemmas. As pointed out in Section 2, the story might be ambiguous when institutions are created by external actors, particularly when moral hazard situations are present.

The Green Side of Collective Action

We have seen earlier that when*VOI* have been created through a local initiative, the environmental impact of *VOI* has been positive. In addition, when considering all CPR, the three-levels regression model illustrates that everything else being equal, deforestation within the island has been lower in areas with higher declared trust between villagers and local traditional authorities. The correlation holds in the eastern ecoregion for moderate and high level of trust, and is particularly strong in the west. The same pattern applies local official authorities. Going in the same direction, there is a slight inverted U-shape correlation between deforestation and the participation rates to rural organizations (Table 8). These are in line with the standard "green side" of collective action from the literature. Yet, when taking the whole sample of CPR and regarding how the impact of the policy varies with different levels of collective action, the story becomes different.

The Dark Side of Collective Action

Indeed, if the level of deforestation was lower in areas with higher fairness of traditional authorities, these places are among the ones that have experienced an overall increase in deforestation after the creation of *VOIs* (Table 12). The same logical applies when looking at the heterogeneity of the impact regarding different levels of participation to rural organizations

(Table 14). The later results are even more pronounced when focusing on the trust given to local official authorities. Overall, higher fairness means higher initial deforestation and lower impact (Table 13). In municipalities where fairness given to local official authorities is moderate or high, deforestation is higher than in municipalities where fairness is low and the recognition of CFM has even lead to a small increase in deforestation as opposed to areas with lower fairness.

So that, the standard predictions of the CFM literature regarding collective action may not all be confirmed in the Malagasy context. Particularly, higher cohesion within communities does not systematically mean *ceteris paribus* lower deforestation and higher impact of the policy as if a "dark side" of collective action coexists with the standard "green side" often debated. With the national data that I use, it appears difficult to test more finely explanations to explain this result. An experimental approach allows me to test more finely for trust and for the presence the presence of intrinsic motivations for nature conservation.

7 Between Collective Action and Motivations for Nature Conservation: Experimental Evidence

I have organized lab in the field games in two forested areas in the eastern ecoregion: Vohibola and Vohimana. Vohibola and Vohimana are community managed forests, with the active support of a local NGO.

In the experimental literature, different games are suited for the exploration of group dynamics. Between them, I chose the trust game (also called investment game) (Berg, Dickhaut, and McCabe 1995) that allows me to study general patterns of trust and fairness, with rules simple enough to be understood by villagers with low educational standards and with rules simple enough for participants that have never played such games before. In addition, trust games have now been played in the field in various countries (Cardenas and Carpenter 2008). These other studies provide me a benchmark to see if Malagasy cooperates less or more than elsewhere in other contexts. At the end of the trust game, I framed a voluntary contribution game around conservation issues to assess locals' perceptions about nature conservation more precisely.

Protocol

In December 2014, I organized two test sessions with 10 local official and traditional authorities to test the general understanding of the rules of the trust game, to obtain their agreement to play the game with the villagers, to associate them to my investigation, to obtain their suggestions for the framing and the organization of the game. We agreed upon the organization of the standard Berg's original trust game (Berg, Dickhaut, and McCabe 1995) with one slight variation: player one was given the choice of the payment vehicle between cash (1000 Ariary, the equivalent of about one third of the local wage) or its equivalent in an agricultural commodity. This choice was let as many villagers are more confident to play with an agricultural commodity in areas where modern market mechanisms remain recent. At the opposite, the exchange of agricultural commodities is a common traditional exchange mechanism in the two areas, known as *Frandriaka* and *Tambirô*.

From February to April 2015, I have organized 11 2-hours sessions of a trust game in 6 villages with a team of 3 research assistants. For each session, we have randomly invited 20 to 30 villagers to experimental games organized in a communal place (generally, the local elementary school). When arriving, each villager answered a rapid general socio-economic questionnaire and was provided with a number. After a general exposition of the rules, they were randomly split in two groups: half were player one, half were player 2. The two groups were separated in two rooms. Player one and player two were matched randomly. So as to avoid the creation of potential conflicts after the game, the game was played semi-anonymously: instead of revealing the identity of the two players, we provided each player with a set of general information regarding the other player based on the rapid questionnaire: its sex and age, the number of years she or he lives in the area and if she or he participates actively to local nature conservation activities. We then started the game. First, the research assistant recalled the rules to player 1. Player 1 then chose one of the two payment vehicle(money or the commodity), the research assistant revealed the information on player 2, player 1 took the decision of how much to keep and put the amount he transfered in a sealed envelope. Second, the research assistant went in the other room, recalled the rules to player 2, revealed her or him the information on player 1, gave her or him the sealed envelope. Player 2 decided how much to keep and put what he gave back in another sealed envelope. Third, the envelope was given back to player 1. For all but one session, we asked if the villagers want to play a second round, with player one becoming player two and player two becoming player one. They all agreed and thus repeat the same protocol. Fifth, we gathered everyone in the same room, thanked them and congratulated them. Finally, we recalled that we were a team dedicated to the issue of nature conservation in Madagascar and offered them to donate a part their payoffs to the local villager association dedicated to nature conservation as in a framed Voluntary Contribution Mechanism.

Results

232 villagers participated to the game sessions. I display descriptive statistics of the sample in Table 15, the results of the two games in Table 16 and an econometric analysis of the results in Table 17. On average, villagers in the first move transferred 55% of their endowment to player 2. Then, player 2 transferred back 72% of what has been initially transferred. For the first move, the fraction sent by player 1 to player 2 is not statistically different regarding the payment vehicle. Yet, more has been sent back by player 2 when player 1 has chosen the agricultural commodity instead of cash. In Vohimana, players 1 have transferred 5% more to players 2 on average compared to villagers in Vohibola (Table 17). Three strategies have dominated in the first move. The first one has been transferring half of the endowment to player 2 (45% of players) - a fair and trust strategy. The second has consisted in giving slightly less of the endowment -a "skeptical trust" strategy - and third, giving everything -a full trust strategy (Figure 9). These results echo the declarative measures of trust reported within the Afrobarometer (Table 3) and are in line with results of the trust game played in the field in different contexts. However, I do not find in the econometric analysis that the level of trust is higher when playing with members of local associations compared to when playing with standard villagers (Table 17) as one could have expect from Section 2.

As for the second move, 70% of the players gave back to player 1 less that what she or he transferred. In this situation, player 1 found himself in a worse situation after collaborating. In 14% of the cases, player 2 gave back exactly what player 1 gave her or him and 10% split in two the total amount earn. Only 2% of players 2 gave back to player one more than what she or he kept (Figure 9). All these results are in line with what has been found in other countries where a trust game were played (Cardenas and Carpenter 2008), confirming the idea of existing patterns of trust and collaboration in Madagascar. It put into perspective the idea of a complete breakdown in collective action in communities as Madagascar.

Voluntary Contribution Mechanism Game Overall, rare are people who did not give anything back for nature conservation (5%, Figure 9). Nonetheless, 54% of people only gave the smallest amount possible (100 Ariary), while an additional 28% gave 200 Ariary. Even if we attempted to limit social pressure during the game (sealed envelope, everybody was invited to hide from others, anonymity during the game - only an id number was provided but no name was recorded), a willingness of trying to satisfy our team surely explained why 95% of participants shared something, as noted by anthropologists when to satisfy the desires of visitors (particularly, foreigners - called *vahaza*) (Blanc-Pamard and Fauroux 2004).

It is as well somehow difficult to highlight a clear trend explaining the amount shared by participants: richer individuals gave more yet, the amount given is not linked to the gains from the game, people living for a longer time in the area gave less and the people the less integrated to the community gave more (Table 18). This combination of low transferred amounts, this absence of clear patterns to explain decision suggest that preoccupation for nature conservation at best limited, that the amount shared might be more a question of social pressure. So that at the end, what these two case studies suggest is that there might not be a generalized problem of distrust or failure of collective action in Madagascar, but mainly an absence of interest for nature conservation among community members.

8 Discussion

In Madagascar, I have shown that the establishment of officially recognized community forests from the 1990s has not yet allow to decrease deforestation. The economic incentives for a sustainable use of CPR were weak over the period and the limited intrinsic motivations have not permitted to overcome the cooperation dilemma. In this context, social capital has played an ambivalent role: if it has permitted to keep initial lower overall level of deforestation but it is often in the areas where collective action is better that the environmental outcome of *VOI* creation has been the worse. Within the later, the creation of *VOI* may even have had a reverse effect, *i.e.*, an increase in deforestation. I come back on the question of nature-conservation oriented motivations in Madagascar and on the seemingly counterproductive role played by collective action in this discussion.

8.1 Intrinsic Motivations

The absence of intrinsic motivations in Madagascar might be understood by historical reasons. In Madagascar, there is only few ethnic group living in the forest for centuries. Among the 18 ethnic groups of the country, only the *Mikea* in the south-west of the Island tends to be considered as an indigenous group.[12]. Mikea define themselves as the ones living in the Mikea forest (Poyer and Kelly 2000). Two other ethnic groups have names suggesting a direct derivation with forests: the *Tanala* that can be translated by "the ones from the forest", and the *Antondroy*: the ones from the spiny forest. Research has however shown that these ethnic groups are recent (mid $XVII^{th}$ century for the *tanala* who in fact are the union of the *Betsimisaraka*, the *Taimoro* (two ethnic groups coming from the coast), and the *Betsileo* who come from the inland (Gaudebout and Molet 1957)).

[12]Indigenous people are defined following the UNO definition from the Working Group of Indigenous Populations.

Instead, most settlements within forests date back from the XIX^{th} and XX^{th}. Obviously, Malagasy have developed some traditional Human beings - Environment relations. Many villages have stories regarding the life of their ancestors in the forest (e.g. in Vohimana, this ancestor is known as *Mongoala*), several forest plots are sacred and it is taboo (*fady*) to enter inside them. It is also *fady* to hunt particular species as many lemurs. Yet, even if this system of prohibition helps reducing pressure on some species or areas, they did not appear as a conservation strategy (Jones, Andriamarovololona, and Hockley 2008). In addition, they are reported to currently breaking down in several areas (Jones, Andriamarovololona, and Hockley 2008; Desbureaux and Brimont 2015).

8.2 Counterproductive social capital

Deforesting in Madagascar is illegal. There is thus a necessity to hide deforested areas or the identity of the individual who has cleared forest, at least from people outside the community. Doing so requires some internal cohesion.

As presented in Section 3, the principal driver of deforestation in Madagascar is slash and burn agriculture (*tavy*). *Tavy* is at the center of the collective dimension of appropriated forest territories and land tenure in the *tavy* system is often complex. Fallows are collectively managed but individually harvested (Aubert, Razafiarison, and Bertrand 2003). Some fallows are collectively owned, some are family owned and other are individually owned.Moreover, from one village to another, the system can slightly change. When working in a village, it is thus difficult from an outsider to know to whom each fallow belongs. Local traditional leaders (the *tangalamena*) is at the center of the system. In a village where I worked, one of the *tangalamena* recognized during an informal discussion that it would be difficult for us to know the owners of fallows. He however emphasized that himself knows perfectly the information.

Neither it is the idea to say that the tenure system in the *tavy* scheme is made to hide the information on the identity of fallows' owners from the outsiders, nor to say that this tenure system explains why in areas with better collective action the impact of CPR recognition has been worse. I however believe that this tenure system helps to defend locals in continuing to practice *tavy* and deforest. It also highlight why collective action might be counter productive in CPR management. Nonetheless, more research might be necessary to understand elsewhere in Madagascar the role played by collective action to sometimes favoring deforestation.

9 Conclusion

In this paper, I have determined at a national scale the environmental impact of the decentralization of natural resources management in Madagascar by focusing on forest CPR, and I statistically explore how collective action affects the impact. I additionally use first hand data from a survey and from two *lab in the field* games in four case studies to refine the understanding of collective action patterns. I show that CPR management has currently failed to slow down deforestation. A pure economic reasoning of profit maximization in a politically unstable context explains part of this failure. In this context, I do not find however solid evidence that stronger social capital have helped to attain better environmental outcomes. At the opposite, the environmental effect of CPR management might have been even worse within well organized areas, within areas with higher trust between inhabitants. Instead of favoring the emergence of environmentally friendly behaviors as generally stated in the literature, social capital seems to have favored the depletion of the resource in Madagascar. This is what I called the "dark side" of collective action. I explain this reverse effect by the limited presence of "intrinsic motivations" for nature conservation in Madagascar.

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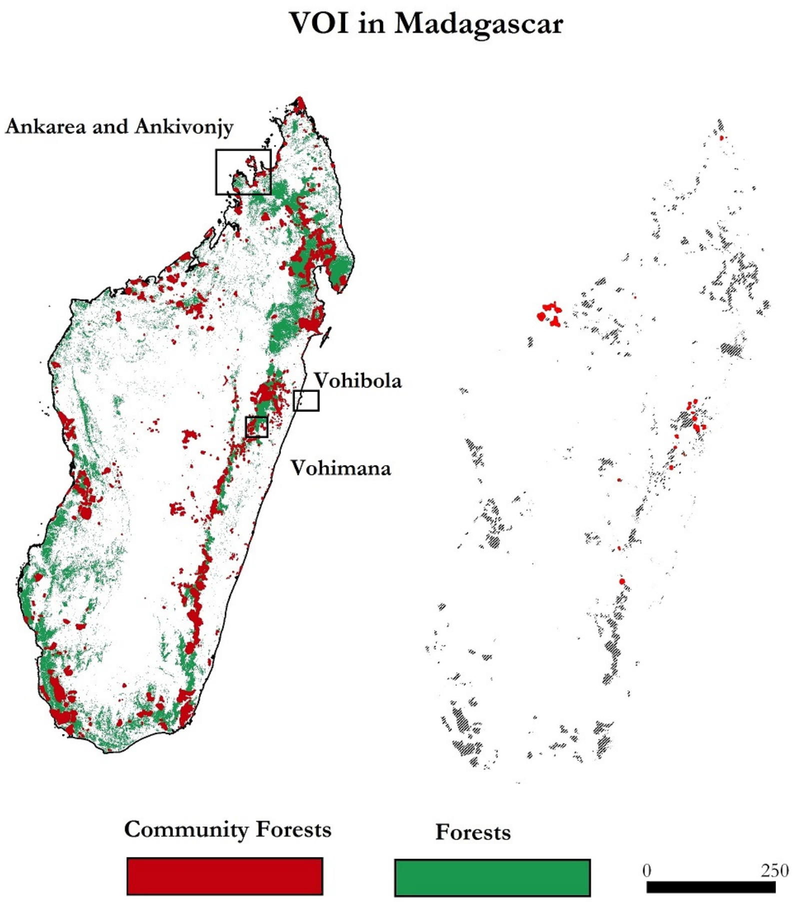
10 Figures

Figure 1: Spatial distribution of *VOI* in Madagascar



Note: This figure displays forests in 2000 in Madagascar and the spatial distribution of VOI. Forest cover comes from the BiosceneMada derived from landsat images and are available online. Close-up from study sites are presented in Figures 2 and 3.

Figure 2: Vohimana and Vohibola

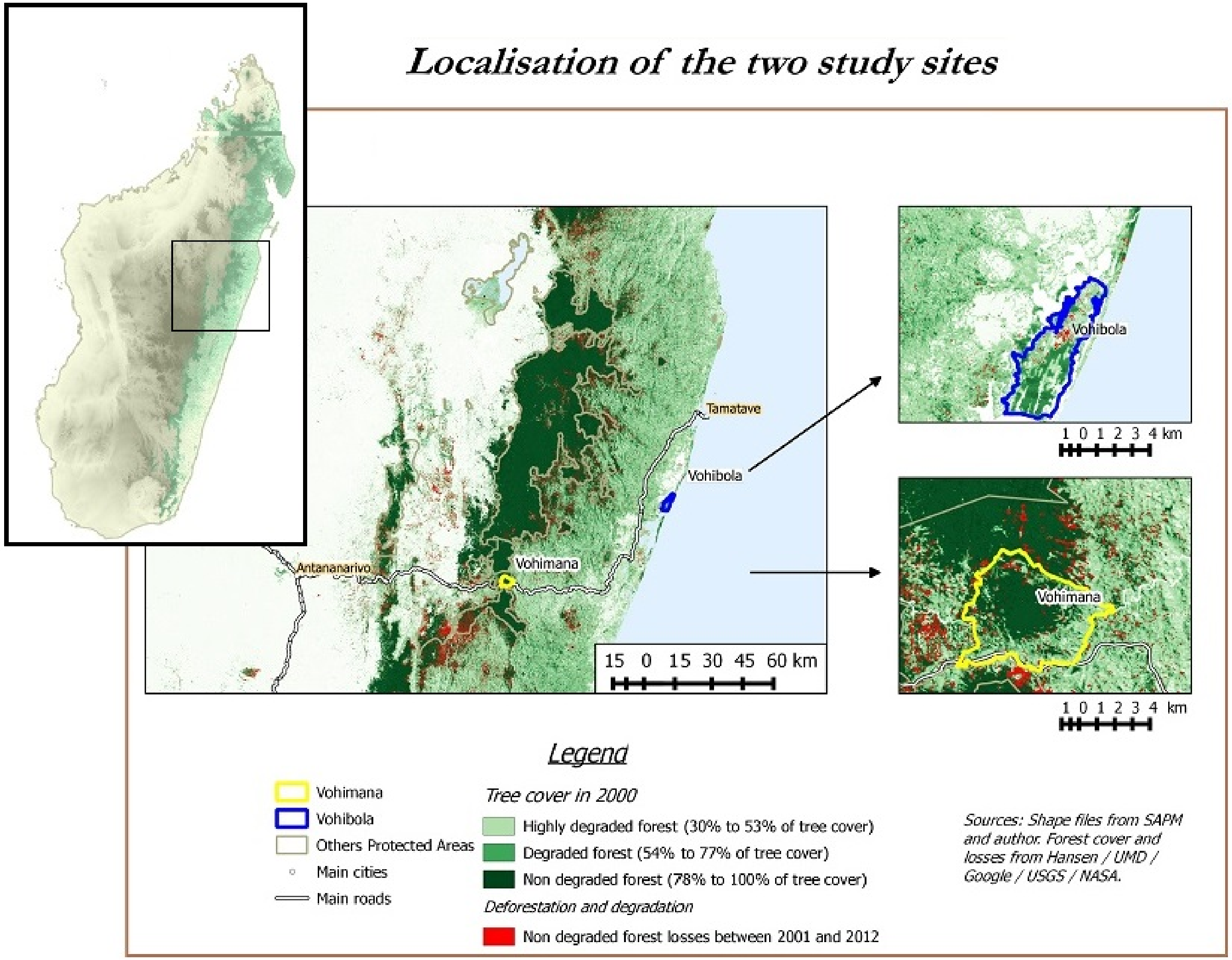


Figure 3: Ankarea and Ankivonjy

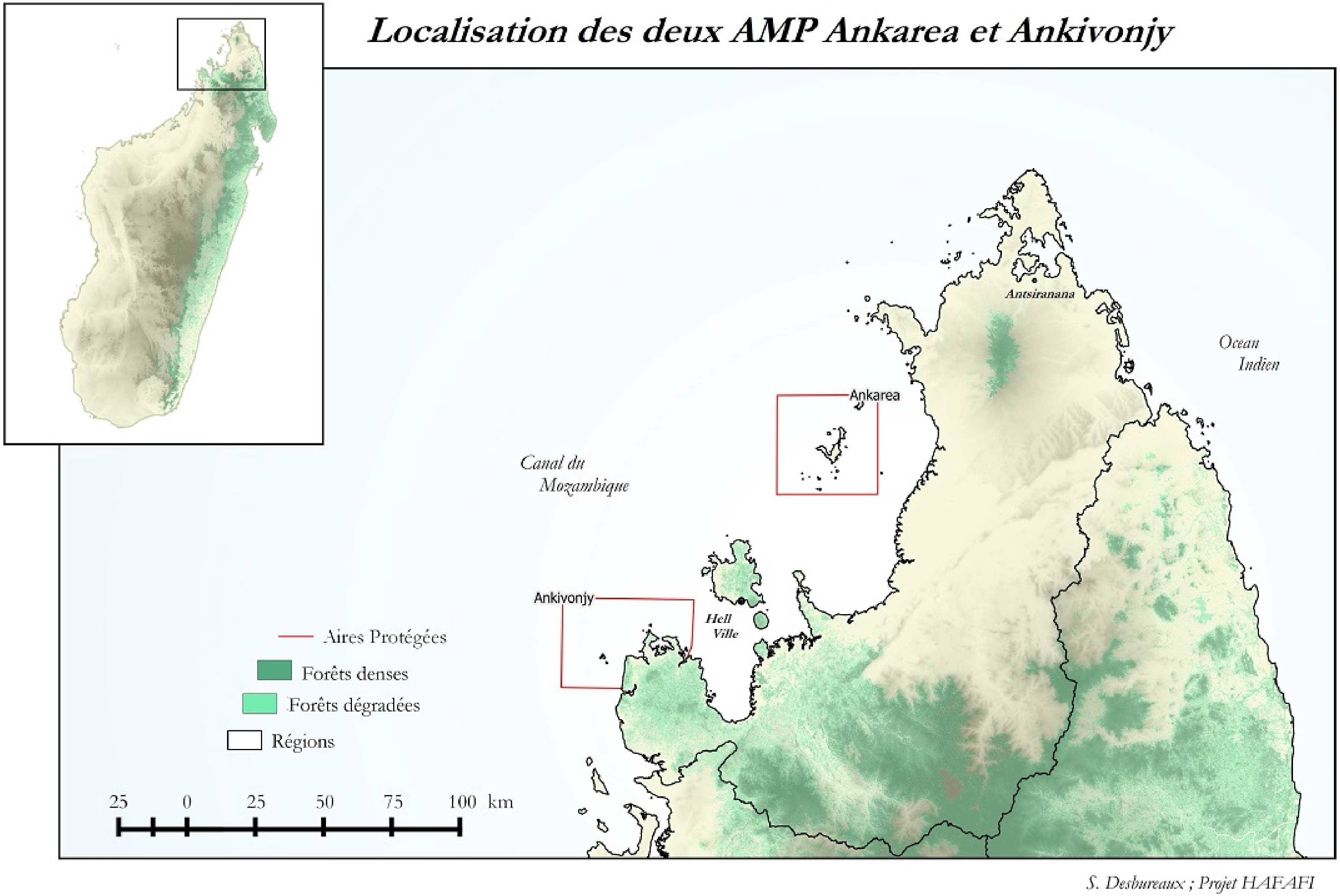
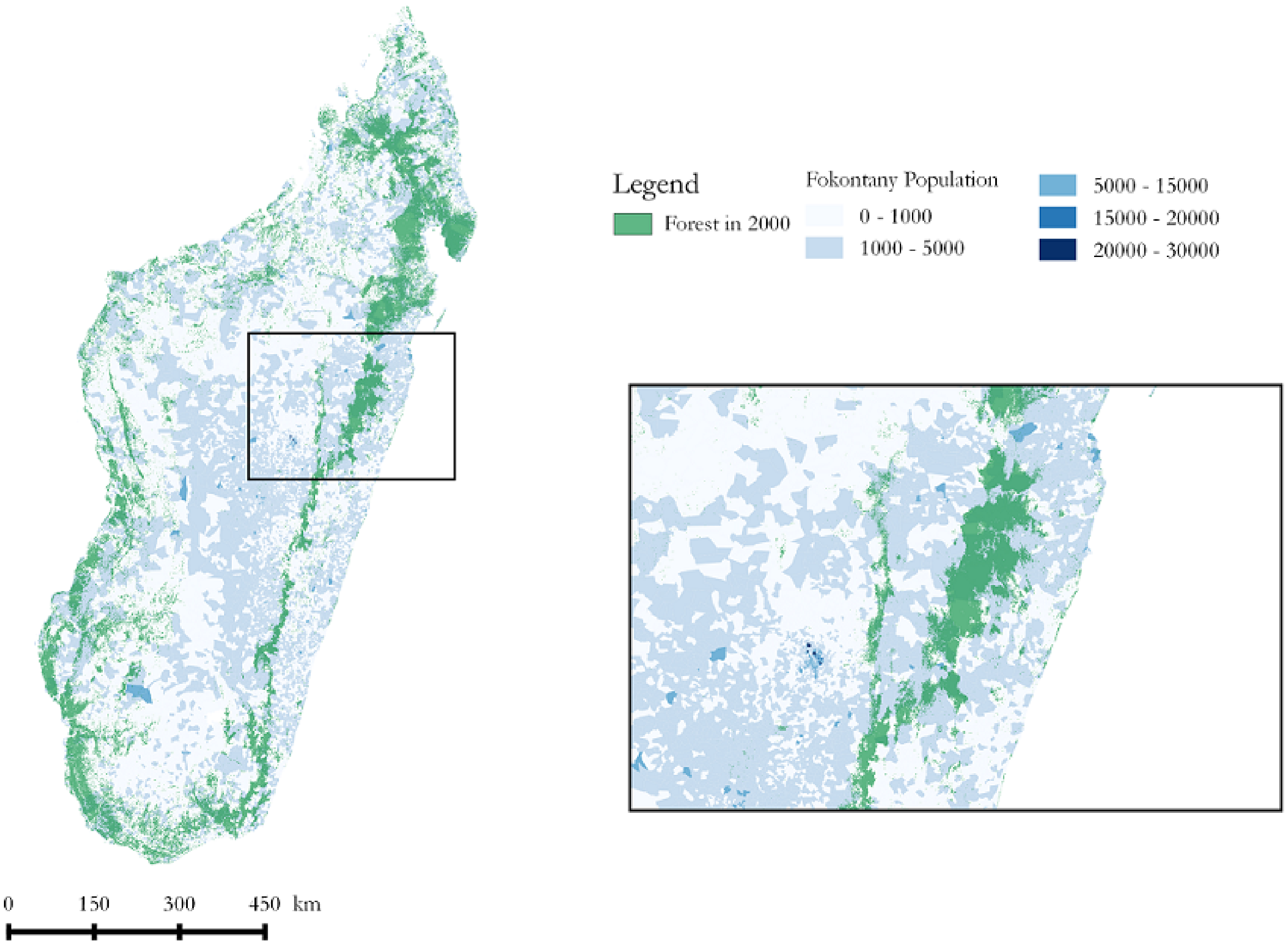
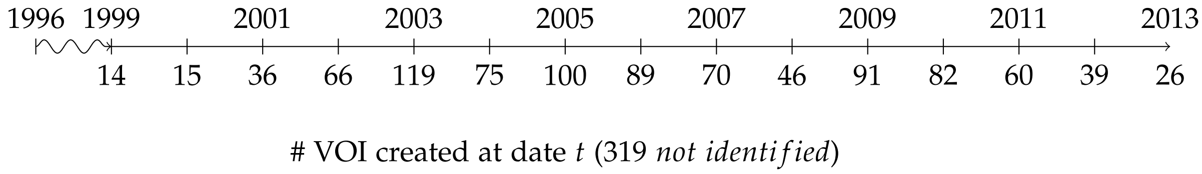


Figure 4: A spatial estimation of the number of forest dependent people in Madagascar



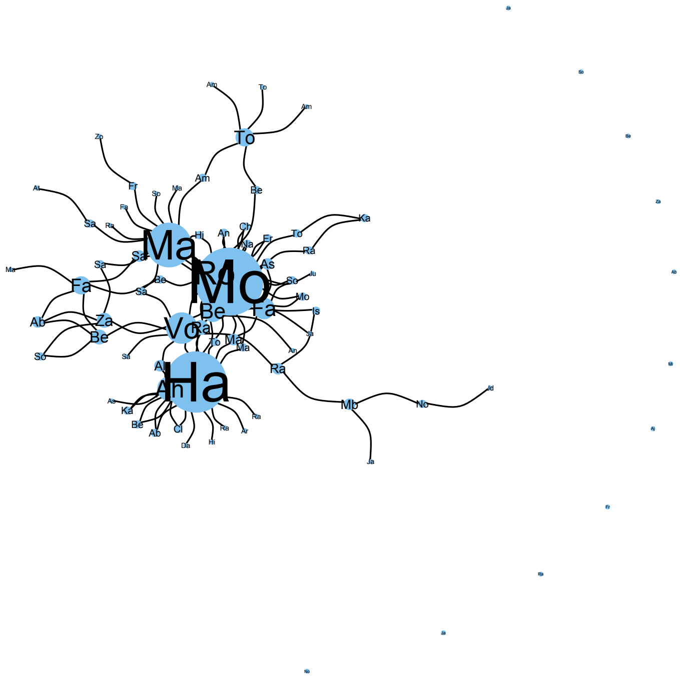
Note: This figure represents population at the fokontany level from the the 2008 INSTAT census and forest cover in 2000 from the BioSceneMada project. By overlapping the two layers, I estimate the population living directly by forest CPRs. I estimate that about 2.5 millions inhabitants live in fokontany covered by at least 20% of forest cover and about 1 million live in fokontany covered by 50% or more by forests. (Table 1). In addition, I count 990 coastal fokontany where 1,5 million inhabitants lived in 2008. Within them, reliance on fisheries is direct. So that in total, there would be probably about 2.5 to 4 millions inhabitants in Madagascar who rely in their daily lives on CPR.

Figure 5: Timeline of VOIs' creation



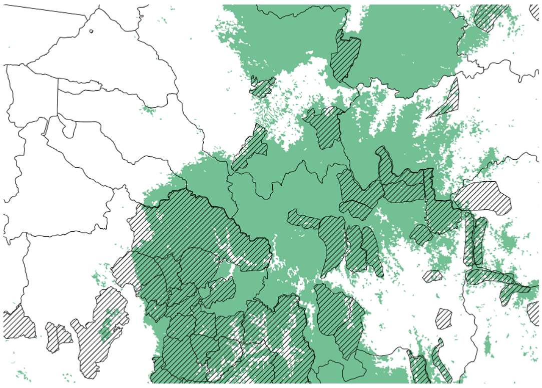
Note: This figure represents the number of VOI officially recognized at date t in the census. Many VOI have been created in the mid-2000, then the process has slow down in the early 2010s following the political upsurges in the country. For 319 VOI, the year of creation was not reported in the database because it was not known from official authorities. They have then be excluded from the analysis. One might expect that this absence of registration reveals some shortcomings in their implementation, making them perfect candidate for simple "paper VOI".

Figure 6: A network representation of CPR leaders in Ankarea

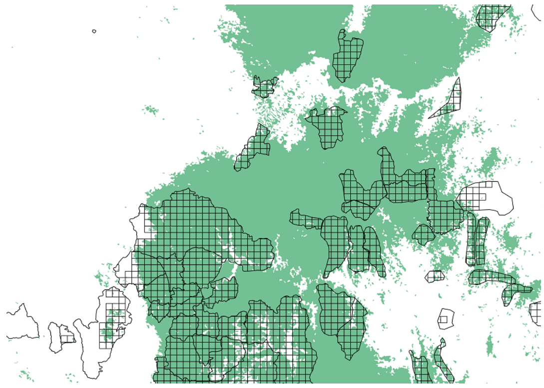


Note: This figure displays relations between locals and their representatives in the CPR management council in Ankarea from a network analysis. We asked them to cite the name of councils members and how they were related to her or him. Each dot represents an individual and each line a link between individuals. The larger the dot, the higher the centrality of the individual in the network. In Ankarea, it appears that 3 individuals are highly central in the network. Most locals know them and are directly related to them (friends or family members). 11 individuals over the 68 interviewed were not related to them. Data have been collected in November and December 2014 within a collaboration with the Hafafi project.

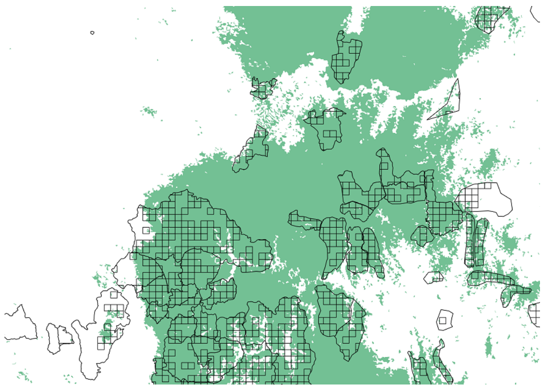
Figure 7: The spatial dimension of the data



(a) Forest, Municipalities (borders), VOI (hatched)



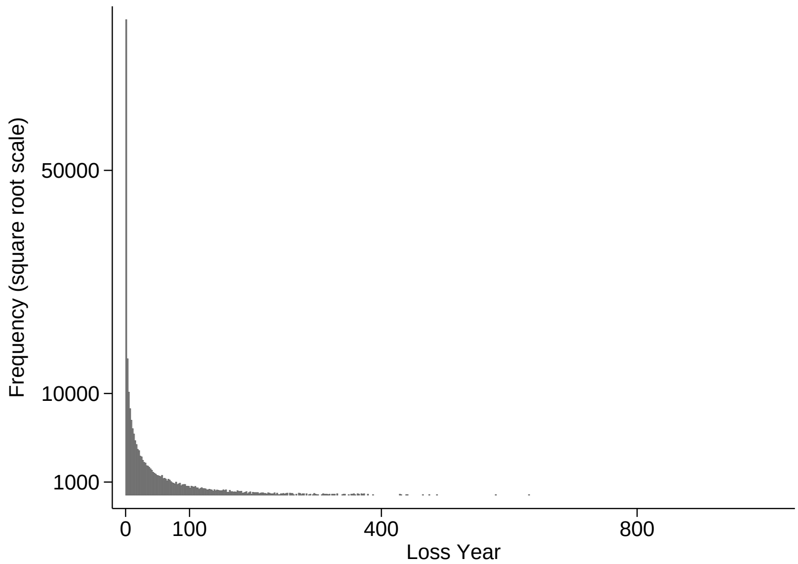
(b) Forest, VOI and grid cells



(c) Forest, VOI and random grid cells

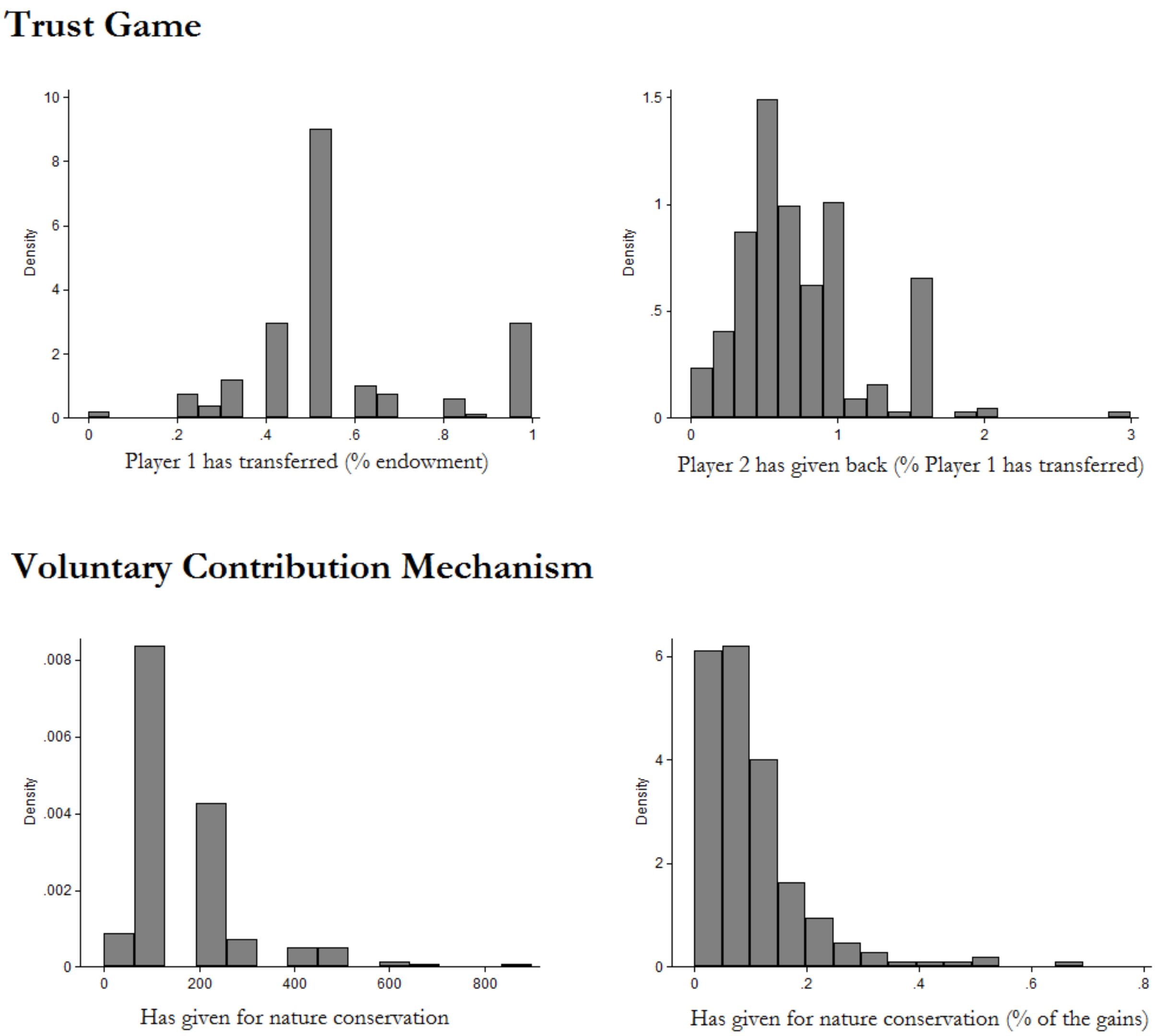
Note: This figures illustrates the spatial imbrication of the dataset. VOI belong to municipalities (Panel a). Their spatial limits correspond to municipalities limit so that a VOI belongs to one and only one municipality. As VOI are of heterogeneous sizes, I divided them into 1lm x 1km cells that I have overlapped with VOI boundaries (Panel b). Among them I randomly select 15,000 of them (about 1/3 of the cells) to conduct my analysis (Panel c).

Figure 8: Distribution of the outcome variable



Note: This figure displays the distribution of my outcome variable $Def(i,t)$. As deforestation remains a rare event, the distribution is particularly left skewed. A survival analysis as a Poisson or Quasi-Poisson models seems appropriated for this study. Figure A2) displays the distribution for every year in the study period.

Figure 9: Trust Game and Voluntary Contribution Mechanism



Note: Figure 9 displays the raw results of the two experimental games I have organized in Vohibola and Vohimana in early 2015. Results are detailed in Section 8.2.

11 Tables

Table 1: A raw estimation of the number of forest dependent people in Madagascar

Proportion of forest in the *Fokontany*	Number *Fokontany*	Total Population
10% to 19%	3 738	3 645 246
20% to 29%	2 517	2 404 691
30% to 39%	1 760	1 675 725
40% to 49%	1 225	1 163 201
50% to 59%	832	804 656
60% to 69%	534	520 642
70% to 79%	335	329 528
80% to 89%	155	152 810
90% to 100%	36	30 792

Note: This table displays some spatial statistics to grasp better the number of people who depend from natural forests in their daily lives. *Fokontany* is the smallest administrative division in Madagascar. Population statistics are available at this scale for the year 2007-08 (source: Instat *Fokontany* census). Forest data come from the BioSceneMada project. From my field experience, forest is important in a daily basis even in *fokontany* with about 30% of forest cover. A spatial representation of the results is proposed in Figure 4.

Table 2: On the profile of CPR leaders

Panel A: Ankarea and Ankivonjy

	Component 1			Component 2			Component 3		
	Coef.	*Std. Err.*	*P*	*Coef.*	*Std. Err.*	*P*	*Coef.*	*Std. Err.*	*P*
Member Decision Commitee	**0.429**	0.087	**0**	0.194	0.166	0.243	-0.275	0.284	0.332
Has other functions	**0.388**	0.088	**0**	0.052	0.187	0.78	-0.196	0.675	0.771
Years living in the area	**0.464**	0.101	**0**	-0.358	0.148	0.016	0.221	0.245	0.366
Sex	**0.212**	0.109	**0.052**	0.062	0.224	0.78	-0.462	0.89	0.603
Age	**0.491**	0.089	**0**	-0.3	0.143	0.035	-0.03	0.233	0.896
Education	-0.011	0.167	0.945	0.693	0.085	0	-0.134	0.292	0.645
Number of children	0.19	0.119	0.111	0.241	0.228	0.291	0.76	0.279	0.006
Number of goods owned	**0.357**	0.121	**0.003**	0.445	0.137	0.001	0.164	0.297	0.581
Explained total variance		0.238			0.171			0.125	

Panel B: Vohibola and Vohimana

	Component 1			Component 2			Component 3		
	Coef.	*Std. Err.*	*P*	*Coef.*	*Std. Err.*	*P*	*Coef.*	*Std. Err.*	*P*
Member of supported associations	0.07	0.139	0.611	**0.448**	0.185	**0.015**	-0.658	0.137	0
Years living in the area	-0.454	0.116	0	**0.455**	0.125	**0**	0.134	0.155	0.388
Sex	0.214	0.117	0.067	0.275	0.209	0.189	0.729	0.101	0
Age	-0.239	0.156	0.126	**0.633**	0.083	**0**	0.087	0.192	0.649
Education	0.619	0.054	0	0.168	0.154	0.275	0.04	0.109	0.716
Number of goods owned	0.55	0.082	0	**0.296**	0.143	**0.038**	-0.096	0.129	0.457
Explained total variance		0.269			0.219			0.184	

Note: This table displays the results of a Principal Component Analysis to determine the charcateristics of the persons involved in CPR management in Madagascar. These leaders tend to held previously decision positions prior CPR management, live in the area for a longer period, are men in Ankarea and Ankivonjy, older and richer. Standard errors computed assuming normal distributions.

Table 3: Descriptive evidence on trust and collective action in Madagascar

Panel A: Do you trust ...

	Relatives		Neighbours		Other People that you know		Local Government		Traditional Leaders	
	Africa	**Madagascar**	**Africa**	**Madagascar**	**Africa**	**Madagascar**	**Africa**	**Madagascar**	**Africa**	**Madagascar**
Not at all	5,1	5,2	13,5	13,6	23,9	22,6	21,2	11,3	11,7	6,5
Just a little	12,8	18,3	24,5	31,2	32,4	41,6	26,1	21,6	18	12,4
Somewhat	20,8	35,7	33,7	41,2	28,3	29,5	26,6	40,1	24,2	33,3
A lot	61	40,8	27,9	13,9	14,7	5,9	21,7	26,8	37,5	45,9

Panel B: Politicians' performance

	Corruption					Good Performance			
	Local Government		Traditional Leaders			Local Government		Traditional Leaders	
	Africa	**Madagascar**	**Africa**	**Madagascar**		**Africa**	**Madagascar**	**Africa**	**Madagascar**
None	11,2	38,1	25,3	65,6	Strongly disapprove	16,4	5,7	8,8	1,7
Some of them	45,8	47,9	41,4	28,5	Disapprove	27,7	24,5	15,1	10
Most of them	23,8	11,2	14,2	3,1	Approve	38,5	61,1	41	64,4
All of them	10,4	1,9	6,2	0,3	Strongly approve	11,4	8,6	21,9	21,9

Panel C: Accountability

People are ...	Listened by Local Gvnmt		Treated unequally		Respondents already have ...	Participate to community meeting		Join other to raise an issue	
	Africa	**Madagascar**	**Africa**	**Madagascar**		**Africa**	**Madagascar**	**Africa**	**Madagascar**
Never	36,4	51,6	17,4	12,1	No, would never do this	12,1	22,5	15	25,4
Only sometimes	35,4	30,8	21,2	33,1	No, but would do if had the chance	33,1	46,8	40,2	48,1
Often	16,1	15,3	32,7	38,9	Yes, once or twice	13,9	5,4	12,9	6
Always	6,9	2,1	25	16	Yes, several times	22,8	13,9	17,3	13,6
					Yes, often	17,6	11,4	13,9	6,9

Note: This data displays descriptive statistics on collective action from the Afrobarometer Round 5 2011-13 (Panel A) and Round 6 2014-2015 (Panels B & C. Round 5 & 6 include: Algeria, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Egypt, Ghana, Guinea, Ivory Coast, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Senegal, Sierra Leone, South Africa, Sudan, Swaziland, Tanzania, Togo, Tunisia, Uganda, Zambia, Zimbabwe.

Table 4: Collective Action in Ankarea and Ankivonjy: Descriptive Statistics

	Number of CPR meetings over the last 6 months? (Answer: 3)	For how many you have been cosulted?	For how many did have post-meeting reports?
	% Population	% Population	% Population
Doesn't know	38.71	3.23	6.99
0	3.76	88.17	67.74
1	5.91	4.84	12.9
2	22.58	3.23	9.14
3	18.28	0.54	2.15
4	8.6	.	0.54
5	1.61	.	.
10	0.54	.	.

Note: These table displays descriptive statistics on accountability in Ankarea (n=68) and Ankivonjy (n=119) coming from fieldwork conducted between October and December 2014.

Table 5: Collective Action in Ankarea and Ankivonjy: Principal Components Analysis

Panel A: PCA - Number of meetings?

	Component 1			Component 2			Component 3		
	Coef.	Std. Err.	P	Coef.	Std. Err.	P	Coef.	Std. Err.	P
Number meetings	0.09	0.19	0.635	0.474	0.172	0.006	-0.5	0.38	0.188
Years living here	0.542	0.101	0,000	-0.235	0.205	0.25	0.154	0.234	0.51
Has social fonction	0.384	0.141	0.006	0.321	0.192	0.094	0.215	0.517	0.677
Sex	0.241	0.149	0.106	0.289	0.208	0.165	-0.591	0.353	0.094
Age	0.55	0.073	0,000	-0.067	0.213	0.754	0.161	0.294	0.584
Education	-0.211	0.199	0.289	0.535	0.146	0,000	0.311	0.32	0.332
Number of good owned	0.231	0.179	0.198	0.447	0.175	0.011	0.361	0.508	0.477
Study Site	-0.303	0.127	0.017	0.206	0.197	0.297	0.281	0.522	0.59
Explained variance		0.22			0.18			0.14	

Panel B: PCA - For how many meetings have you been consulted?

	Component 1			Component 2			Component 3		
	Coef.	Std. Err.	P	Coef.	Std. Err.	P	Coef.	Std. Err.	P
Number consulted	0.225	0.184	0.223	0.467	0.149	0.002	-0.3	0.301	0.32
Years living here	0.532	0.1	0	-0.221	0.206	0.285	-0.011	0.251	0.966
Has social fonction	0.384	0.115	0.001	0.175	0.203	0.387	0.514	0.254	0.043
Sex	0.263	0.134	0.05	0.218	0.198	0.27	-0.609	0.301	0.043
Age	0.531	0.084	0	-0.139	0.211	0.509	0.247	0.219	0.258
Education	-0.134	0.231	0.56	0.638	0.093	0	0.089	0.227	0.696
Number of good owned	0.265	0.172	0.123	0.422	0.158	0.008	0.142	0.402	0.724
Study Site	-0.282	0.131	0.031	0.227	0.188	0.227	0.431	0.379	0.255
Explained variance		0.224			0.18			0.13	

Panel C: PCA - For how many have you been informed about taken decisions?

	Component 1			Component 2			Component 3		
	Coef.	Std. Err.	P	Coef.	Std. Err.	P	Coef.	Std. Err.	P
Number reports	0.222	0.179	0.215	0.457	0.156	0.003	-0.226	1.068	0.832
Years living here	0.526	0.104	0	-0.243	0.199	0.223	0.069	0.364	0.85
Has social fonction	0.388	0.12	0.001	0.228	0.193	0.238	0.453	0.396	0.253
Sex	0.262	0.132	0.047	0.209	0.199	0.293	-0.702	0.245	0.004
Age	0.548	0.071	0	-0.069	0.209	0.74	0.191	0.566	0.735
Education	-0.151	0.227	0.506	0.646	0.093	0	0.009	0.322	0.978
Number of good owned	0.24	0.163	0.142	0.379	0.179	0.034	0.152	1.549	0.922
Study Site	-0.273	0.137	0.045	0.264	0.184	0.152	0.432	0.685	0.529
Explained variance		0.224			0.179			0.127	

Note: These table displays results regarding accountability of local leaders for environmental decisions in Ankarea (n=68) and Ankivonjy (n=119). I conducted a Principal Component Analysis to understand the determinants of why locals know or not decisions taken. PCA has been preferred to standard regressions because of the colinearity between regressors. As the sample size is limited (n=181), the inflation of the error term would lead to important difficulty to interpret tests (Type 1 error).

Table 6: The Data

	N	Mean	S.D.	Min	Max
Def	167,745	3.862	19.79	0	1,024
Tree Cover	167,745	422.1	372.6	0	1,156
Pop. Density	167,733	26.58	37.91	0	2,335
Protected Area	164,116	0.226	0.419	0	1
Slope	167,745	5.427	142.9	0	40.04
Elevation	167,745	514.0	840.5	0	2,182
Proximity Town	167,745	1.259	0.815	0	6.455
Proximity Road	167,745	16,505	18,677	143.5	165,529
Proximity River	167,745	271.6	331.6	0	3,550
Risk Theft	232	2.250	1.052	0	4
Fair Local Authorities	232	3.461	0.695	2	4
Fair Trad Authorities	183	3.514	0.710	2	4
Part Rural Orga	232	1.228	1.111	0	3
Type Contract (N=414)					
GCF	266	64			
GELOSE	113	27			
Unidentified	35	9			

Note: These table displays descriptive statistics of the sample use for impact evaluation at the national scale.

Table 7: The Environmental Impact of CPR (1996-2014)

Panel A: National results (N=105,318)

	Standard Treatment			Continuous Treatment			Binary - Officially created only		
	Coeff	*std, Error*	*p*	*Coeff*	*std, Error*	*p*	*Coeff*	*std, Error*	*p*
Tr	0.344	0.275	0.212	0.013	0.117	0.912	-0.034	0.275	0.902
Tr2				0.005	0.008	0.562			
Tree Cover	-0.004	0.001	0.000	0.001	0.000	0.000	-0.004	0.001	0.000
Pop. Density	0.004	0.008	0.589	0.001	0.001	0.229	0.005	0.008	0.576
R2	0.244			0.237			0.237		

Panel B: Eastern Rainforests (N=71,311)

	Standard Treatment			Continuous Treatment			Binary - Officially created only		
	Coeff	*std, Error*	*p*	*Coeff*	*std, Error*	*p*	*Coeff*	*std, Error*	*p*
Tr	0.064	0.095	0.499	0.201	0.069	0.003	-0.475	0.118	0.000
Tr2				-0.013	0.004	0.001			
Tree Cover	-0.005	0.001	0.000	0.001	0.000	0.000	-0.005	0.001	0.000
Pop. Density	-0.013	0.004	0.002	0.001	0.001	0.170	-0.013	0.004	0.001
R2	0.536			0.231			0.342		

Panel C: Southern Spiny Forests (N=15,484)

	Standard Treatment			Continuous Treatment			Binary - Officially created only		
	Coeff	*std, Error*	*p*	*Coeff*	*std, Error*	*p*	*Coeff*	*std, Error*	*p*
Tr	1.032	0.626	0.099	0.076	0.085	0.369	1.012	0.606	0.095
Tr2				0.000	0.006	0.954			
Tree Cover	-0.003	0.001	0.005	0.001	0.000	0.002	-0.003	0.001	0.006
Pop. Density	0.113	0.046	0.014	0.047	0.031	0.131	0.112	0.046	0.015
R2	0.536			0.281			0.535		

Panel D: Western Dry Forests (N=18,523)

	Standard Treatment			Continuous Treatment			Binary - Officially created only		
	Coeff	*std, Error*	*p*	*Coeff*	*std, Error*	*p*	*Coeff*	*std, Error*	*p*
Tr	-0.555	0.371	0.135	0.030	0.094	0.751	-0.590	0.372	0.113
Tr2				0.011	0.007	0.107			
Tree Cover	-0.004	0.000	0.000	0.001	0.000	0.017	-0.004	0.000	0.000
Pop. Density	-0.008	0.026	0.761	-0.014	0.020	0.484	-0.008	0.026	0.773
R2	0.330			0.116			0.331		

Note: This table presents the causal impact of the establishment of *VOI* on annual deforestation between 1990 and 2014. The model is estimated using a Pseudo-Poisson Maximum Likelihood with fixed effects for each observation (a 1km x 1km grid cell). Standard errors are clustered within each *VOI* to account for spatial correlation. I present results at a national scale and within each ecoregion as each one presents different ecological dynamics which necessitates different extraction strategies.

Table 8: The Impact of VOI creation - Three levels model estimates

	Impact National			South			East			West		
	Coeff	*std, Error*	*p*	*Coeff*	*std, Error*	*p*	*Coeff*	*std, Error*	*p*	*Coeff*	*std, Error*	*p*
Fixed Parts												
$TrVOI$	0,519	0,01	**<,001**	0,863	0,01	**<,001**	0,02	0,01	**0,004**	-0,777	0,02	**<,001**
Cell level variables - $w_{i,j,k,t}$												
TreeCov_c	-0,598	0	**<,001**	-0,511	0	**<,001**	-0,755	0	**<,001**	-0,545	0	**<,001**
TreeCov	0,122	0	**<,001**	0,131	0	**<,001**	0,113	0	**<,001**	0,157	0	**<,001**
DensPop_c	0,02	0	**<,001**	0,03	0	**<,001**	-0,01	0	**<,001**	0,03	0	**<,001**
DensPop	0	0	**<,001**	-0,01	0	**<,001**	0	0	**<,001**	-0,041	0	**<,001**
Slope	0,02	0,01	**<,001**	-0,357	0,02	**<,001**	0,039	0,01	**<,001**	0,457	0,06	**<,001**
Elev	-0,151	0	**<,001**	0,191	0,01	**<,001**	-0,163	0	**<,001**	0,285	0,02	**<,001**
ProxRiv	0	0	**0,001**	0	0	**0,002**	0	0	**<,001**	0	0	0,263
ProxRoad	0,113	0,01	**<,001**	0,565	0,03	**<,001**	-0,062	0,01	**<,001**	0,385	0,03	**<,001**
ProxTown	0,113	0,01	**<,001**	-0,139	0,02	**<,001**	0,02	0,01	0,13	0,399	0,02	**<,001**
VOI level variables - $x_{j,k,t}$												
Type of contract (Base: Conservation)												
Sustainable Use	-0,083	0,12	0,478	1,437	0,08	**<,001**	-0,315	0,13	**0,016**	1,466	0,41	**<,001**
Unidentified	-0,248	0,21	0,231	1,67	2,01	0,407	-0,528	0,22	**0,019**	-1,347	0,84	0,109
With a Protected Area	-0,211	0,01	**<,001**	-0,174	0,01	**<,001**	-0,315	0,01	**<,001**	0,307	0,03	**<,001**
Municipality level variables - z_k												
Risk Theft (Base: Low -0)												
1	0,507	0,03	**<,001**	3,285	3,36	0,329	0,451	0,03	**<,001**	1,515	0,72	**0,034**
2	-0,073	0,02	**0,002**	0,82	3,36	0,807	0,077	0,03	**0,003**	0,148	0,51	0,775
3	-0,062	0,02	**0,004**	2,411	3,93	0,54	-0,03	0,03	0,339	0,464	0,55	0,397
4	0,174	0,03	**<,001**	1,974	0,11	**<,001**	-0,562	0,07	**<,001**	1,197	0,53	**0,024**
Fair Traditional Authorities (Base: Low)												
Moderate	-0,4	0,02	**<,001**	3,198	3,74	0,393	-0,301	0,03	**<,001**	-0,288	0,28	0,306
High	-0,211	0,02	**<,001**	0,577	5,65	0,918	-0,139	0,02	**<,001**	-0,916	0,33	**0,005**
Part. Rural Orga (Base: Low)	0,215	0,01	**<,001**	1,599	3,93	0,684	0,174	0,02	**<,001**	0,542	0,23	**0,019**
Moderate	0,122	0,02	**<,001**	0,536	0,8	0,503	0,058	0,02	**<,001**	0,718	0,32	**0,024**
High	0,039	0,02	0,068	-2,526	1,86	0,174	0,068	0,03	**0,011**	0,432	0,22	**0,046**
FoodShort	-0,462	0,02	**<,001**	1,896	0,09	**<,001**	-0,462	0,03	**<,001**	-2,408	0,16	**<,001**
(Intercept)	1,942	0,14	**<,001**	-5,584	10,33	0,589	2,408	0,16	**<,001**	-1,609	0,81	**0,049**
Manager FE		Yes			Yes			Yes			Yes	
Year FE		Yes			Yes			Yes			Yes	
Random Parts												
NVOI		414			32			349			63	
NComm		222			20			177			43	
ICCVOI		0,185			0,467			0,173			0,086	
ICCComm		0,232			0			0,243			0,261	
Observations		85023			15413			61141			7461	
AIC		1502614,595			348823,03			777201,194			150777,33	

Note: This table presents the causal impact of the establishment of *VOI* on annual deforestation between 1990 and 2014. I explicit location effects through a 3-levels model that accounts for the spatial structure of the data: the outcome variable is measured within a 1km x 1km cell itself located a *VOI* located within a municipality. Standard error is broken in 3 parts at each level. I present pooled results at a national scale then results split for each ecoregions. Each ecoregion presents different ecological dynamics which necessitates different extraction strategies.

Table 9: Manager type

	National			East			South			West		
	Coeff	*std, Error*	*p*	*Coeff*	*std, Error*	*p*	*Coeff*	*std, Error*	*p*	*Coeff*	*std, Error*	*p*
Fixed Parts:												
Treatment	1,075	0,02	**<,001**	0,14	0,02	**<,001**	-0,868	0,1	**<,001**	0,02	0,07	0,779
Manager type (Base: Malagasy State and Public Agencies):												
Others	-0,223	0,14	0,114	-0,994	0,19	**<,001**	-1,139	1,5	0,447	-0,371	0,69	0,595
Private companies	-0,942	0,28	**0,001**	-1,661	0,49	**0,001**	-3,219	2,13	0,144	0,863	0,77	0,26
International Conservation NGOs	0,113	0,08	0,16	-0,635	0,1	**<,001**	-1,273	1,22	0,298	0,588	0,52	0,262
Malagasy NGOs	0,095	0,25	0,7	-0,713	0,3	**0,018**				3,127	0,61	**<,001**
International Development NGOs	-0,994	0,18	**<,001**	-1,561	0,22	**<,001**	2,71	1,45	0,061	1,308	0,63	**0,039**
Local Communities	-0,734	0,38	0,052	-0,654	0,53	0,213				-7,208	125,08	0,954
Tr x Participation (Base: Tr x Malagasy State and Pub Agencies):												
Tr x Others	0,285	0,02	**<,001**	0,399	0,02	**<,001**	4,93	0,15	**<,001**	0,693	0,13	**<,001**
Tr x Private Comp	-0,654	0,03	**<,001**	-0,261	0,07	**<,001**	1,754	0,11	**<,001**	-0,58	0,09	**<,001**
Tr x Inter Cons NGO	-0,821	0,01	**<,001**	-0,211	0,02	**<,001**	1,746	0,1	**<,001**	-0,128	0,08	0,128
Tr x Malagasy NGO	-0,174	0,02	**<,001**	-0,083	0,02	**<,001**				-1,204	0,07	**<,001**
Tr x Inter Dev NGOs	-0,994	0,02	**<,001**	-0,821	0,03	**<,001**	1,497	0,13	**<,001**	0,122	0,08	0,154
Tr x Local Comm	-0,844	0,04	**<,001**	-0,654	0,04	**<,001**				12,576	125,07	0,92
Random Part:												
NVOI	414			349			32			63		
NComm	222			177			20			43		
ICCVOI	0,187			0,175			0,462			0,091		
ICCComm	0,234			0,246			0			0,279		
Observations	85023			61141			15413			7461		
AIC	1489608,149			774167,554			347803,912			148933,517		

Note: This table explores the heterogeneity of the impact regarding the type of entity that has helped the community to establish the *VOI* with a 3-levels model. Multi-levels models account for the spatial structure of the data: the outcome variable is measured within a 1km x 1km cell itself located a *VOI* located within a municipality. Standard error is broken in 3 parts at each level. I present pooled results at a national scale then results split for each ecoregions. Each ecoregion presents different ecological dynamics which necessitates different extraction strategies. Additional control variables are the ones reported in Table 8. 37 actors have helped to establish *VOI*. I have reclassified them within 7 groups. See the Appendix for the classification.

Table 10: Type of Contract

	National			East			South			West		
	Coeff	*std, Error*	*p*	*Coeff*	*std, Error*	*p*	*Coeff*	*std, Error*	*p*	*Coeff*	*std, Error*	*p*
Fixed Parts:												
Treatment	0.708	0.01	**<.001**	-0.01	0.01	0.126	0.892	0.03	**<.001**	-1.05	0.02	**<.001**
Type of contract (Base: Conservation):												
Sustainable Use	0.365	0.12	**0.002**	-0.223	0.13	**0.073**	1.44	0.08	**<.001**	0.908	0.42	**0.03**
Unidentified	-0.693	0.21	**0.001**	-0.844	0.22	**<.001**	-7.313	132.11	0.956	-1.273	0.87	0.143
Tr x Type (Base: Tr x Conservation):												
Tr x Sustainble Use	-0.799	0.01	**<.001**	-0.117	0.01	**<.001**	-0.03	0.03	0.331	0.912	0.03	**<.001**
Tr x Unidentified	0.652	0.01	**<.001**	0.495	0.01	**<.001**	9.221	132.1	0.944	-0.261	0.76	0.735
Random Part:												
NVOI	414			349			32			63		
NComm	222			177			20			43		
ICCVOI	0.185			0.173			0.468			0.089		
ICCComm	0.232			0.242			0			0.259		
Observations	85023			61141			15413			7461		
AIC	1487689.932			775843.408			348825.048			149737.903		

Note: This table explores the heterogeneity of the impact regarding the type of contract has been signed for the *VOI* with a 3-levels model. Multi-levels models account for the spatial structure of the data: the outcome variable is measured within a 1km x 1km cell itself located a *VOI* located within a municipality. Standard error is broken in 3 parts at each level. I present pooled results at a national scale then results split for each ecoregions. Each ecoregion presents different ecological dynamics which necessitates different extraction strategies. Additional control variables are the ones reported in Table 8. 2 types of contracts can be signed: GELOSE which allows for a commercial sustainable extraction of timber and GCG for which commercial extraction is forbidden in most cases.

Table 11: Risk Theft

	National			East			South			West		
	Coeff	*std. Error*	*p*	*Coeff*	*std. Error*	*p*	*Coeff*	*std. Error*	*p*	*Coeff*	*std. Error*	*p*
Fixed Parts:												
Treatment	0.732	0.01	**<.001**	0.732	0.01	**<.001**	0.673	0.08	**<.001**	0.519	0.2	**0.009**
Risk Theft (Base: Low - 0):												
1	0.525	0.03	**<.001**	0.525	0.03	**<.001**				2.416	0.85	**0.005**
2	-0.329	0.02	**<.001**	-0.329	0.02	**<.001**	0.693	0.81	0.393	0.293	0.62	0.633
3	0.104	0.02	**<.001**	0.104	0.02	**<.001**	2.162	0.85	**0.011**	1.421	0.65	**0.029**
4	0.9	0.03	**<.001**	0.9	0.03	**<.001**	1.975	0.11	**<.001**	1.144	0.63	0.069
Tr x Risk Theft (Base: Tr x 0):												
Tr x 1	0.049	0.02	**0.014**	0.086	0.02	**<.001**				-1.273	0.2	**<.001**
Tr x 2	0.329	0.02	**<.001**	0.174	0.02	**<.001**	0.174	0.09	0.064	-0.342	0.2	0.083
Tr x 3	-0.386	0.01	**<.001**	-0.083	0.02	**<.001**	0.501	0.08	**<.001**	-2.996	0.2	**<.001**
Tr x 4	-1.238	0.02	**<.001**	-0.734	0.03	**<.001**	-0.236	0.08	**0.006**	0.315	0.2	0.125
Random Part:												
NVOI		414			349			32			63	
NComm		222			177			20			43	
ICCVOI		0.184			0.173			0.468			0.074	
ICCComm		0.228			0.243			0.355				
Observations		85023			61141			15413			7461	
AIC		1483470.133			775778.191			345996.659			142649.609	

Note: This table explores the heterogeneity of the impact regarding the differences in general property right enforcement in the municipality with a 3-levels model. Multi-levels models account for the spatial structure of the data: the outcome variable is measured within a 1km x 1km cell itself located a *VOI* located within a municipality. Standard error is broken in 3 parts at each level.

Table 12: Fair Traditional Authorities

	National			East			South			West		
	Coeff	*std. Error*	*p*	*Coeff*	*std. Error*	*p*	*Coeff*	*std. Error*	*p*	*Coeff*	*std. Error*	*p*
Fixed Parts:												
Treatment	0.351	0.01	**<.001**	-0.083	0.02	**<.001**	0.863	0.01	**<.001**	-1.47	0.03	**<.001**
FairTrad Auth (Base: Low):												
Moderate	-0.799	0.03	**<.001**	-0.478	0.03	**<.001**	3.202	2.64	0.226	-0.713	0.29	**0.015**
High	-0.139	0.02	**<.001**	-0.117	0.03	**<.001**				-1.609	0.34	**<.001**
Tr x Fair Trad Auth (Base: Tr x Low):												
Tr x Moderate	0.896	0.01	**<.001**	0.372	0.02	**<.001**	-0.01	0.12	0.929	0.975	0.05	**<.001**
Tr x High	-0.128	0.01	**<.001**	-0.073	0.02	**<.001**				1.33	0.03	**<.001**
Random Part:												
NVOI	414			349			32			63		
NComm	222			177			20			43		
ICCVOI	0.192			0.175			0.467			0.093		
ICCComm	0.231			0.242			0			0.268		
Observations	85023			61141			15413			7461		
AIC	1484536.815			774585.602			348825.022			148230.606		

Note: This table explores the heterogeneity of the impact regarding the level of trust accorded to traditional authorities in the municipality with a 3-levels model. Multi-levels models account for the spatial structure of the data: the outcome variable is measured within a 1km x 1km cell itself located a *VOI* located within a municipality. Standard error is broken in 3 parts at each level.

Table 13: Fair Local Authorities

	National			East			South			West		
	Coeff	*std. Error*	*p*	*Coeff*	*std. Error*	*p*	*Coeff*	*std. Error*	*p*	*Coeff*	*std. Error*	*p*
Fixed Parts:												
Treatment	-0.301	0.01	**<.001**	0.412	0.02	**<.001**	0.815	0.02	**<.001**	-1.772	0.02	**<.001**
Fair Local Auth (Base: Low):												
Moderate	0.49	0.01	**<.001**	0.365	0.03	**<.001**	-0.58	0.06	**<.001**	-2.303	0.08	**<.001**
High	0.56	0.01	**<.001**	0.344	0.03	**<.001**	-0.635	0.09	**<.001**	-2.526	0.08	**<.001**
Tr x Fair Local Auth (Base: Tr x Low):												
Tr x Moderate	2.69	0.01	**<.001**	-0.329	0.02	**<.001**	0.916	0.02	**<.001**	1.601	0.03	**<.001**
Tr x High	1.72	0.01	**<.001**	-0.462	0.02	**<.001**	-0.342	0.02	**<.001**	1.253	0.02	**<.001**
Random Part:												
NVOI	491			389			33			111		
NComm	266			194			21			72		
ICCVOI	0.182			0.176			0.112			0.133		
ICCComm	0.265			0.278			0.468			0.204		
Observations	104966			70196			15427			18321		
AIC	1861503.485			875755.398			343774.814			392045.768		

Note: This table explores the heterogeneity of the impact regarding the level of trust accorded to local authorities in the municipality with a 3-levels model. Multi-levels models account for the spatial structure of the data: the outcome variable is measured within a 1km x 1km cell itself located a *VOI* located within a municipality. Standard error is broken in 3 parts at each level.

Table 14: Participation in Rural Organizations

	National			East			South			West		
	Coeff	*std. Error*	*p*	*Coeff*	*std. Error*	*p*	*Coeff*	*std. Error*	*p*	*Coeff*	*std. Error*	*p*
Fixed Parts:												
Treatment	0.392	0.01	**<.001**	-0.186	0.01	**<.001**	1.16	0.01	**<.001**	0.02	0.09	0.812
Part. Rural Orgas (Base: Really low):												
Low	0.372	0.01	**<.001**	0.122	0.02	**<.001**	2.04	1.07	0.057	1.179	0.24	**<.001**
Moderate	-0.545	0.02	**<.001**	-0.342	0.02	**<.001**	0.892	0.55	0.105	0.336	0.33	0.311
High	-0.386	0.03	**<.001**	-0.186	0.03	**<.001**	-2.303	1.62	0.147	0.798	0.23	**0.001**
Tr x Participation (Base: Tr x Really low):												
Tr x Low	-0.4	0.01	**<.001**	0.104	0.01	**<.001**	-0.734	0.01	**<.001**	-1.079	0.09	**<.001**
Tr x Moderate	1.095	0.01	**<.001**	0.626	0.01	**<.001**	0.039	0.18	0.804	0.47	0.1	**<.001**
Tr x High	0.718	0.01	**<.001**	0.47	0.01	**<.001**	0.307	0.08	**<.001**	-0.4	0.09	**<.001**
Random Part:												
NVOI	414			349			32			63		
NComm	222			177			20			43		
ICCVOI	0.184			0.172			0.467			0.1		
ICCComm	0.232			0.242			0			0.249		
Observations	85023			61141			15413			7461		
AIC	1478442.948			773215.044			345864.319			149188.815		

Note: This table explores the heterogeneity of the impact regarding the level of participation in rural organizations in the municipality with a 3-levels model. Multi-levels models account for the spatial structure of the data: the outcome variable is measured within a 1km x 1km cell itself located a *VOI* located within a municipality. Standard error is broken in 3 parts at each level.

Table 15: Trust Game and Voluntary Contribution Mechanism: Sample Characteristics

Variables	N	Median	Mean	SD
Age	228	35	37.539	14.94
Education	226	5	5.137	3.277
Live in the area for ... (year)	228	30	21.564	10.445
Number of goods	232	1	1.151	1.064
Sexe				
F	131			
H	97			
Study site				
Vohibola	128			
Vohimana	104			
Integration:				
Not a member of associations - no relatives are members (0)	50			
Not a member, relatives are simple members (1)	21			
Not a member, relatives are decision making members (2)	62			
Member of a local association	99			

Note: This table presents the sample characteristics from the experimental approach in Vohibola and Vohimana.

Table 16: Trust Game and Voluntary Contribution Mechanism: Results

		All		
	Outcome	N	mean	sd
Trust Game	Fraction sent	215	0.551	0.226
	Fraction returned	215	0.725	0.43
VCM	Amount shared	212	165.566	127.659
	Fraction shared	212	0.103	0.093

		Cash			Commodity			
		N	mean	sd	N	mean	sd	Mean difference
Trust Game	Fraction sent	174	0.543	0.218	41	0.585	0.258	-0.042
	Fraction returned	174	0.689	0.397	41	0.878	0.524	-0.189***
VCM	Amount shared	188	165.957	129.626	24	162.5	113.492	3.457
	Fraction shared	188	0.098	0.092	24	0.14	0.096	-0.042**

		Vohibola			Vohimana			
		N	mean	sd	N	mean	sd	Mean difference
Trust Game	Fraction sent	128	0.529	0.239	87	0.584	0.203	-0.055**
	Fraction returned	128	0.669	0.405	87	0.808	0.453	-0.139***
VCM	Amount shared	123	156.098	105.695	89	178.652	152.608	-22.554
	Fraction shared	123	0.09	0.072	89	0.12	0.115	-0.03**

		Session 1			Session 2			
		N	mean	sd	N	mean	sd	Mean difference
Trust Game	Fraction sent	116	0.552	0.225	99	0.551	0.229	0.001
	Fraction returned	116	0.758	0.434	99	0.687	0.424	0.071*
VCM	Amount shared	11	209.091	197.386	95	160.526	116.699	93.211*
	Fraction shared	11	0.185	0.155	95	0.093	0.079	0.106***

Note: This table presents the mean results of our trust game and of our voluntary contribution mechanism. We decompose the results regarding the chosen payment vehicle (Panel 2), the study site (Panel 3) and the session played (Panel 3). For these decomposition, we test for mean differences using a student mean comparison test. ***: p<0.01, **: p<0.05, *: p<0.1

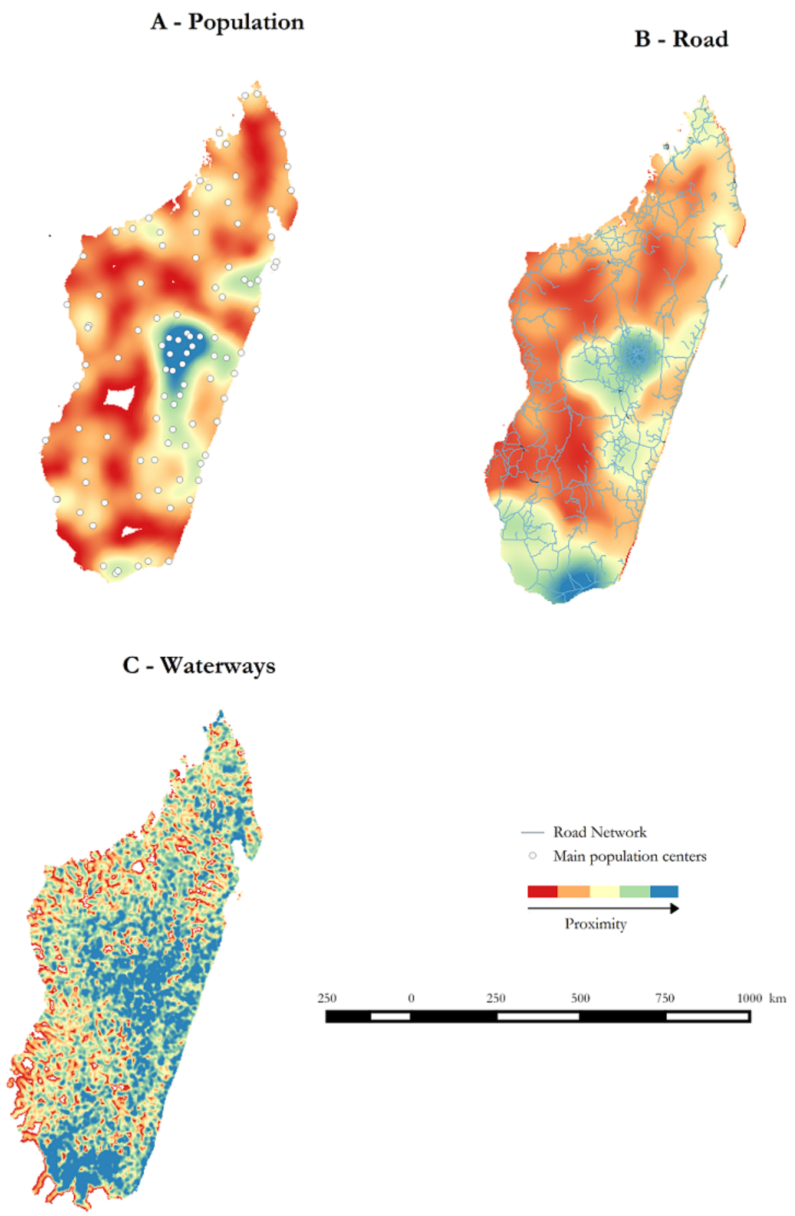
Table 17: Trust Game and Voluntary Contribution Mechanism: Econometric Analysis

	Trust Game				VCM	
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	First move	Second move	Second move if Game A	Second move if Game B	Has Given	Share Given
Integration (Base=3, members)						
0	-0.051	0.054	0.036	-0.029	0.051	0.132***
	(0.046)	(0.057)	(0.109)	(0.053)	(0.084)	(0.042)
1	-0.067	-0.027	0.058	-0.264**	-0.027	0.093
	(0.058)	(0.063)	(0.100)	(0.100)	(0.126)	(0.105)
2	0.016	0.041	-0.019	0.015	-0.112	-0.071
	(0.027)	(0.037)	(0.108)	(0.037)	(0.119)	(0.050)
Other member association (Base= No)	0.002	-0.000	-0.050	-0.078		
	(0.032)	(0.049)	(0.061)	(0.042)		
Age	0.006**	0.011	0.004	0.025**	0.025*	0.031***
	(0.002)	(0.006)	(0.010)	(0.006)	(0.015)	(0.002)
Age^2	-0.000*	-0.000	-0.000	-0.000***	-0.000	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Education	0.000	0.008	0.003	-0.005	-0.029	-0.028***
	(0.005)	(0.005)	(0.009)	(0.008)	(0.018)	(0.007)
Number of good owned	0.044*	0.010	0.014	0.059	0.093	0.126***
	(0.020)	(0.019)	(0.025)	(0.048)	(0.061)	(0.043)
Sex (Base = W)	0.089*	-0.020	-0.040	0.057	-0.052	-0.054
	(0.038)	(0.036)	(0.023)	(0.034)	(0.114)	(0.121)
Sex other (Base=W)	-0.029	-0.018	-0.025	-0.033		
	(0.031)	(0.049)	(0.096)	(0.056)		
Live in the area for	-0.001	0.001	0.003	-0.001	-0.014***	-0.014***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.004)	(0.002)
Other live in the area for	-0.003**	0.001	0.003	-0.003		
	(0.001)	(0.002)	(0.002)	(0.003)		
Payment Vehicle	0.031***	0.096	0.108*	0.053		
	(0.007)	(0.061)	(0.047)	(0.098)		
Site (Base=Vohibola)	0.011	0.008	-0.014	0.036	0.067	0.090*
	(0.040)	(0.086)	(0.081)	(0.079)	(0.149)	(0.053)
Game Round (Base = Round 1)	0.012					
	(0.012)					
Player 1 gave		1.296***	1.213***	1.444***		
		(0.150)	(0.195)	(0.168)		
Player 2 received in round A				0.066		
				(0.040)		
Total Gains					0.000*	-0.000***
					(0.000)	(0.000)
Constant	0.459***	-0.330	-0.120	-0.543**	4.612***	-2.027***
	(0.085)	(0.202)	(0.288)	(0.190)	(0.370)	(0.215)
Observations	209	417	111	98	208	208
R-squared	0.146	0.581	0.499	0.744		

Note: Cluster (Scale = village) standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. For the trust game, OLS estimation. For the VCM game, MLE estimation assuming a Poisson distribution. There is only 208 on 232 participants that have played the VCM game as 24 only played with the agricultural commodity.

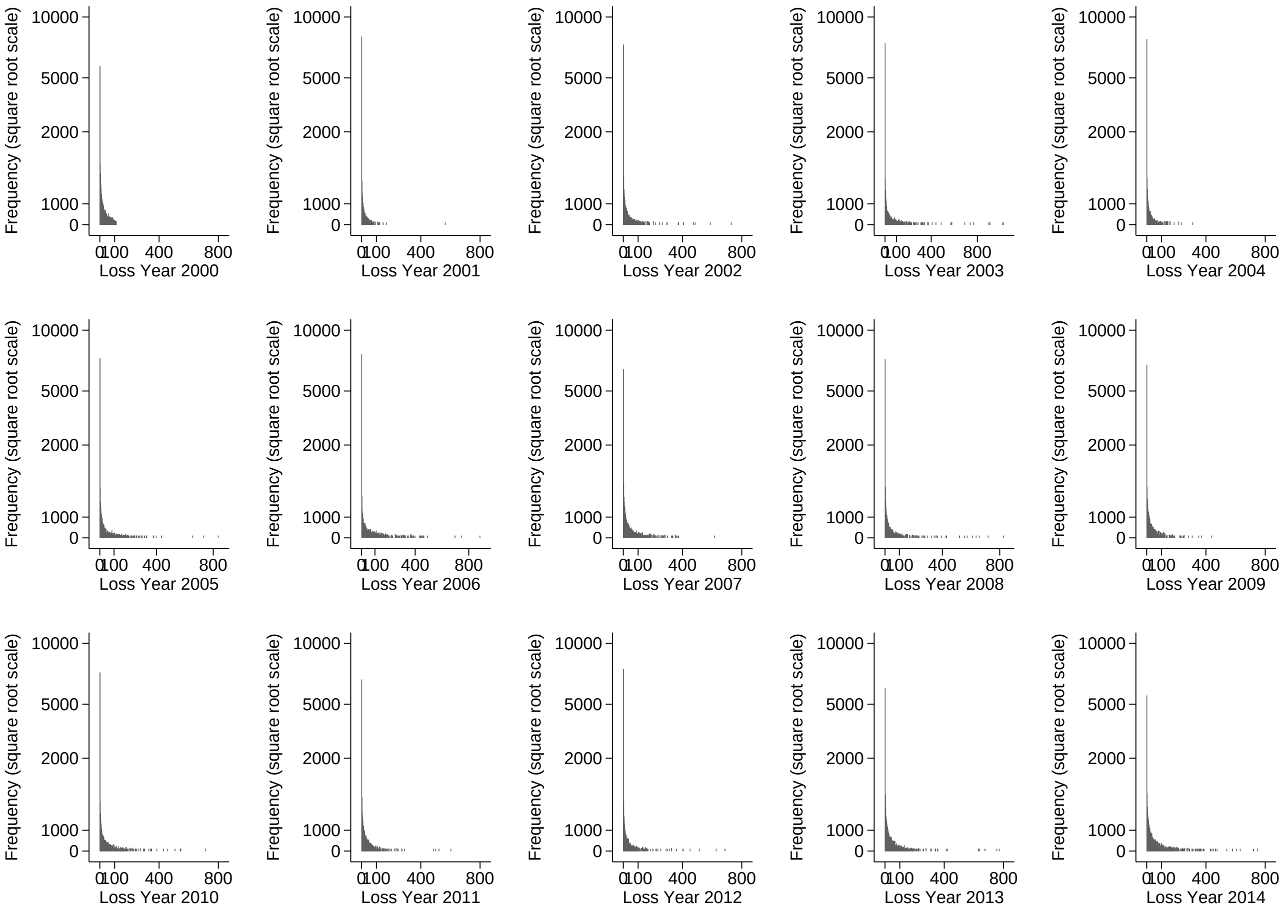
12 Appendix

Figure 10: Covariates construction: Heat map



Note: I have constructed Heat maps with QGIS 2.8 to get a better approximation than a simple euclidean distance to forest edge.

Figure 11: Distribution of the outcome variable - annual details



Note: This figure breaks the distribution of my outcome variable $Def(i,t)$ presented in Figure 5 for every year of the study period. As deforestation remains a rare event, the distribution is particularly left skewed. A survival analysis as a Poisson or Quasi-Poisson models seems appropriated for this study.