



Impacts of Community Forest Management on human economic well-being across Madagascar

Rasolofoson, Ranaivo; Ferraro, Paul J.; Ruta, Giovanni; Rasamoelina, Maminaiaina S.; Randriankolona, Patrick L.; Larsen, Helle O.; Jones, Julia P.G.

Conservation Letters

DOI:

[10.1111/conl.12272](https://doi.org/10.1111/conl.12272)

Published: 01/05/2017

Peer reviewed version

[Cyswllt i'r cyhoeddiad / Link to publication](#)

Dyfyniad o'r fersiwn a gyhoeddwyd / Citation for published version (APA):

Rasolofoson, R., Ferraro, P. J., Ruta, G., Rasamoelina, M. S., Randriankolona, P. L., Larsen, H. O., & Jones, J. P. G. (2017). Impacts of Community Forest Management on human economic well-being across Madagascar. *Conservation Letters*, 10(3), 346-353. <https://doi.org/10.1111/conl.12272>

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1 **Title:** Impacts of Community Forest Management on human economic well-being across Madagascar

2 **Running title:** Madagascar community forestry welfare impacts

3 **Authors:** Ranaivo A. Rasolofoson^{1,2,*}, Paul J. Ferraro³, Giovanni Ruta⁴, Maminaiaina S. Rasamoelina⁴,
4 Patrick L. Randriankolona⁴, Helle O. Larsen¹, Julia P. G. Jones²

5 ¹Food and Resource Economics, University of Copenhagen, Rolighedsvej 25, 1958 Frederiksberg C,
6 Denmark

7 ²School of Environment, Natural Resources and Geography, Bangor University, UK

8 ³Carey Business School and Department of Geography and Environmental Engineering, Whiting
9 School of Engineering, Johns Hopkins University, USA

10 ⁴The World Bank, Antananarivo Country Office, Madagascar

11 *Corresponding author, e-mail: rrasolof@gmail.com, Telephone: +358 46 5715876

12 **Keywords:** Community Forest Management, effectiveness, falsification test, impact evaluation,
13 Madagascar, matching, placebo test, poverty, REDD+, welfare

14 **Type of article:** Letter

15 **Number of words in abstract:** 141

16 **Number of words in the main text:** 2,994

17 **Number of references:** 35

18 **Number of tables and figures:** 5

19 **Abstract**

20 Community Forest Management (CFM) devolves forest management to local communities to achieve
21 conservation and human well-being goals. Yet the evidence for CFM's impacts is mixed and difficult
22 to interpret because of inadequate attention to rival explanations for the observed empirical patterns. In
23 a national-scale analysis in Madagascar that carefully considers these rival explanations, we estimate
24 CFM impacts on household living standards, as measured by per capita consumption expenditures. The
25 estimated impact is positive, but small and not statistically different from zero. However, we can
26 statistically reject substantial negative impacts (which others have suggested may exist). The estimated
27 impacts vary conditional on household education and proximity to forests: they are more positive and
28 statistically significant for households closer to forest and with more education. To help improve CFM
29 design, scholars and practitioners should anticipate heterogeneity in CFM impacts and work to better
30 characterize them, theoretically and empirically.

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38 **Introduction**

39 Community Forest Management (CFM) is one of the most widespread conservation approaches in
40 developing countries. It can also play an important role in the climate mitigation mechanism Reducing
41 Emissions from Deforestation and Degradation, REDD+ (Newton et al. 2015). CFM advocates suggest
42 it can avoid the negative impacts of forest protection on the well-being of local communities (Behera
43 2009). However, evidence for the impact of CFM on human well-being is mixed, with studies reporting
44 both negative and positive impacts (Bandyopadhyay & Tembo 2010; Ameha et al. 2014; Gelo & Koch
45 2014), and many studies having major design limitations (Bowler et al. 2012). Therefore, well-
46 designed studies evaluating the impacts of CFM on human well-being are needed to better direct future
47 efforts.

48 Quantifying the impacts of conservation interventions is challenging (Baylis et al. 2016). One
49 challenge is that conservation interventions are rarely randomly assigned. Characteristics that influence
50 intervention assignment may also affect outcomes and thus can confound impact estimates (Ferraro &
51 Pattanayak 2006). In studies of CFM impacts on well-being, these confounders are rarely identified and
52 controlled (Engel et al. 2013).

53 When confounders are observable, matching designs can address the non-random assignment of
54 interventions (Ferraro & Pattanayak 2006). Matching involves selecting comparison units that are
55 observably similar to intervention units in terms of pre-intervention confounding characteristics (Joppa
56 & Pfaff 2011). Ideally, matching designs have outcome baseline data gathered before intervention to
57 control for initial conditions that may confound measures of effectiveness (Ferraro & Hanauer 2014).
58 Unfortunately, such data rarely exist in CFM impact evaluation (Bowler et al. 2012). To indirectly

59 assess if missing baselines are a problem, Ferraro et al. (2015) propose a falsification or placebo test. In
60 such a test, the researcher postulates a hypothesis that is true if the empirical design does not suffer
61 from bias because of missing baselines (Ferraro & Hanauer 2014). If the hypothesis cannot be rejected,
62 the researcher can be more confident in a design's ability to estimate impacts without bias. To our
63 knowledge, no CFM impact studies have used a placebo test to address the missing baseline issue.

64 Another major challenge in conservation impact evaluation is that different groups within the same
65 community could experience impacts differently (Milner-Gulland et al. 2014). Consideration of
66 heterogeneous impacts on different groups can inform policy aiming to equitably distribute
67 conservation benefits.

68 Madagascar is world renowned for the biodiversity of its forests. It was also one of the first nations in
69 the southern hemisphere to put in place a legal CFM framework (Andriantsilavo et al. 2006), which
70 aims to conserve its highly threatened forests while providing benefits to local communities (Aubert et
71 al. 2013). Only a few case studies (Hockley & Andriamarivololona 2007; Toillier et al. 2011;
72 Ramamonjisoa & Rabemananjara 2012) have empirically investigated the impacts of CFM on human
73 well-being. None of these studies were at a national scale and none adequately controlled for
74 confounding variables.

75 We investigate the impacts of CFM in Madagascar on household living standards, as measured by
76 household consumption expenditures. CFM could produce positive and negative impacts on household
77 living standards. Negative impacts could result from benefits forgone (due to restrictions on use of
78 forest resources) or the costs of forest management (e.g. patrolling). Positive impacts could result from
79 improved forest management, which could enhance forest productivity and ecosystem services

80 important for livelihoods. CFM communities can also benefit from developing ecotourism or through
81 external support (Hockley & Andriamarivololona 2007). For example, Madagascar's new protected
82 areas, which include most CFM sites, received up to US\$ 10.5 million of external support in 2011
83 alone (Carret 2013).

84 These impacts may be heterogeneous. Previous studies suggest that that more educated households
85 capture more CFM benefits (Pollini & Lassoie 2011) and that households within or nearer forests are
86 more politically and socio-economically disadvantaged and more negatively affected by conservation
87 interventions (Ratsimbazafy et al. 2011). Thus we hypothesize that positive and negative effects will
88 vary as a function of household education level and proximity to forest.

89 **Methods**

90 *Study areas*

91 Our study covers all of Madagascar's land area. We define CFM as natural forests, with clearly defined
92 boundaries, managed by a local forest management group that entered into a signed management
93 agreement with the state forest department under the 1996 or 2001 Malagasy CFM legislation. Our data
94 report 1,019 CFM sites in 2014, covering about 15% of the nation's natural forests (Figure 1A, Table
95 S1 for sources of data).

96 *Unit of analysis*

97 Our unit of analysis is the household. CFM households are defined as households within a commune
98 that has 10% or more of its area covered by CFM; we also performed a sensitivity test using a threshold
99 of 25%. Non-CFM households are households within a commune that has less than 1 % of its area

100 covered by CFM. Households within urban communes, communes that have between 1% and 10% of
101 their area covered by CFM, or communes that have less than 5% of their areas forested were excluded
102 (Figure 1B). More detail concerning our justification for choosing the percent CFM cover of a
103 commune to define the unit of analysis is in Text S1.

104 *Well-being outcome variable*

105 The outcome variable is annual household per capita consumption expenditure. Household
106 consumption has been the core of living standard surveys in many developing countries (Beegle et al.
107 2012) and living standard is widely recognized as an important component of well-being (Bérenger &
108 Verdier-Chouchane 2007). While we acknowledge that “well-being” is multi-dimensional (King et al.
109 2014), data on other dimensions of well-being at an appropriate scale are unavailable.

110 We pooled cross sectional data on household consumption from the 2010 and 2012 national household
111 surveys undertaken by Madagascar statistical agency (INSTAT). The two surveys, carried out on
112 different nationally representative samples, provide comparable data covering food and non-food
113 consumption, spending on durable goods and housing from 29,380 randomly sampled households.
114 These consumption items were aggregated following Deaton & Zaidi (2002). We adjusted for regional
115 and temporal differences in prices and converted to US dollar using the World Bank 2005 purchasing
116 power parity conversion factor.

117 We estimated the average impact of CFM on consumption for the CFM households, also known as the
118 Average Treatment effect on the Treated (ATT). Because CFM restricts some forest use and past
119 studies suggest that CFM has had negative impacts on human well-being in Madagascar (Hockley &
120 Andriamarovololona 2007; Toillier et al. 2011; Ramamonjisoa & Rabemananjara 2012), we explicitly

121 tested whether we can reject the hypothesis that CFM has caused a moderate decline in per capita
122 consumption, which we define as a decline of a quarter standard deviation (of the outcome variable for
123 the matched comparison units).

124 To allow at least three years of impact, we only evaluated CFM established before 2007 (inclusive)
125 with the 2010 household data. For the 2012 household data, only CFM established before 2009
126 (inclusive) was considered. The numbers of sampled CFM and non-CFM households are shown in
127 Table 1.

128 *Matching and post-matching analyses*

129 Matching pairs CFM households with non-CFM households that are similar in terms of potentially
130 confounding characteristics at baseline. If one assumes that, after matching, the only systematic
131 difference between CFM and non-CFM households is the presence of CFM, the difference in
132 consumption in CFM and matched non-CFM households is an unbiased estimator of the ATT; in other
133 words, one can assume that the expected non-CFM household consumption equals the expected
134 counterfactual consumption in the CMF households had there been no CFM.

135 We executed one-to-one matching with replacement with a genetic matching algorithm (see
136 “matching” package in R; Sekhon 2011). To adjust for remaining post-matching covariate imbalance,
137 we performed weighted mixed-effects linear regression, with commune as random intercept, on the
138 matched dataset. Studies show that combination of matching and regression yield more accurate
139 estimate than either of them alone (Ferraro & Miranda 2014).

140 *Confounding characteristics*

141 Previous research has shown that site level characteristics, like human pressure and access (Table 2),
142 can affect both assignment of forests to CFM (Rasolofoson et al. 2015) and household consumption
143 (Stifel et al. 2003). Moreover, household characteristics (Table 2) not only influence where households
144 choose to live in Madagascar (IOM 2014), but also their consumption. We thus controlled for
145 confounding site and household characteristics in the matching analysis. Because drought in southern
146 Madagascar and the frequent cyclones in the east are known to significantly influence household's
147 living standards, we executed exact matching on arid and cyclonic areas (INSTAT 2011). We also
148 performed exact matching on the year when the data were produced (2010 or 2012). We did not include
149 community characteristics because we do not believe they strongly affect selection of sites to CFM in
150 Madagascar, after matching on year, region, and household and site characteristics. The establishment
151 of CFM in Madagascar has been driven by external conservation agendas rather than communities
152 themselves (Pollini & Lassoie 2011). Many CFM sites have been designed to improve the management
153 of newly created protected areas or to form a "green belt" that buffers the cores of these protected areas
154 (Rasolofoson et al. 2015). Site characteristics thus have a much more powerful influence on CFM
155 selection than community characteristics. This assumption is supported by our placebo test (next
156 section). Nevertheless, in the Discussion and Text S2, we describe the implications of incorrectly
157 excluding community attributes. Data sources are in Table S1.

158 *Placebo test*

159 Ideally, we would confirm that the matched CFM and non-CFM households had similar consumption
160 before CFM began, thus helping to rule out pre-existing differences as explanations for post-CFM
161 differences in consumption. We do not have pre-CFM consumption data because earlier surveys used a
162 different sample of households. Instead, we performed a placebo test (Ferraro & Hanauer 2014) to test

163 whether the pre-CFM observable confounding characteristics we used are sufficient to control for pre-
164 CFM household consumption.

165 For the test, we used data from a 2005 INSTAT survey, which used a design similar to the 2010 and
166 2012 surveys, but with a different sample (Table S2). None of the sample households were in CFM
167 sites in 2005, but some became CFM sites after 2005. We match these soon-to-be CFM (placebo) sites
168 to sites never exposed to CFM using the same matching procedure and variables we apply to the 2010
169 and 2012 household data. In 2005, there is no CFM treatment yet, and thus if the matching procedure is
170 effective, consumption expenditures in the placebo CFM and non-CFM sites should be similar, on
171 average. If this null hypothesis cannot be rejected, the assumption that the matching procedure balances
172 the unobservable pre-CFM consumption levels in the 2010 and 2012 samples is more plausible.

173 *Heterogeneous impacts of CFM*

174 To explore the heterogeneity of impacts as a function of the distance of the household location to the
175 nearest forest edge and number of years of household head education, we followed Ferraro et al. (2011,
176 2015) and used a two-stage semi-parametric partial linear differencing model (PLM). The first stage
177 consists of linearly controlling for the confounding characteristics. The second stage uses a non-
178 parametric locally weighted scatter plot smoothing (LOESS) to estimate per capita consumption as a
179 function of the continuous moderators: household proximity to forest or household head education. In
180 other words, PLM allows estimating impacts across the possible values of the moderators, holding
181 constant the other confounding characteristics (Ferraro & Hanauer 2014). We performed PLM on the
182 matched dataset with the plm and plmplot R functions (Hanauer 2015).

183 **Results**

184 Before matching, the household characteristics of CFM and non-CFM households do not differ much
185 (Tables S4, S5). In contrast, some site characteristics clearly differ: CFM communes have more forest
186 area, a greater percentage of forest area, and less roadless and cart trackless volume. They are also less
187 densely populated and closer to urban centers (Tables S4, S5). Matching improved covariate balance:
188 the post-matching mean differences and mean raw eQQ differences of covariates are smaller (Tables
189 S4, S5).

190 We cannot reject the null hypothesis of the placebo test, which provides indirect support for the
191 adequacy of our empirical design. The estimated effect is 4.09% (US\$ 13.60) more per capita
192 consumption in the placebo CFM, a result that is not statistically significant ($p=0.76$).

193 After matching (Figure 2), the estimated effect of CFM on per capita consumption is positive, but small
194 and with a confidence interval that covers US\$0, regardless of whether treatment is defined as 10% of
195 the commune covered by CFM (mean effect US\$12.57; 95% CI[-\$21.34, \$46.48]) or 25% covered
196 (mean effect 18.53; 95% CI[-\$45.52, \$82.58]). For both definitions, a quarter standard deviation
197 decline in per capita consumption falls outside the 95% confidence interval.

198 Impacts of CFM are heterogeneous (Figure 3). Close to the forest edge, impacts appear positive (with a
199 maximum estimated effect of US\$50) and become negative as distance from the edge increases (with a
200 minimum estimated effect of US\$-60). Although we do not have enough data to estimate the effect
201 precisely over the entire range, the estimates are statistically significant between one and twelve
202 kilometers from the edge (Figure 3A).

203 Impacts also vary with level of education (Figure 3B). The estimated impacts increase with education
204 (with a maximum estimated effect of US\$110). For low levels of education, the estimated impacts are
205 negative, but imprecisely estimated.

206 **Discussion**

207 Our results imply small mean effects of CFM on household consumption. Although one of our
208 estimators of average impacts is too imprecise to rule out moderate positive impacts on consumption
209 (i.e., greater than $\frac{1}{4}$ standard deviation), we can statistically reject moderate or larger negative impacts.
210 This result is important given concerns that CFM restricts forest uses and thus may have negative
211 impacts on household well-being (Hockley & Andriamarivololona 2007; Toillier et al. 2011;
212 Ramamonjisoa & Rabemananjara 2012).

213 There are two rival explanations for this result; in other words, two factors that could mask a negative
214 effect in our design. First, we may have omitted an important confounding variable that, even after
215 matching on year, region and site and household characteristics, is positively correlated with exposure
216 to CFM and with expected consumption in the absence of CFM (or negatively correlated with both;
217 i.e., positive selection). If such a variable were to exist, CFM households, in the absence of CFM,
218 would have had higher average consumption than their matched, non-CFM households. Estimating
219 impacts by contrasting CFM with their matched non-CFM counterparts could thus mask a negative
220 impact of CFM. Our understanding of CFM selection in Madagascar and the result of our placebo test
221 are inconsistent with the presence of this form of hidden bias in our estimator, but they cannot rule it
222 out completely.

223 Secondly, restrictions imposed by CFM rules could displace poor households from CFM communities
224 to other communities (Pollini & Lassoie 2011). That displacement would increase the mean household
225 consumption in CFM areas (and potentially lower the consumption in the sample of matched untreated
226 households). That increase could mask a negative impact of CFM. We looked at the effect of CFM on
227 migration and could detect no effect (see Text S3).

228 Estimates of average CFM impacts, however, can mask heterogeneity. While the average effect may be
229 close to zero, some households may benefit and others may suffer. For households living closer to
230 forests or with more education, we detected positive impacts of CFM on consumption. For households
231 living farther from forests or with less education, we estimated negative impacts (albeit not always
232 statistically distinguishable from zero).

233 Heterogeneity of impacts conditional on distance could arise because CFM attracts external assistance
234 to CFM communities quite close to the forest edge, which cushions negative impacts of the forest use
235 restrictions. It could also arise because CFM benefits may be higher for CFM participants and
236 households closer to forest are more likely to participate. Heterogeneity of impacts conditional on
237 education may arise from a variety of potential mechanisms, including elite capture of CFM benefits,
238 which is a well-known problem with community-based interventions in developing countries (Lund
239 and Saito-Jensen 2013), including Madagascar (Pollini & Lassoie 2011). Elite capture can cause
240 conflicts jeopardizing effectiveness (Brown & Lassoie 2010), as well have social justice implications.

241 Our study has some advantages over earlier studies of CFM impacts in Madagascar, including the
242 careful control for site and household characteristics that confound impact estimates and the
243 consideration of potential rival explanations, such as differing baselines and migration. The national

244 scale of the analysis is valuable for evaluating the impact of a national policy, but also has
245 disadvantages: we are reliant on national-scale data and do not have the local insights of finer scale
246 studies. Households living right at the forest frontier (or even within the forests) are difficult to access
247 and may be underrepresented in our study because the INSTAT survey was not designed to look at
248 effects of forest use restrictions. Thus, though our results are valid for the households represented in the
249 sample, extrapolation should be done with caution. We also investigated exposure to CFM, rather than
250 participation in CFM because we do not have information on participation of households in forest
251 management groups. Finally, our study includes all legally-designated CFM sites; we do not have
252 information on the quality of the implementation on the ground. Future studies will be improved by
253 finer-scale analysis that contains information on participation of households in forest management
254 groups and the quality of CFM implementation. To examine conditions associated with CFM
255 effectiveness in terms of conservation and welfare outcomes jointly, future studies can combine our
256 results with results from studies on CFM impacts on ecological outcomes (e.g. Rasolofoson et al.
257 2015).

258 Because CFM continues to be widely promoted as an approach to reducing deforestation and
259 promoting rural development, better evidence about its impacts on human well-being is needed.
260 Madagascar has a rich experience with CFM over nearly two decades and thus provides an opportunity
261 to develop such evidence. To develop more generalizable evidence that can guide CFM design
262 globally, studies in other nations will be required, as will better theories about CFM program
263 participation (why are some communities and households participating and others are not?) and more
264 elaborate, mechanism-based theories about how CFM can affect human welfare and which household
265 and contextual factors moderate those impacts.

266 **Acknowledgments**

267 We dedicate this work to the memory our colleague Patrick Randriankolona who died before this paper
268 was complete. We thank the European Commission for funding through FONASO. We also thank:
269 INSTAT, the environmental section of the World Bank in Antananarivo, T. Tondrasoa Ramaharitra, A.
270 Lohanivo, Direction Générale des Forêts, A. Ravoahangy and R. Andriamasimanana (ASITY),
271 Conservation International, A. Volahy (DWCT), A. Rasolonjanahary (FANAMBY), H. Rakotomanana
272 (ONE), V. Andriamahery (WCS), A. Andriamanalina and L. Rakotondrasoa (WWF MWIOPO) for
273 providing data. We thank M. Hanauer and J. Gibbons for assisting with R codes. We also acknowledge
274 the p4ges project ([NE/K010220/1](#)).

275 **References**

276 Ameha, A., Nielsen, O.J. & Larsen, H.O. (2014). Impacts of access and benefit sharing on livelihoods
277 and forest: Case of participatory forest management in Ethiopia. *Ecol. Econ.*, 97, 162-171.

278 Andriantsilavo, F., Aubert, S. & Bechaux, E. (2006). La convention sur la diversité biologique : défis et
279 perspectives pour la politique forestière à Madagascar. In: *Forêts tropicales et mondialisation: les*
280 *mutations des politiques forestières en Afrique francophone et à Madagascar* (eds Bertrand, A.,
281 Montagne, P. & Karsenty, A.). L'Harmattan, Paris, pp. 373-393.

282 Aubert, S., Tchouso, A. & Razafiarjaona, J. (2013). Les tenants et les aboutissants juridiques des
283 transferts de gestion des ressources naturelles renouvelables. In: *Kajiala. Tattali, Djekabaara. Valoriser*
284 *les Produits pour Mieux Conserver les Forêts* (eds Montagne, P. & Rives, F.). Tome 2. CITE,
285 Antananarivo, pp. 49-67.

286 Bandyopadhyay, S. & Tembo, G. (2010). Household consumption and natural resource management
287 around national parks in Zambia. *J. Nat. Resour. Pol. Res.*, 2, 39-55.

288 Baylis, K., Honey-Rosés, J., Börner, J., Corbera, E., Ezzine-de-Blas, D., Ferraro, P., Lapeyre, R.,
289 Persson, U.M., Pfaff, A. & Wunder, S. (2016). Mainstreaming impact evaluation in nature
290 conservation. *Conserv. Lett.*, 9, 58-64.

291 Beegle, K., De Weerd, J., Friedman, J. & Gibson, J. (2012). Methods of household consumption
292 measurement through surveys: experimental results from Tanzania. *J. Dev. Econ.*, 98, 3-18.

293 Behera, B. (2009). Explaining the performance of state-community joint forest management in India.
294 *Ecol. Econ.*, 69, 177-185.

295 Bérenger, V. & Verdier-Chouchane, A. (2007). Multidimensional measures of well-being: standard of
296 living and quality of life across countries. *World Dev.*, 35, 1259-1276.

297 Bowler, D.E., Buyung-Ali, L.M., Healey, J.R., Jones, J.P.G., Knight, T.M. & Pullin, A.S. (2012). Does
298 community forest management provide global environmental benefits and improve local welfare?
299 *Front. Ecol. Environ.*, 10, 29-36.

300 Brown, H.C.P. & Lassoie, J.P. (2010). Institutional choice and local legitimacy in community-based
301 forest management: lessons from Cameroon. *Environ. Conserv.*, 37, 261-269.

302 Carret (2013). *Madagascar Country Environmental Analysis: Taking Stock and Moving Forward*.
303 World Bank, Washington, DC.

304 Deaton, A. & Zaidi, S. (2002). *Guidelines for constructing consumption aggregates for welfare*
305 *analysis*. The World Bank, Washington, D.C.

306 Engel, S., Palmer, C. & Pfaff, A. (2013). On the endogeneity of resource co-management: theory and
307 evidence from Indonesia. *Land Econ.*, 89, 308-329.

308 Ferraro, P.J. & Hanauer, M.M. (2014). Advances in measuring the environmental and social impacts of
309 environmental programs. *Annu. Rev. Env. Resour.*, 39, 495-517.

310 Ferraro, P.J., Hanauer, M.M., Miteva, D.A., Nelson, J.L., Pattanayak, S.K., Nolte, C. & Sims, K.R.E.
311 (2015). Estimating the impacts of conservation on ecosystem services and poverty by integrating
312 modeling and evaluation. *P. Natl. Acad. Sci. USA*, 112, 7420-7425.

313 Ferraro, P.J., Hanauer, M.M. & Sims, K.R.E. (2011). Conditions associated with protected area success
314 in conservation and poverty reduction. *P. Natl. Acad. Sci. USA*, 108, 13913-13918.

315 Ferraro, P.J. & Miranda, J.J. (2014). The performance of non-experimental designs in the evaluation of
316 environmental programs: A design-replication study using a large-scale randomized experiment as a
317 benchmark. *J. Econ. Behav. Organ.*, 107, 344-365.

318 Ferraro, P.J. & Pattanayak, S.K. (2006). Money for nothing? A call for empirical evaluation of
319 biodiversity conservation investments. *PLoS Biol.*, 4, e105.

320 Gelo, D. & Koch, S.F. (2014). The impact of common property right forestry: Evidence from Ethiopian
321 villages. *World Dev.*, 64, 395-406.

322 Hanauer, M.M. (2015). Partial Linear Differencing Model. Available from
323 http://www.sonoma.edu/users/h/hanauer/Docs/plm_dif2.R. Accessed 8 July 2015.

324 Hockley, N.J. & Andriamarovololona, M.M. (2007). *The economics of community forest management*
325 *in Madagascar : is there a free lunch ? An analysis of Transfert de Gestion*. United States Agency for
326 International Development USAID, Antananarivo.

327 Institut National de la Statistique INSTAT (2011). *Enquête périodique auprès des ménages 2010*.
328 INSTAT, Antananarivo.

329 International Organization for Migration IOM (2014). *Migration à Madagascar*. IOM, Geneva.

330 Joppa, L.N. & Pfaff, A. (2011). Global protected area impacts. *P. Roy. Soc. B-Biol. Sci.*, 278, 1633-
331 1638.

332 King, M.F., Renó, V.F. & Novo, E.M.L.M. (2014). The concept, dimensions and methods of
333 assessment of human well-being within a socioecological context: a literature review. *Soc. Indic. Res.*,
334 116, 681-698.

335 Lund, J.F. & Saito-Jensen, M. (2013). Revisiting the issue of elite capture of participatory initiatives.
336 *World Dev.*, 46, 104-112.

337 Milner-Gulland, E.J., McGregor, J.A., Agarwala, M., Atkinson, G., Bevan, P., Clements, T., Daw, T.,
338 Homewood, K., Kumpel, N., Lewis, J., Mourato, S., Palmer Fry, B., Redshaw, M., Rowcliffe, J.M.,
339 Suon, S., Wallace, G., Washington, H. & Wilkie, D. (2014). Accounting for the impact of conservation
340 on human well-being. *Conserv. Biol.*, 28, 1160-1166.

341 Newton, P., Schaap, B., Fournier, M., Cornwall, M., Rosenbach, D.W., DeBoer, J., Whittemore, J.,
342 Stock, R., Yoders, M., Brodnig, G. & Agrawal, A. (2015). Community forest management and
343 REDD+. *Forest Policy Econ.*, 56, 27-37.

344 Pollini, J. & Lassoie, J.P. (2011). Trapping farmer communities within global environmental regimes:
345 the case of the GELOSE legislation in Madagascar. *Soc. Natur. Resour.*, 24, 814-830.

346 Ramamonjisoa, B. & Rabemananjara, Z. (2012). Une évaluation de la foresterie communautaire. *Les*
347 *Cahiers d'Outres-Mer*, 157, 125-155.

348 Rasolofoson, R.A., Ferraro, P.J., Jenkins, C.N. & Jones, J.P.G. (2015). Effectiveness of Community
349 Forest Management at reducing deforestation in Madagascar. *Biol. Conserv.*, 184, 271-277.

350 Ratsimbazafy, L.C., Harada, K. & Yamamura, M. (2011). Forest conservation and livelihood conflict
351 in REDD : a case study from the corridor Ankeniheny Zahamena. *Int. J. Biodivers. Conserv.*, 3, 618-
352 630.

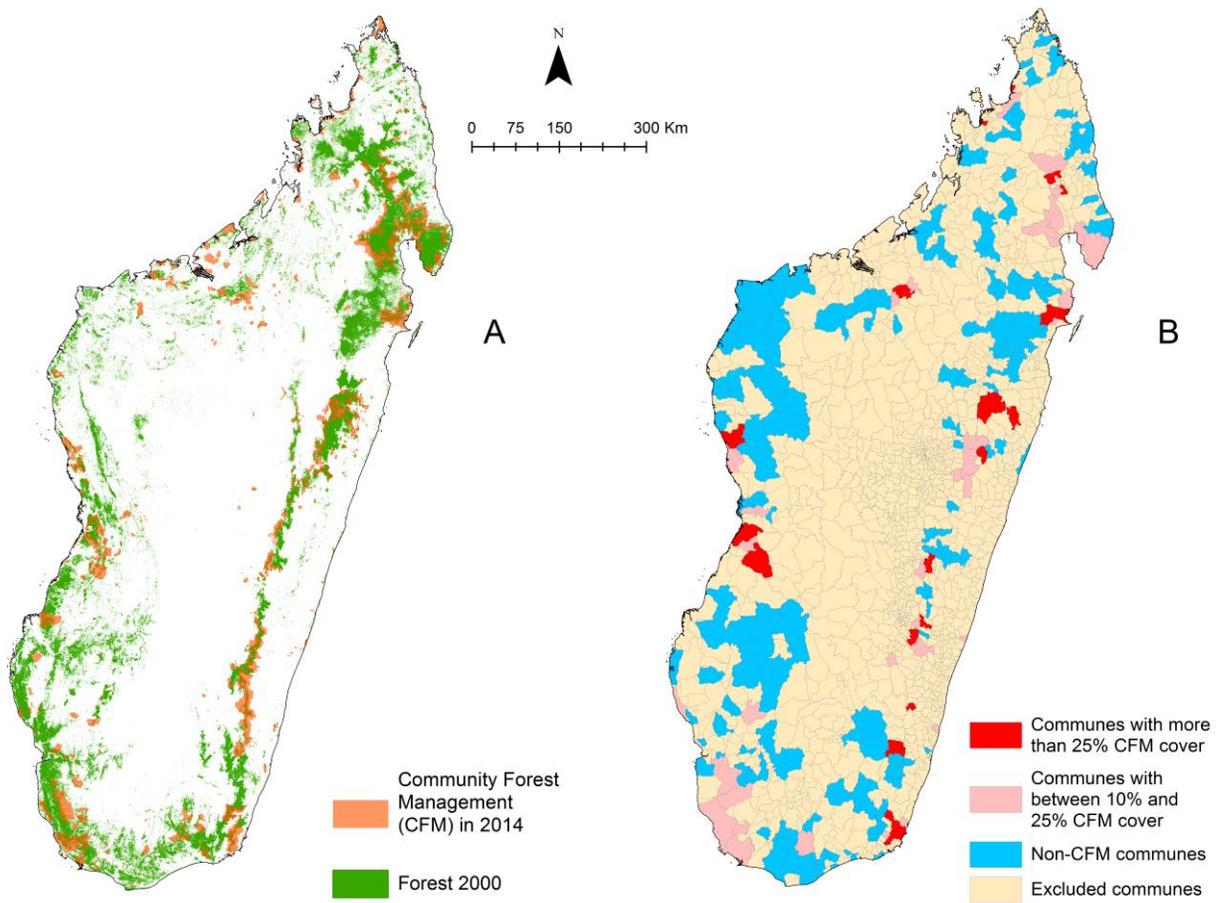
353 Sekhon, J.S. (2011). Multivariate and propensity score matching. Software with automated balance
354 optimization: the Matching Package for R. *J. Stat. Softw.*, 7, 1-52.

355 Stifel, D., Minten, B. & Randrianarison, L. (2003). Eloignement, routes, agriculture et pauvreté. In:
356 *Agriculture, pauvreté rurale et politiques économiques à Madagascar* (eds Minten, B., Randrianarisoa,
357 J.C. & L. Randrianarison). ILO, Ithaca, New York, pp. 66-71.

358 Toillier, A., Serpantié, G., Hervé, D. & Lardon, S. (2011). Livelihood strategies and land use changes
359 in response to conservation: pitfalls of community-based forest management in Madagascar. *J. Sustain.*
360 *Forest.*, 30, 20-56.

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364 **Figure 1.** Study sites. A) Community Forest Management (CFM) sites in 2014; B) CFM communes,
 365 non-CFM communes, and communes excluded from the analyses (Projection: Laborde Madagascar)

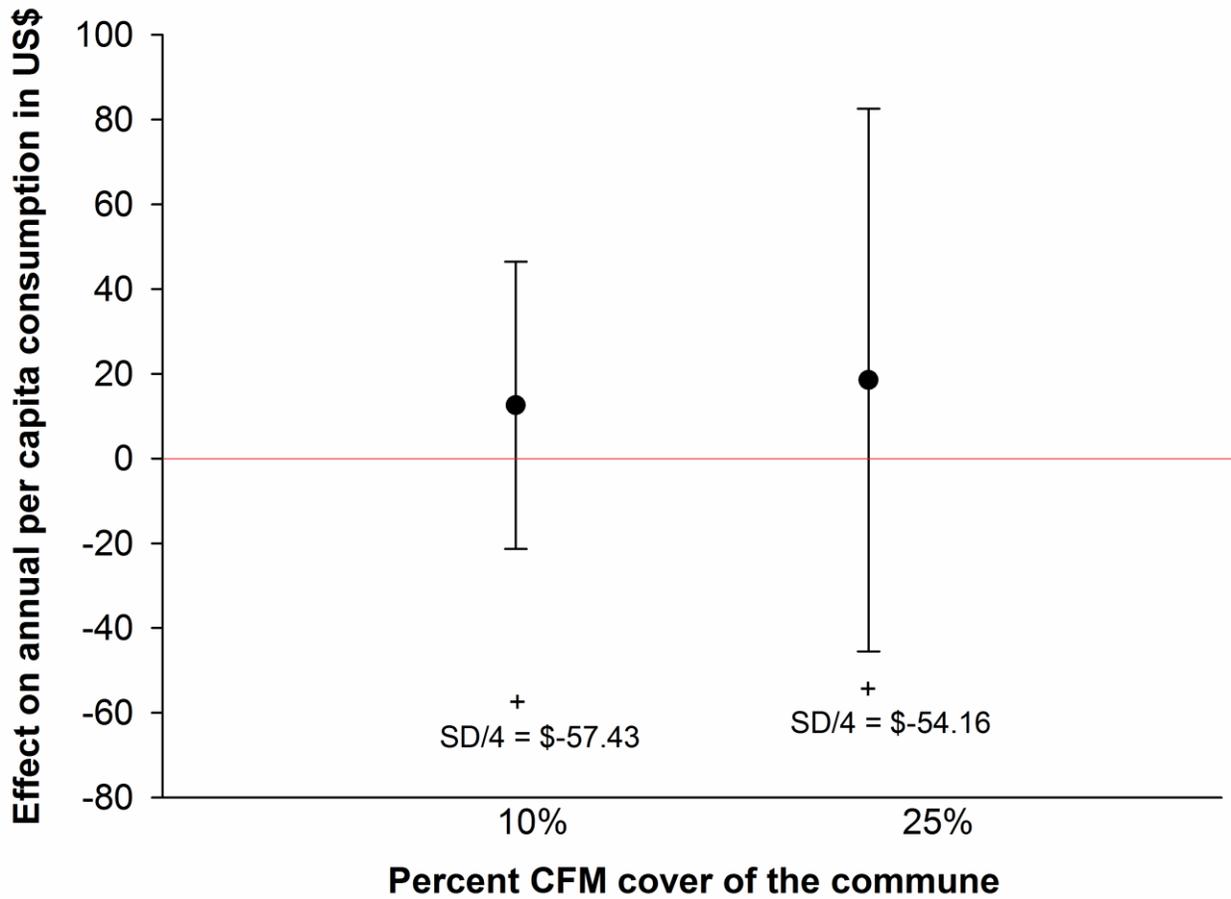
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372 **Figure 2.** Impacts of Community Forest Management (CFM) on per capita consumption expenditure

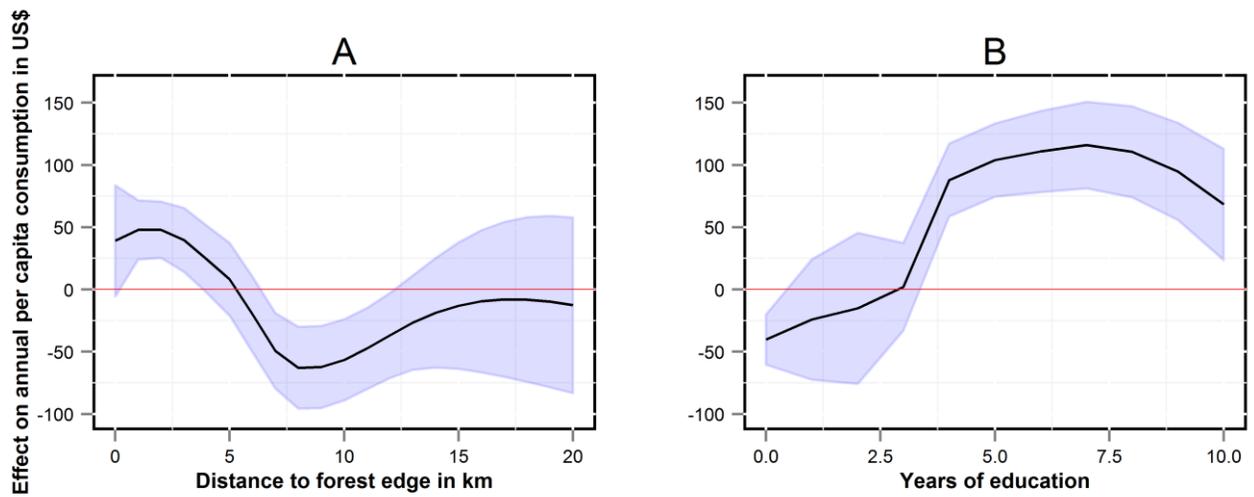
373 (+: SD/4 quarter standard deviation decline in per capita consumption expenditure, error bar: 95%

374 confidence interval)

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379 **Figure 3.** Heterogeneity of Community Forest Management (CFM) impacts. A) Impacts conditional on
 380 distance from the household location to the nearest forest edge, B) Impacts conditional on the number
 381 of years of education of the household head (blue band: 95% confidence interval)

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390 **Table 1.** Numbers of CFM and non-CFM communes and sampled households

Dataset	Commune		Household	
	CFM	Non-CFM	CFM	Non-CFM
Threshold 10% CFM cover of the commune				
2010	54	165	698	2,179
2012	61	164	760	1,938
Total			1,458	4,117
Threshold 25% CFM cover of the commune				
2010	21	165	115	2,179
2012	25	164	303	1,938
Total			418	4,117

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399 **Table 2.** Confounding characteristics

	Variables	Unit
Site	Slope (average, maximum)	Commune
characteristics	Elevation (average, maximum)	Commune
	Roadless volume	Commune
	Cart trackless volume	Commune
	Suitable for irrigated rice	Commune
	Area of forest land	Commune
	Proportion of forested land	Commune
	Duration of trip to the nearest urban center	Commune
	Population density	Commune
	Proportion of forest protected areas (MNP)	Commune
	Proportion of forest land	Commune
	Household	Household head age
characteristics	Household head without any formal education	Household
	Household head with primary education	Household
	Household with secondary education or higher	Household
	Household head gender	Household
	Single female household head	Household
	Presence of a child under 5	Household
	Presence of a disabled individual (5 years old or more)	Household