

Do trees grow better on certified land? Evidence from a smallholder program in Madagascar.

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Research objectives

- Assess the impact of land certification on reforestation outcomes
- Evaluate historical land tenure effects on current land certification

Land certification

- Decentralized process at the commune level
- Based on the 2005 land reform → simplified certification process for **untitled privately held land**

Reforestation program PLAE III

- Programme de Lutte Anti-Érosive* (BMZ-KfW)
- 2014-2019, northern Madagascar (DIANA, Boeny, Betsiboka)
- 3425 beneficiaries → **voluntary participation**
- Smallholder reforestation on marginal land
- Energy wood production → income generation
- Support with land certification** → **voluntary application**

Historical land titles

- Land titles in the name of colonial settlers
- Obsolete land statuses* → State private property
- Unfinished cadastral records

Overlap between the reforested plots and historical land titles

- Unexpected challenge in the context of PLAE III
- Lack of complete information on the legal status of land at the program's outset
- Plots under historical land titles not eligible for certification**

Colonization Perimeters, Indigenous Reserves, AMVR and ZAF

In this paper...

- We study whether land certification enhances the effectiveness of a reforestation program.**
- Drawing on primary data collected in 2024 and combined with remotely-sensed secondary data, we employ a quasi-experimental approach to estimate the program's medium-term effects.
- Our identification strategy leverages variation in the presence of **historical colonial and post-colonial land titles overlapping with reforested plots as an instrument for land certification.**
- These titles were not factored into the program's implementation phase and can be considered quasi-exogenous, conditional on controlling for the overall presence of historical titles.

Data

Primary data

- 1406 program participants
- 38 rural communes
- Jul-Sept 2024
- GPS coordinates of plots (May-June 2026)

Geospatial data

- Local land occupation plans (PLOF)
- Very-high-resolution (5 m) satellite imagery (Planet Lab)
- Enhanced Vegetation Index (EVI)

Tree growth outcomes

- Estimated tree canopy cover (2024)
- Estimated tree canopy cover change (2016-24)
- Estimated tree canopy cover of 10% or more (2024)
- Self-reported trees standing index
- Observed healthy trees

Quasi-experimental approach

$$Y_{(i)jcr} = \alpha_0 + \alpha_1 \widehat{LC}_{ijcr} + \alpha_2 HLT_{jcr} + \alpha_3 \mathbf{X}_{ijcr} + \gamma_r + u_{ijcr}, \quad (1)$$

$$LC_{ijcr} = \beta_0 + \beta_1 OHLT_{ijcr} + \beta_2 HLT_{jcr} + \beta_3 \mathbf{X}_{ijcr} + \delta_r + \varepsilon_{ijcr}. \quad (2)$$

- $Y_{(i)jcr}$ = Tree growth outcomes of household i , in fokontany j , commune c , region r
- LC_{ijcr} = 1 if the household possesses a legal certificate for its reforested plot
- $OHLT_{ijcr}$ = Plot share of overlapping historical land titles
- HLT_j = Share of historical land titles in fokontany j

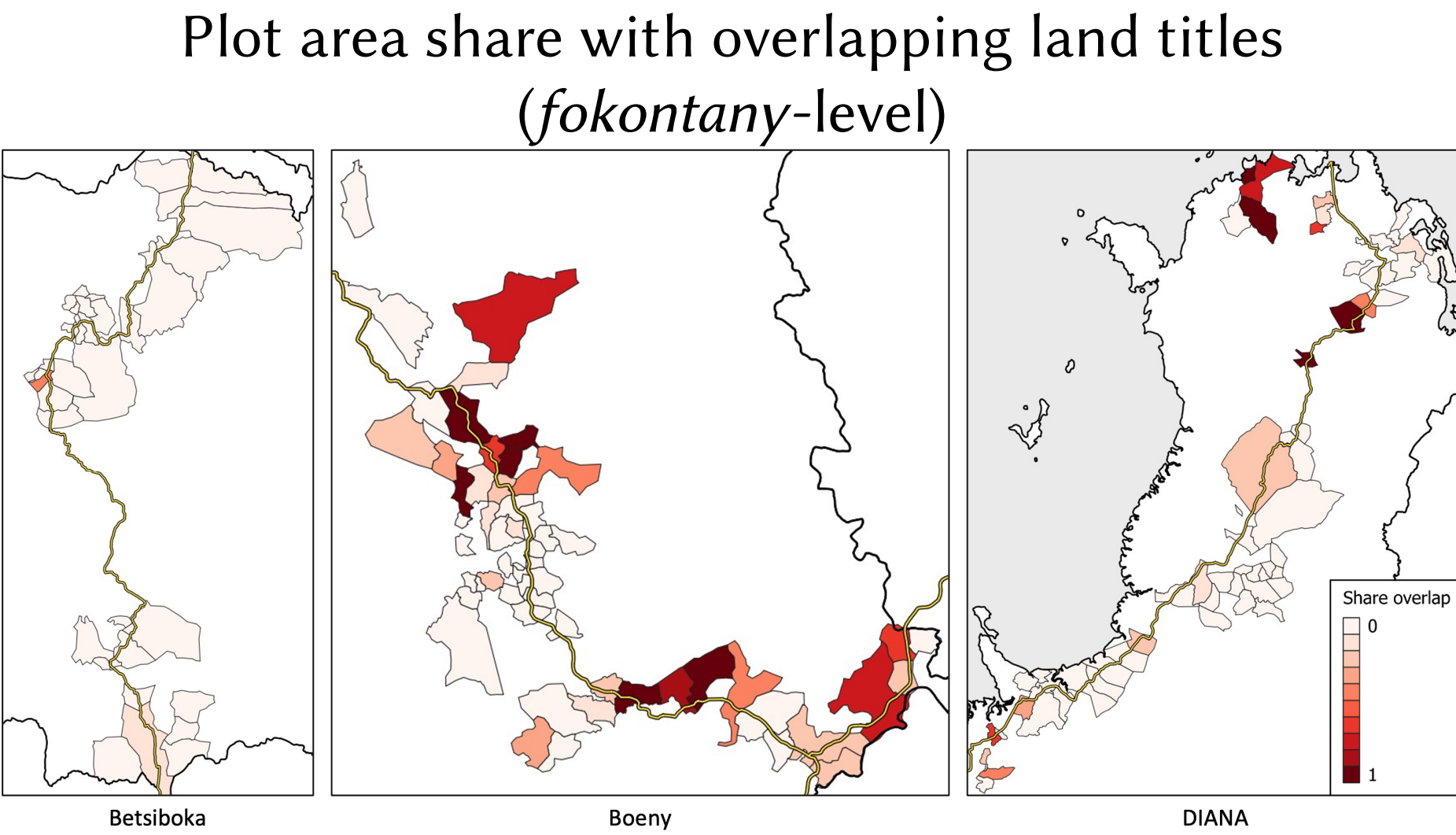
Instrument:

- Plot share of overlapping historical land titles**
- Conditional on the total share of historical land titles per fokontany*

Fokontany is the lowest administrative subdivision in Madagascar

Identifying assumptions

- Historical land titles as an obstacle to land certification today
- A constraint that is clearly recognized by legislators but not widely discussed publicly
- Lack of awareness among PLAE III stakeholders prior to certification process



Results

Land certification and tree growth						
Dependent:	Tree outcomes					Certificate
	Remotely sensed		Hh. report		Observed	Land certificate
	Tree cover % 2024 (1)	Cover change pp. 16-24 (2)	Tree cover ≥10% 2024 (3)	Trees standing index 2024 (4)	Trees healthy 2026 (5)	
Second stage (IV)						1st stage
Land certificate for reforested area	0.263*** (0.096)	0.220** (0.088)	0.375** (0.176)	0.455** (0.222)	0.344 (0.226)	
Plot share overlapping historical land titles						-0.227*** (0.032)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Mean dependent	0.251	0.128	0.559	2.379	2.609	0.314
Number of obs.	1608	1608	1608	1608	1608	
F-statistic (first stage)						50.51

The 2SLS estimates instrument the endogenous indicator (household holds a land certificate) with the share of program plots overlapping historical land titles, conditional on the fokontany land share under any historical title. Dependent variables: (1) estimated tree canopy cover (2024); (2) estimated tree canopy cover change (2016-24); (3) estimated tree canopy cover of 10% or more (2024); (4) self-reported trees standing index; (5) observed healthy trees; Column (6) reports the first stage. Controls: plantation year; log plot size; log walking time to plot; growing-season drought months since planting (remotely sensed); household-level indicators for female head, migrant status, southern ethnicity, head with secondary education or more, household size, household dependency ratio; village-level distance to commune center; fokontany total reforested area; commune-level wealth, human capital, and infrastructure indices, population size, share of non-farm households, title owning households, and migrant households (in 2018). Region fixed effects for Boeny, Betsiboka, and DIANA are included. Robust standard errors clustered at the fokontany level are reported in parentheses. *, **, *** indicate significance levels at 0.10, 0.05, and 0.01.

- Land certification significantly increases tree growth**
- Increased perceived tenure security
- Increased investment in reforested plots
- Decreased incidence of fire damage...
- ... but increased incidence of tree theft
- Weak evidence of self-reported socio-economic outcomes
- Historical land tenure system continues to hinder the formalization of land rights today**

