

Impact of on-farm fuelwood harvesting on fuelwood collection time among small holder rural households: Evidence from Eastern Rwanda

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1 Background

- Fuelwood remains the primary energy source for most rural Sub-Saharan African households
- Fuelwood collection is a major time burden, disproportionately borne by women and children
- Climate change and deforestation are shrinking the resource base; scarcity of preferred species intensifies the crisis – need alternative sources
- On-farm agroforestry offers a locally-managed household-level solution

Q: Does agroforestry adoption causally reduce household fuelwood collection time in the study context?

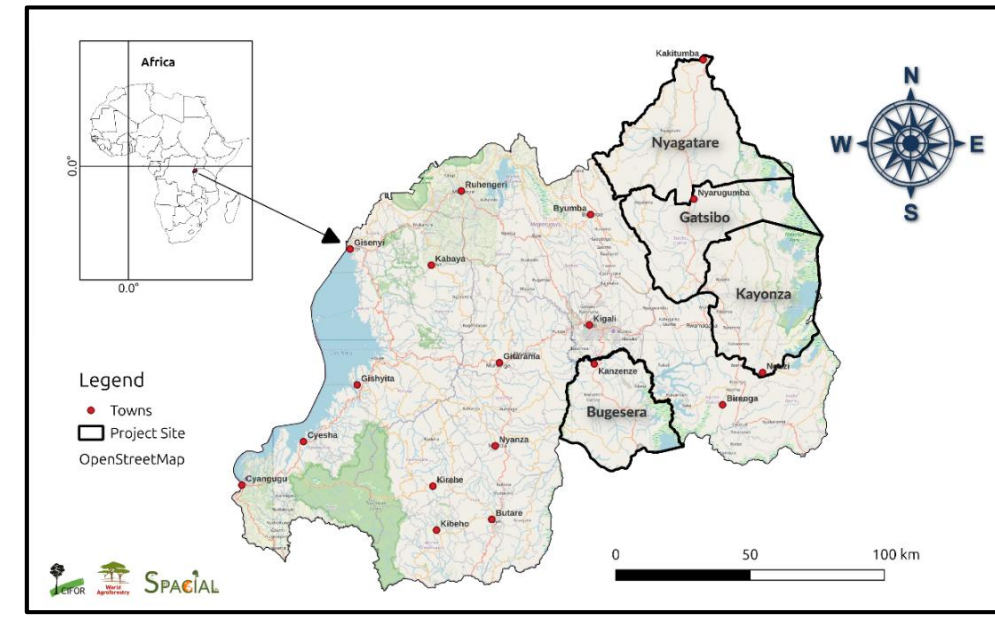


Fig.1: Study area - Eastern Rwanda

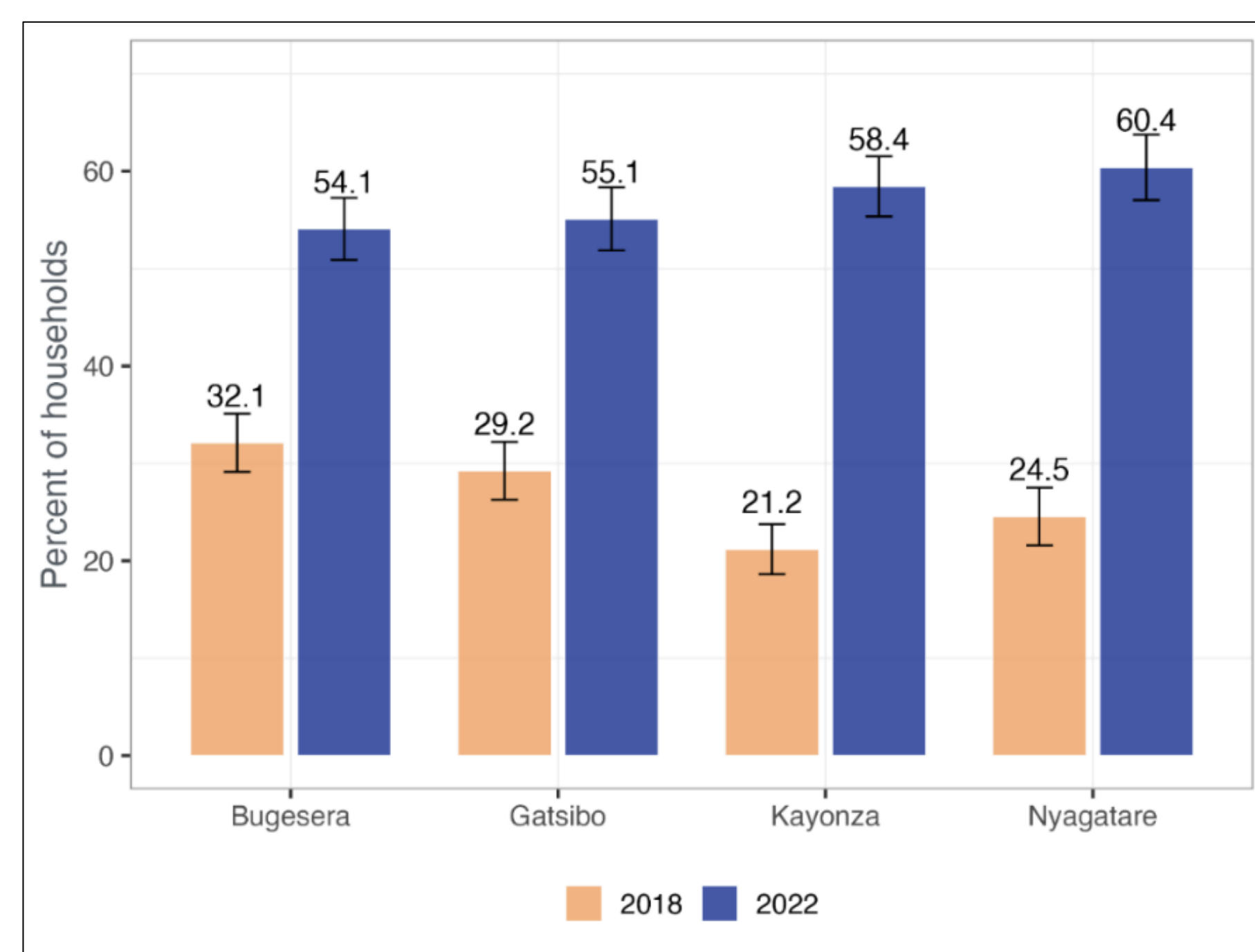
POLS: Pooled ordinary least squares
RE: Random Effects
CRE: Correlated Random Effects
FE: Fixed Effects
2SLS: 2 stage least squares
CFA: Control Function Approach
HHs: households

2 Methods and Data

- Data** : Two-period balanced panel, 945 HHs, Rwanda
- Empirical Strategy**
Two-stage approach to address endogeneity/unobserved heterogeneity of on-farm fuelwood harvesting
 - (i) RE Probit – predict probability of on-farm harvesting using agroforestry exposure as instrument
 - (ii) Panel estimators – to estimate the effect of on-farm fuelwood harvesting on collection time
- Identification**
 - CFA** : correct non-random selection of on-farm harvesting decision
 - Instrument** : HH exposure to agroforestry practices — strong first-stage predictor (11%, $p < 0.001$), **Exclusion restriction** : instrument affects collection time *only through* decision (on-farm harvesting behavior)
- Robustness**
 - Multiple estimators used with progressively stricter assumptions: POLS → RE+CFA → CRE+CFA → FE → 2SLS
 - Other controls, district and year FE included in all specifications

3 Results

a. Descriptive results

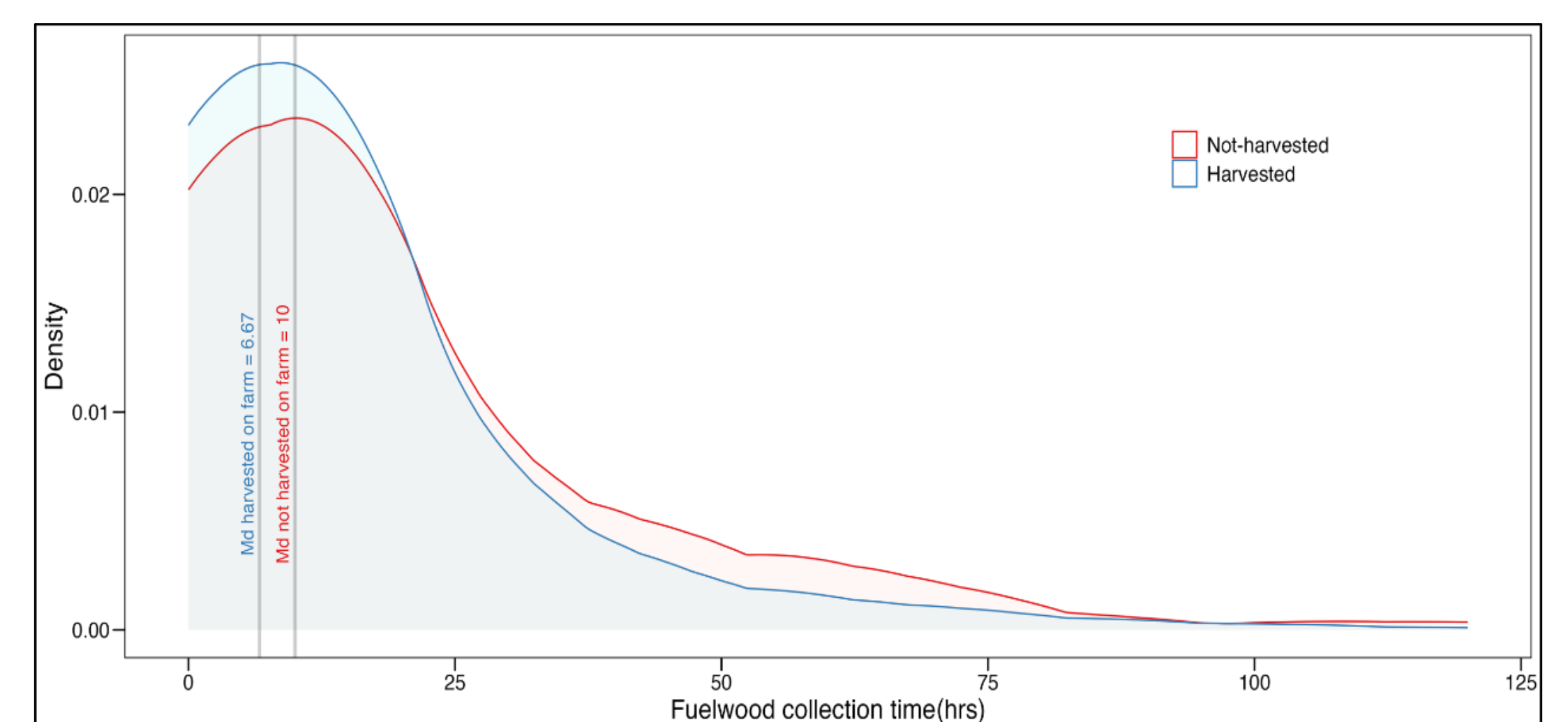


On-farm fuelwood harvesting more than doubled —27% (2018) to 57% (2022)

Fuelwood is mainly for self-consumption — commercial trade by HHs is negligible (only 2%)

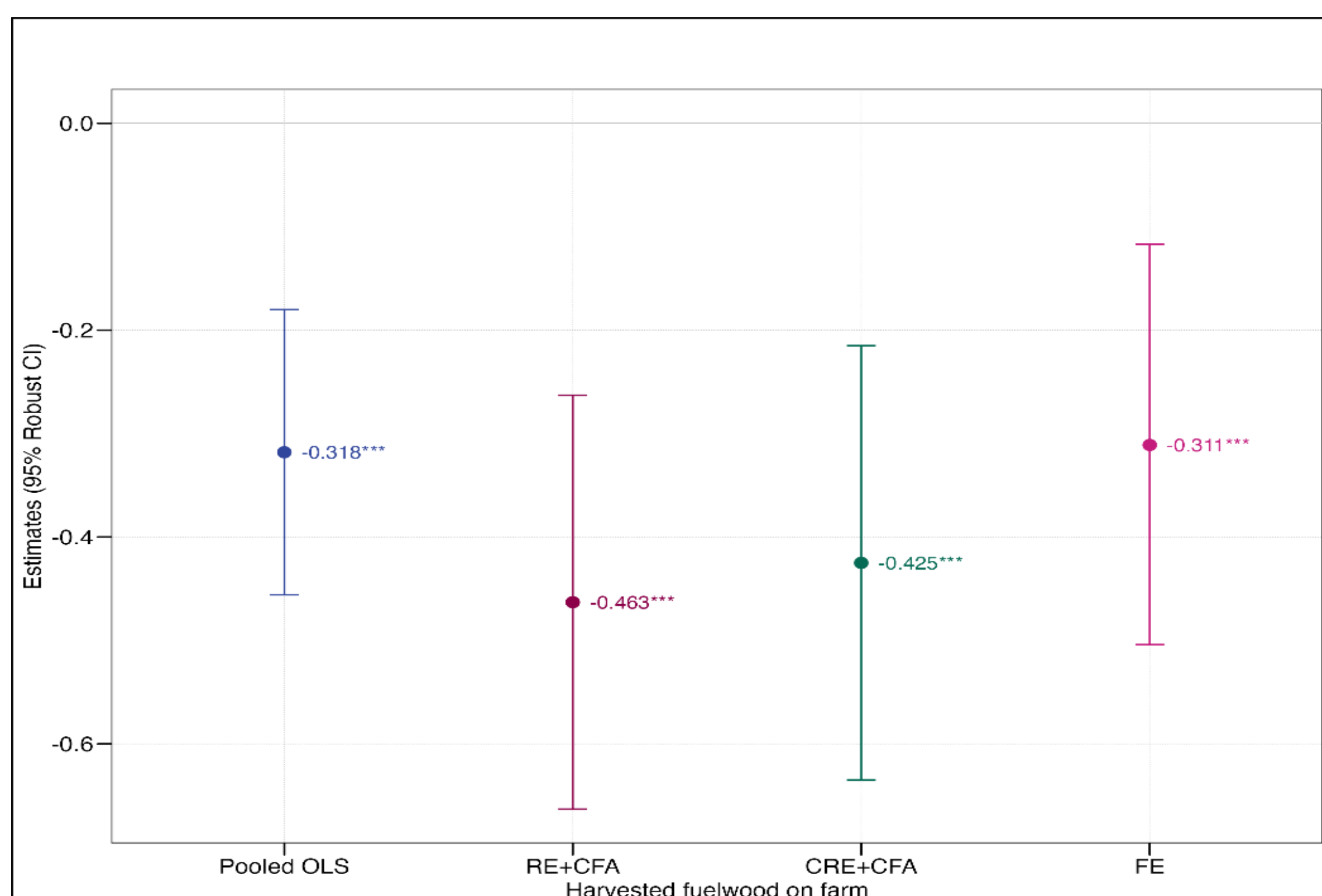
Farms are a major supply source — > 50% HHs meet at least half their fuelwood needs from on-farm

Drivers of this increase likely multi-causal — e.g., reduced access to communal/forest resources, population growth, market dynamics, or policy changes



- Baseline median time is app. 7 hrs & 10 hrs for on-farm fuelwood harvesting HHs & non-farm harvesting HHs, respectively.
- Highly skewed

b. Econometric results



Actual observations			Median baseline	Mean baseline	Median endline	Mean endline
Actual mean and median times for non-farm harvesting HHs			10.00	19.63	9.00	16.40
Actual mean and median times for farm-harvesting HHs			6.67	15.34	7.00	12.36
Model	Est. log-coef.	Est. % reduction in time [#]	Median baseline estimates	Mean baseline estimates	Median endline estimates	Mean endline estimates
Pooled OLS	-0.318***	27.24%	7.28	14.28	6.55	11.93
RE+CFA	-0.463***	37.06%	6.29	12.36	5.66	10.32
CRE+CFA	-0.425***	34.62%	6.54	12.83	5.88	10.72
FE	-0.311***	26.66%	7.33	14.40	6.60	12.03
2SLS	-0.276***	24.42%	7.56	14.84	6.80	12.40

Significance level: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. # (Percentage reduction = $(\exp(\text{coefficient}) - 1) \times 100\%$)

- On-farm fuelwood harvesting reduces collection time by **24–37%**, consistent and significant ($p < 0.01$) across all estimators

Effect remains significant even under the most conservative FE model (–27%), ruling out simple HH-level characteristic explanations

- Preferred Model**
RE+CFA specification — cleanest identification, most efficient use of within- and between-HH variation, retains time-invariant controls

4 Conclusions and practical implications

- What works:** On-farm tree presence — not particular species cuts fuelwood collection time
- Pathway:** AF extension → on-farm harvesting → time savings is a scalable, valid pathway for reducing rural energy poverty
- Fair program design:** Deliberate targeting of on-farm fuelwood production required to reach households demanding and collecting the most
- Measure what matters for program targeting:** Not community-level scarcity indicators but HH-level adoption/behavior indicators