



Improved cookstoves and forest recovery in Rwanda

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- Rwanda's Tubeho Neza cookstove program increased forest and non-forest cover in treated areas.
- The program's effects were not immediate: gains appeared after a few years, consistent with the time needed for ecological recovery.
- Forest gains were strongest in areas with better baseline forest conditions. Other areas still became greener, but mainly through non-forest vegetation.
- Fieldwork suggests that households actively used the stoves, spent less on fuelwood, and relied less on children for firewood collection.
- Improved cookstoves can contribute to forest growth, but program design, size, monitoring and marketing, and local ecological conditions are critical.

The policy issue

Rwanda's Vision 2050 targets include becoming a carbon-neutral economy. Many rural households in Rwanda depend on firewood for cooking. This has consequences for health, time use, and environmental pressure. Improved cookstoves are often promoted as a way to reduce fuel use and improve household welfare. They are also increasingly financed through carbon markets, where claims about reduced biomass use and forest protection are central to project credibility. At the same time, the Rwandan economy also relies heavily on coffee exports, and the European Union's Deforestation Regulations (EUDR) can have significant consequences for Rwandan exports.

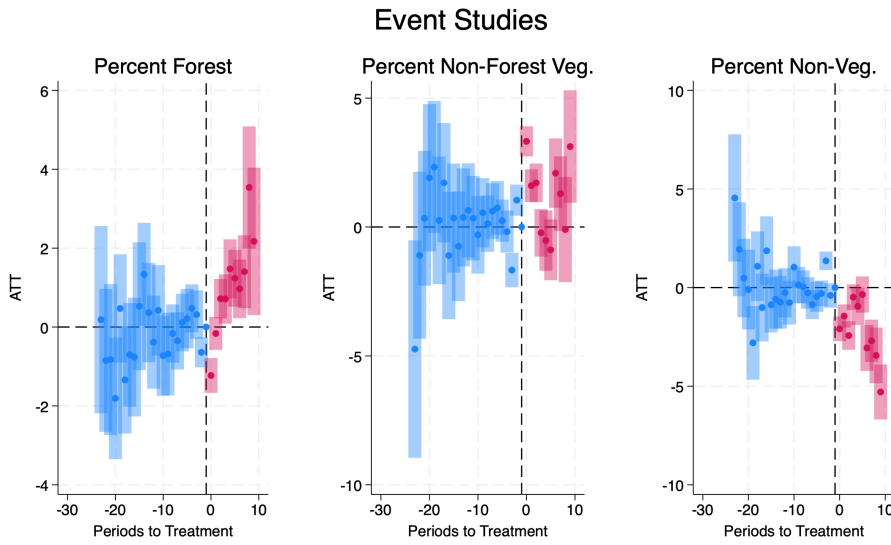
Yet there has been little causal evidence on whether large-scale cookstove programs actually improve forest outcomes. That evidence gap matters for governments, donors, and carbon-finance actors deciding whether and how to invest in clean cooking.

What this research studies

This research evaluates Tubeho Neza, a large-scale cookstove program in Rwanda delivered by DelAgua Health Rwanda Implementation Ltd in partnership with the Government of Rwanda. Since 2014, the program has distributed more than 1.5 million improved cookstoves. Its phased roll-out across different parts of rural Rwanda allows comparison between areas that received stoves earlier and areas that had not yet received them.

The study combines full program distribution records with (a) satellite measures of forest and vegetation cover augmented with land classifications from Machine-Learning-based algorithms that minimise measurement error; and (b) qualitative fieldwork conducted in Rwanda on user experience with improved cookstoves and competing cookstove designs, energy constraints, and community forest use. The analysis focuses on administrative cells and uses a difference-in-differences design suited to staggered treatment.

Figure 1. Event-study estimates for forest, non-forest vegetation, and non-vegetation outcomes.



Note: Colours represent leads and lags: blue for relative years pre-stove receipt, and red for years after stove receipt

Main findings

The program increased vegetation cover on average. During the 2014-2023 period, we find that treated cells experienced a 0.61 percentage point increase in forest cover, a 1.256 percentage point increase in non-forest vegetation, and a 1.866 percentage point decline in non-vegetated area. While quantifying the monetary benefits associated with these gains is beyond the scope of the present version of the study, our fieldwork suggests that they are linked to reduced fuelwood expenditure, time savings, and lower reliance on children for fuelwood collection.

Panel A	Forest Cover/ Dense Vegetation	Non-Forest Cover/ Sparse Vegetation	Non-Vegetation/ Barer Ground
MODIS Classifications	Average forest cover rises by 0.61 percentage points.	Average non-forest vegetation rises by 1.256 percentage points.	Non-vegetated area falls by 1.866 percentage points.
LANDSAT Bespoke Classifications	Dense vegetation increases by 0.505 percentage points.	Sparse vegetation increases by 2.259 percentage points.	Open/bare land declines, but the estimate is not statistically significant.
Panel B	Treatment Cohort	Baseline Forest Quartile	Road Network
Heterogeneity	Early treated cohorts show the clearest forest gains; later cohorts show non-forest gains.	Higher baseline forest cells see stronger forest gains, while other cells gain non-forest vegetation.	Cells with worse access to paved roads see more forest growth.

The timing of these effects is important. The gains appear in a few years, which is consistent with the time needed for vegetation recovery to become visible in satellite data.

The effects were also heterogeneous. Areas with stronger baseline forest conditions experienced larger forest gains. Areas with lower baseline forest cover still became greener, but the gains showed up more in non-forest vegetation.¹ than in the forest. Cookstove-receiving areas further from roads experience the most forest growth relative to areas with greater road proximity. This likely reflects the heterogeneity of the effect by differences in market access and wealth.²

The alternative analysis with bespoke land classifications derived through Machine-learning methods supports the same broad conclusion. It shows increases in dense and sparse vegetation and provides little evidence that these gains were driven by agricultural expansion. The robustness of the results is also ensured by using alternative estimators from among the class of differences-in-differences estimators.

Why the program may have worked

The fieldwork provides evidence on likely mechanisms. Households reported regular stove use, especially for newer models. Respondents also reported lower fuelwood spending, reduced firewood collection burdens, and less reliance on children for this work.

The qualitative evidence also suggests that major competing cookstove and forestry interventions began only around 2020–21, near the end of the study period. That reduces concern that the main findings are driven by overlapping programs.

Policy implications

- **Forest recovery need not break the bank.** Earlier estimates suggest that the EcoZoom Dura stove cost approximately USD 35 per unit during the 2014 and 2016 distributions, with additional annual costs of around USD 7

¹While forest vegetation quantifies the share of closed tree canopy detected by the MODIS satellite, non-forest vegetation refers to vegetation that does not meet the threshold for classification as forest in the MODIS Vegetation Continuous Fields data. This includes herbaceous cover as well as sparse or open-canopy woody (tree) vegetation. As such, the non-forest vegetation outcome captures not only reductions in shrub or other non-tree extraction, but also foregone tree harvesting in sparsely tree-covered landscapes (Dimiceli et al., 2015)

²For example, households closer to markets may substitute away from firewood consumption while increasing sales of firewood, whereas those further from markets may reduce foraging time overall. To the best of our knowledge, this heterogeneity does not impact implementation. DelAgua spoke to us about their determination to reach villages regardless of remoteness, and they use four-wheel-drive vehicles to travel on muddy mountain roads to reach these beneficiaries.

per stove for replacements, repairs, and associated support systems (Barstow et al., 2019).

- **Treat clean cooking as both a household and environmental policy.** Improved cookstoves can deliver more than health and time-use benefits. At scale, they can also improve land-cover outcomes.
- **Build maintenance and follow-up into program design.** Fieldwork shows that older stoves often stop being used if they break down. The environmental returns to distribution are therefore likely to depend on repair systems, user support, and replacement planning.
- **Set realistic expectations about where forest gains will occur.** Forest recovery is more likely in areas with stronger baseline forest conditions. In other locations, gains may still be meaningful but may appear as broader vegetation recovery rather than forest regeneration.
- **Strengthen monitoring for carbon-financed projects.** Project assessment should rely more on direct evidence of land-cover change and less on assumptions alone.

Implementation considerations

Many households continue to use traditional and improved stoves together. That means benefits may depend on how much the improved stove displaces traditional biomass use, rather than simply whether a stove was distributed.

Ecological gains take time. Policymakers and funders should not expect immediate forest recovery within a year or two of roll-out.

References

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