# Disease at the Root, Deforestation at the Edge

Cassava Brown Streak Disease outbreaks and the ecological cost of a staple-crop epidemic in Uganda

**Neha Deopa [1]** **Nilesh Shinde [2]**

[1] University of Exeter Business School | [2] Indiana University Bloomington

## 1. CONTEXT AND QUESTION

**Can plant disease shocks generate persistent ecological spillovers?**

- Sub-Saharan Africa accounts for 36% of global forest loss, with agricultural expansion the single most important proximate driver.
- Crop disease pushes farmers to clear additional land to compensate for yield shortfalls — an important but unrecognized channel linking food-security shocks to environmental degradation.
- Carbon released by disease-driven deforestation is a negative externality absent from cost–benefit analyses of disease management, risking systematic underinvestment in resistant varieties and phytosanitary infrastructure.

*We investigate CBSD outbreaks for a staple crop in Uganda and their impact on deforestation and land-use reallocation.*

**STUDY DESIGN**

**Uganda | 1,467 ADM4 sub-counties | 2001–2021**
**30,807 unit-year observations | first CBSD outbreak 2004**

## 2. A STAPLE MEETS A CRYPTIC DISEASE

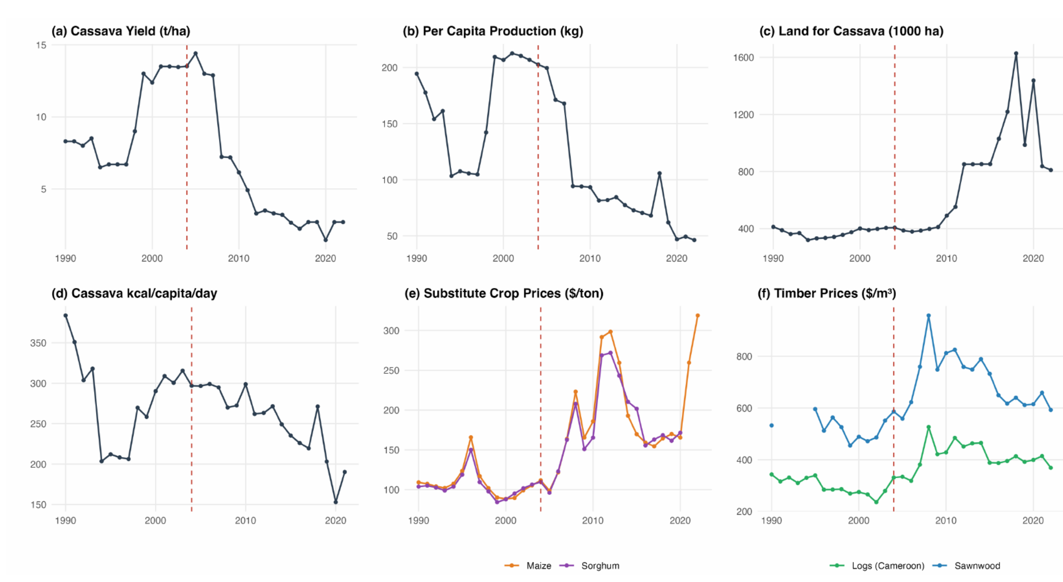
**Cassava feeds an estimated 800 million people; over 500 million growers across sub-Saharan Africa rely on this drought-resilient, low-input staple.**

- Cassava brown streak disease (CBSD) is caused by two viral strains (CBSV and UCBSV), spread by the whitefly vector and infected planting material.
- Root necrosis is invisible until harvest, rendering tubers unmarketable and inedible — cryptic symptoms make CBSD far harder to detect and control than mosaic virus.
- First confirmed in Uganda in the early 2000s; between 2002 and 2015 outbreaks reached nearly every major cassava-growing sub-county.

**−60%**
collapse in cassava yield
≈13 → 5 tonnes per hectare

**<100 kg**
per-capita production
down from a ≈200 kg peak

## 3. THE CRISIS IN THE DATA



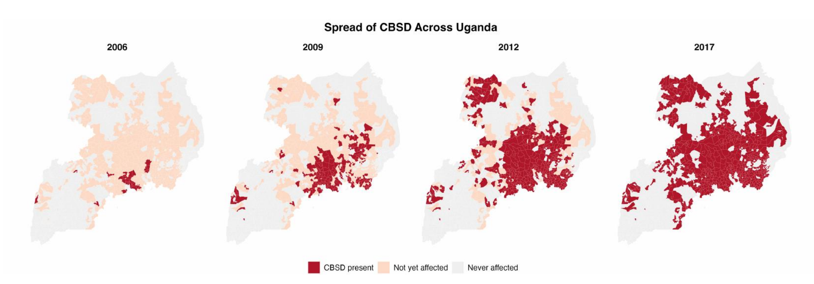

*Yield collapsed while cassava land area expanded and timber prices rose (dashed line = first CBSD outbreak, 2004).*

**DATA SOURCES**

- Geo-referenced CBSD outbreaks: Alicai et al. (2019), NARO & IITA survey reports
- Forest loss: Hansen Global Forest Change v1.9 (2001–2023)
- JRC Tropical Moist Forest: separates permanent deforestation from reversible degradation
- Land cover: MODIS MCD12Q1 • plus climate, population and night-lights controls

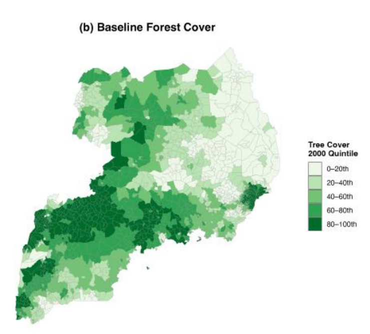
## FROM OUTBREAK RECORDS TO FOREST LOSS: A staggered difference-in-differences design

### 1 TRACK THE DISEASE FRONTIER



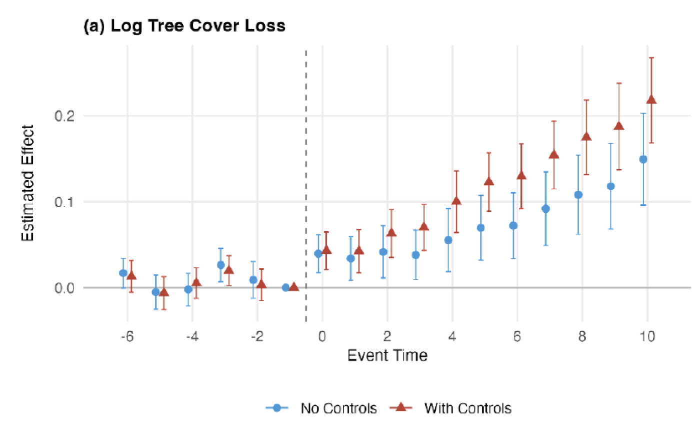

Geo-referenced outbreak records date each sub-county's first CBSD arrival as the epidemic sweeps Uganda, 2004–2017.

### 2 MEASURE FORESTS FROM SPACE




Hansen tree-cover loss, JRC TMF deforestation and degradation, and MODIS land-cover classes for all 1,467 sub-counties.

### 3 ESTIMATE THE CAUSAL EFFECT




Event studies around each unit's first outbreak: Callaway–Sant'Anna, Sun–Abraham, SDID and TWFE estimators.

### 4 TRACE THE MECHANISM

**Table 10.4 — Mechanism: Land Cover Transitions (MODIS IGBP)**

| MODIS Class | Description | Pre-Mean ($km^2$) | ATT | SE |
|---|---|---|---|---|
| *Expanding* | | | | |
| Class 12 | Cropland (>60% cultivated) | 26.1 | $3.929^{***}$ | (0.819) |
| *Declining* | | | | |
| Class 14 | Crop/natural mosaic (40–60%) | 51.6 | $-2.595^{***}$ | (0.850) |
| Class 8 | Woody savanna (30–60% tree) | 17.9 | −2.091 | (1.621) |
| Class 10 | Grassland | 44.7 | −1.858 | (1.817) |
| Class 1–5 | Forest (>60% tree cover) | 4.1 | −0.326 | (0.233) |

MODIS land-cover transitions reveal which landscape classes expand and which give way after outbreaks.

**IDENTIFICATION CHECKS** No detectable pre-trends • estimates consistent across four estimators • unit and year fixed effects • climate, population and night-lights controls

## 4. RESULTS: FORESTS PAY FOR THE DISEASE

**+13.7%**
tree-cover loss after outbreak
Hansen; Callaway–Sant'Anna ATT

**−22.7%**
forest degradation
JRC TMF; potentially reversible loss

**Table 10.3 — Effect of CBSD Outbreaks on Deforestation**

| | C&S (1) | Sun-Abraham (2) | SDID (3) | TWFE (4) |
|---|---|---|---|---|
| *Panel A: Log Hansen Tree Cover Loss* | | | | |
| ATT | $0.128^{***}$ | $0.082^{***}$ | $0.094^{***}$ | $0.040^{***}$ |
| | (0.015) | (0.014) | (0.013) | (0.014) |
| Pre-treatment mean (log) | 0.134 | 0.134 | 0.134 | 0.134 |
| Relative effect (%) | +13.7 | +8.5 | +9.8 | +4.0 |
| *Panel B: Log TMF Deforestation* | | | | |
| ATT | $0.029^{***}$ | $0.020^{***}$ | 0.012 | 0.016 |
| | (0.007) | (0.007) | (0.007) | (0.010) |
| Relative effect (%) | +3.0 | +2.0 | +1.2 | +1.6 |
| *Panel C: Log TMF Degradation* | | | | |
| ATT | $-0.258^{***}$ | $-0.163^{***}$ | $-0.164^{***}$ | $-0.104^{***}$ |
| | (0.031) | (0.031) | (0.034) | (0.035) |
| Relative effect (%) | −22.7 | −15.0 | −15.1 | −9.9 |
| Controls | Yes | Yes | Yes | Yes |
| Unit FE / Year FE | Yes | Yes | Yes | Yes |
| Observations | 29,340 | 29,340 | 29,340 | 29,340 |
| Units | 1,467 | 1,467 | 1,467 | 1,467 |

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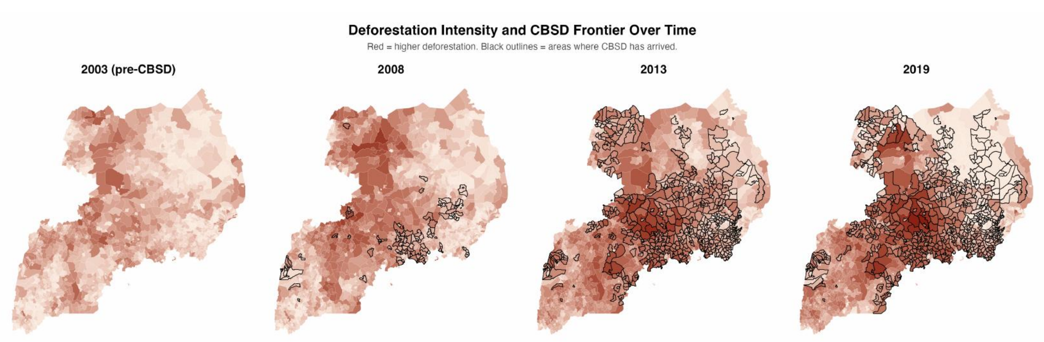
- Permanent deforestation (TMF) rises by up to 3% while degradation falls sharply.
- Land that would otherwise face only selective logging or fuelwood extraction is instead fully cleared to accommodate expanded cassava cultivation.

## 5. MECHANISM: INTENSIFICATION

**+15%**
pure cropland
>60% cultivated (MODIS Class 12)

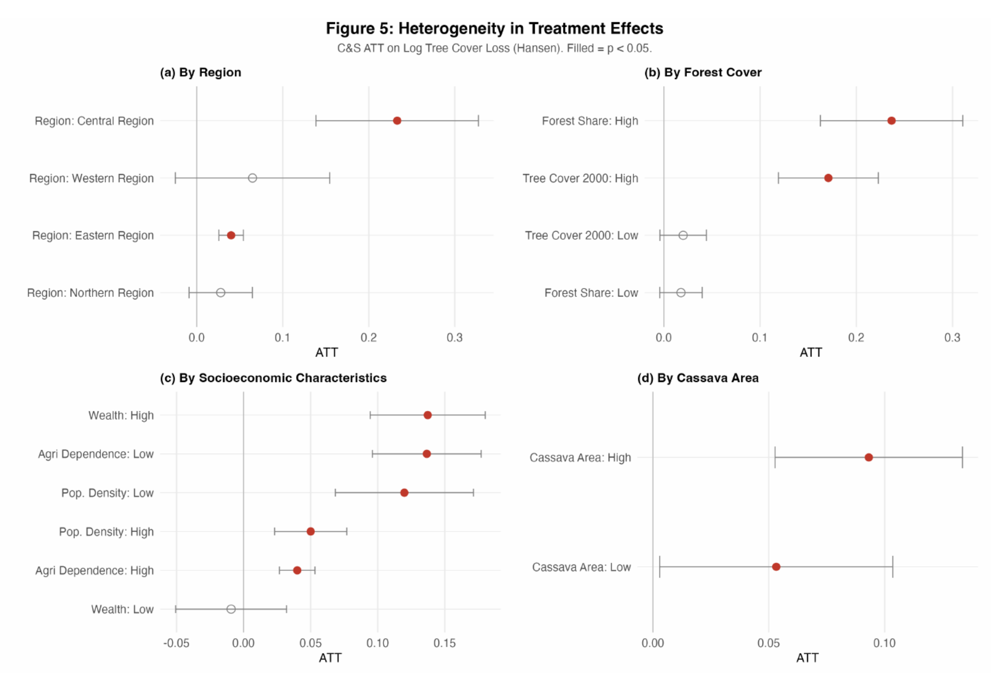
**−5%**
crop-natural mosaics
40–60% cultivated (Class 14)

- After an outbreak, cropland expands by ≈3.9 km² per sub-county while mosaics, woody savanna and grassland all decline.
- Dense primary forest (>60% tree cover) barely changes — only 3.6% of the average unit to begin with.
- CBSD drives landscape intensification of partially cultivated mosaics into full cropland, not frontier encroachment into virgin forest.




*Deforestation intensity (red) deepens as the CBSD frontier (black outlines) advances, 2003–2019.*

## 6. WHO CLEARS — AND WHY IT MATTERS




- Effects are concentrated in the Central region and in sub-counties with high baseline forest cover and high cassava area.
- Wealthier, less agriculture-dependent and low-density areas clear the most — clearing requires resources, not just need.

**Disease control is also climate policy.** The carbon cost of disease-driven clearing belongs in cost–benefit analyses of resistant varieties and phytosanitary systems — leaving it out means systematic underinvestment.

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**CROP DISEASE SHOCKS LEAVE A LASTING FOOTPRINT ON FORESTS — CBSD SHIFTED UGANDA'S LANDSCAPES FROM REVERSIBLE DEGRADATION TO PERMANENT CLEARING**

Indiana University Bloomington