

Drought Risk on Common Bean (*Phaseolus vulgaris* L.) in Rwanda — 2003–2025

A 23-year district-level Bayesian, Machine-Learning and Copula framework

1. Inputs

Data sources & coverage



Bean area, production, price

NISR · MINAGRI · FAOSTAT



Rainfall (CHIRPS v2.0)

5 km grid · monthly · 1981–



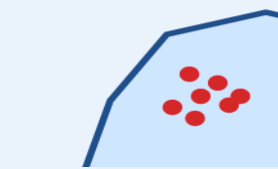
Temperature & PET (ERA5-Land)

ECMWF / Copernicus C3S



Soils (SoilGrids) · DEM (SRTM)

ISRIC · USGS



23 yrs × 30 districts × 690 obs

All five provinces (East, South, West, North, Kigali)

2. Advanced Analytics

Six complementary methods



1. Bai–Perron change-point

Break in 2019 · sup-Wald $F = 18.7$ ($p < 0.01$)



2. Bayesian hierarchical (brms)

Slope -0.034 t/ha/yr · 94 % HDI $[-0.056, -0.012]$



3. Random Forest + SHAP

OOB $R^2 = 0.71$ · drivers: SPEI-3, ΔT_{max} , P



4. Gaussian copula (compound)

$\hat{\rho} = 0.62$ $[0.55, 0.68]$ · hot-dry $\approx 6\times$ independence



5. Moran's I + LISA

$I = 0.41$ ($p = 0.001$) · 7 High–High districts



6. LSTM + split-conformal

Coverage 0.92 @ 0.90 nominal · forecast to 2030

3. Key Findings

Headline results & adaptation



USD 1.057 billion

Cumulative drought loss, 2015–2025 (2024 const.)



-0.034 t/ha · yr

Post-2019 national yield decline (94 % HDI)



$\hat{\rho} = 0.62$

Tail dependence of compound hot-dry hazard



7 districts

Eastern Province High–High drought-risk cluster

District-targeted adaptation



Drought-tolerant bean varieties (RWR, NUA-types)



Supplementary & micro-irrigation in Eastern districts



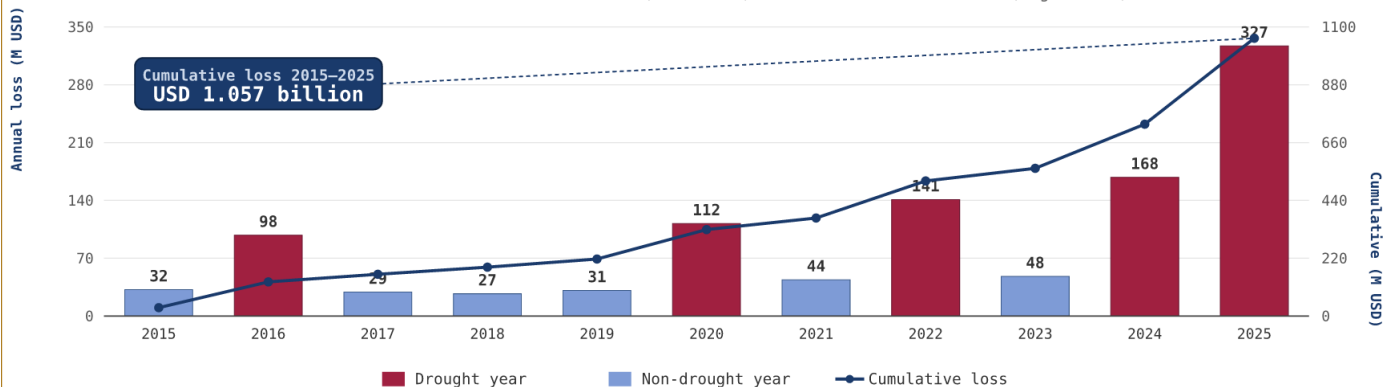
Index-based crop insurance + price stabilisation



Climate-smart advisory scaling via NAEB / RAB

Annual drought-attributable bean loss in Rwanda (M USD, 2024 const.)

2015 – 2025 · bars = annual loss (left axis) · line = cumulative loss (right axis)



Dushime Jean Claude. (2026) · University of Rwanda · <https://github.com/ITClaude/Assessment-of-Drought-Risk-in-Common-Bean> · MIT licence · Journal of Agriculture and Food Research