

Yield recording in practice: Implications for Cocoa Yield Improvement



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Background

- Cocoa pods mature **throughout the year**, requiring repeated harvests to estimate annual yield accurately.
- In large on-farm trial networks, harvests are often **incomplete and irregularly spaced** due to logistical constraints.
- This makes annual yields difficult to **estimate consistently and compare across farms**.
- **Research gap:** A scalable method is needed to derive **reliable, comparable annual yields from irregular/incomplete on-farm harvest records**.

Objectives

- Develop a statistical method to estimate standardised annual cocoa yields from partial, irregularly timed on-farm harvest records.
- Test whether the method can also recover meaningful yield responses to treatments (e.g., fertiliser).

Methods

Study area & data

On-farm trials in Cameroon, Côte d'Ivoire, Ghana and Nigeria (CocoaSoils programme, 2020–2025); each site carries four treatments, from farmer practice to fertiliser at two rates.

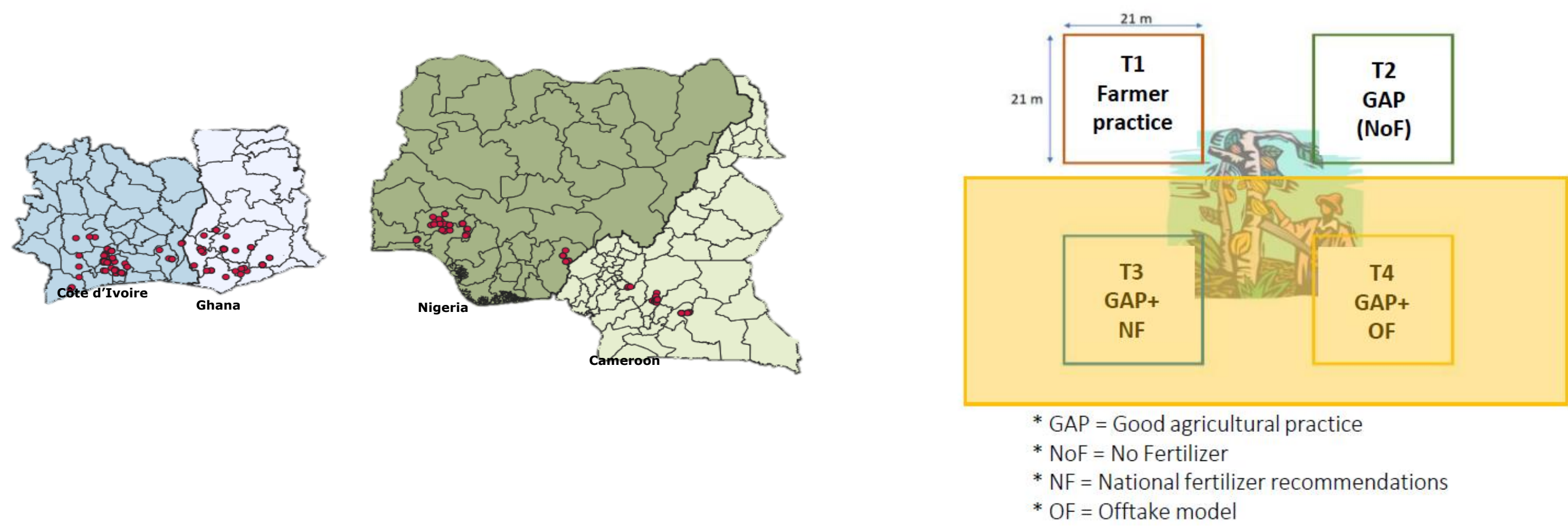


Figure 1. Left: CocoaSoils Satellite Trials. Right: Treatments defined as: T1 = current farmer practice; T2 = weeding, pruning, and pesticide application without fertiliser; T3 = T2 plus NPK fertiliser added at the nationally recommended rate; and T4 = T2 plus NPK fertiliser added at the estimated offtake rate.

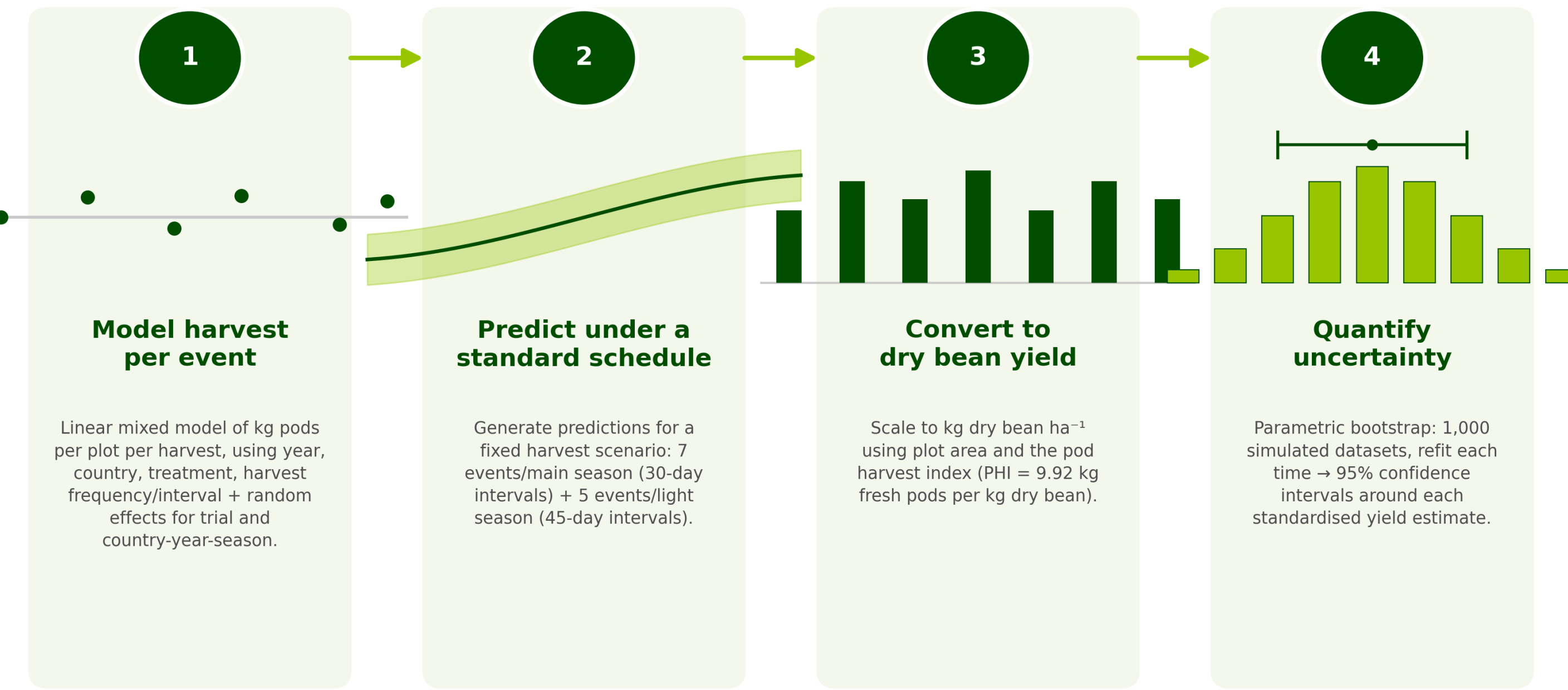


Figure 2. Workflow for estimating standardised annual cocoa yields from partial, irregular harvest records.

Results

Harvest dynamics

Harvested quantity per event fell as harvests became more frequent and increased with longer intervals, consistent with pod accumulation between visits. Days since the season start had opposite effects in the main vs. light season. Fixed effects explained 25% of the variance, rising to 58% once trial- and site-level random effects were included.

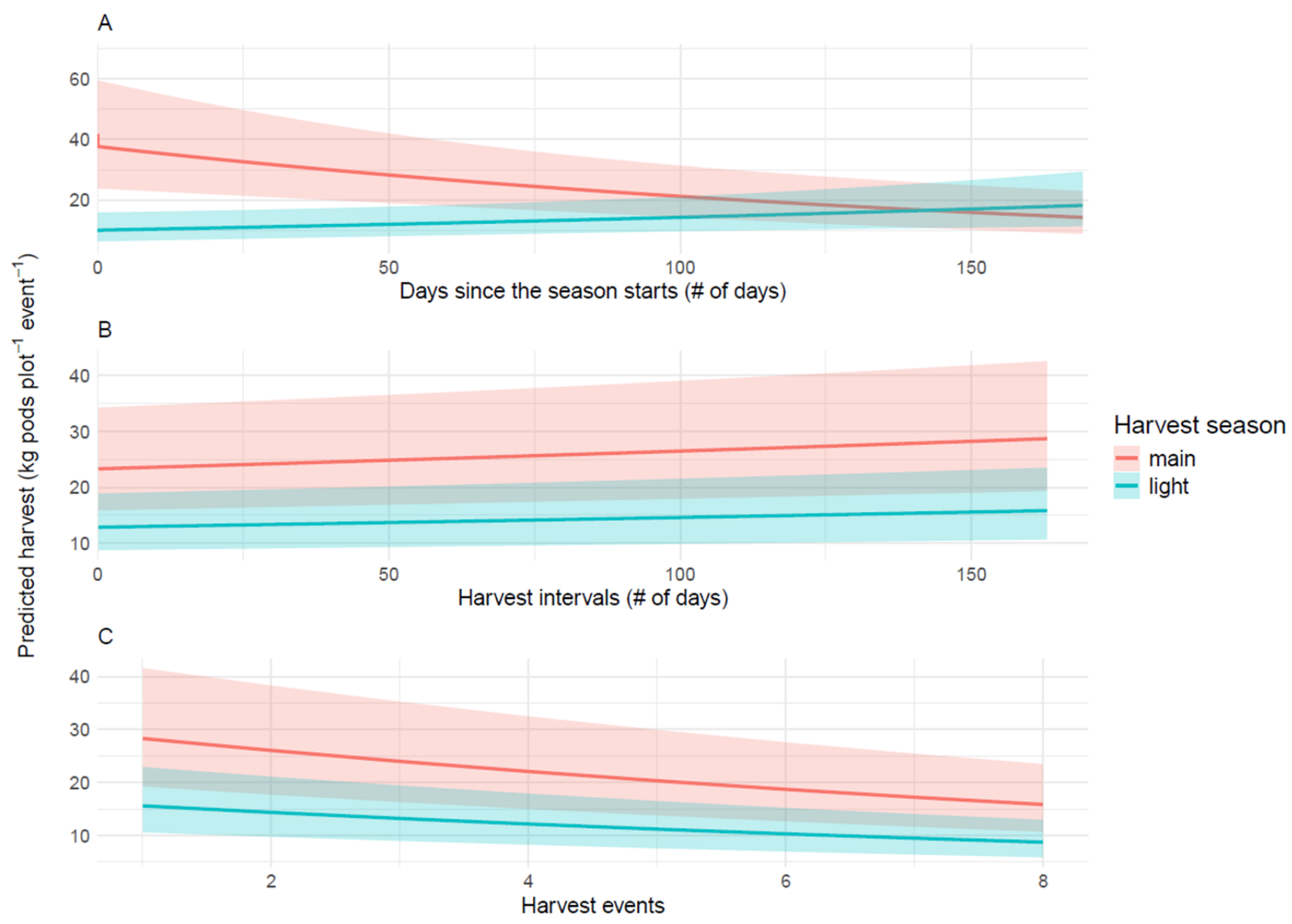


Figure 3. Relationship between harvest dynamics and predicted cocoa harvest per event: (A) days since the season start, (B) harvest interval, and (C) number of harvest events, by season.

Table 1. Standardised* annual cocoa yield (kg dry beans ha⁻¹) by treatment and country, averaged across five evaluation years, with 95% confidence intervals.

Country	T2 no fertiliser	T3 national rate	T4 offtake rate	T3 vs T2	T4 vs T2
Cameroon	554 (450-661)	676 (552-806)	782 (636-934)	+121 (102-146)	+228 (186-274)
Côte d'Ivoire	788 (685-915)	1,100 (961-1,269)	1,248 (1,091-1,435)	+313 (276-355)	+461 (406-520)
Ghana	1,081 (891-1,266)	1,347 (1,107-1,578)	1,450 (1,195-1,694)	+266 (217-312)	+369 (304-428)
Nigeria	404 (343-479)	567 (479-667)	618 (522-732)	+163 (136-188)	+214 (179-252)

*Estimates assume a fixed standardised harvest schedule; absolute values are schedule-dependent, though treatment contrasts are according to this assumption.

Method validation

Internal cross-validation (same-dataset trial-years) showed predictions fell within the model's 95% intervals, consistent with internal reliability, though independent (out-of-sample) validation was not conducted.

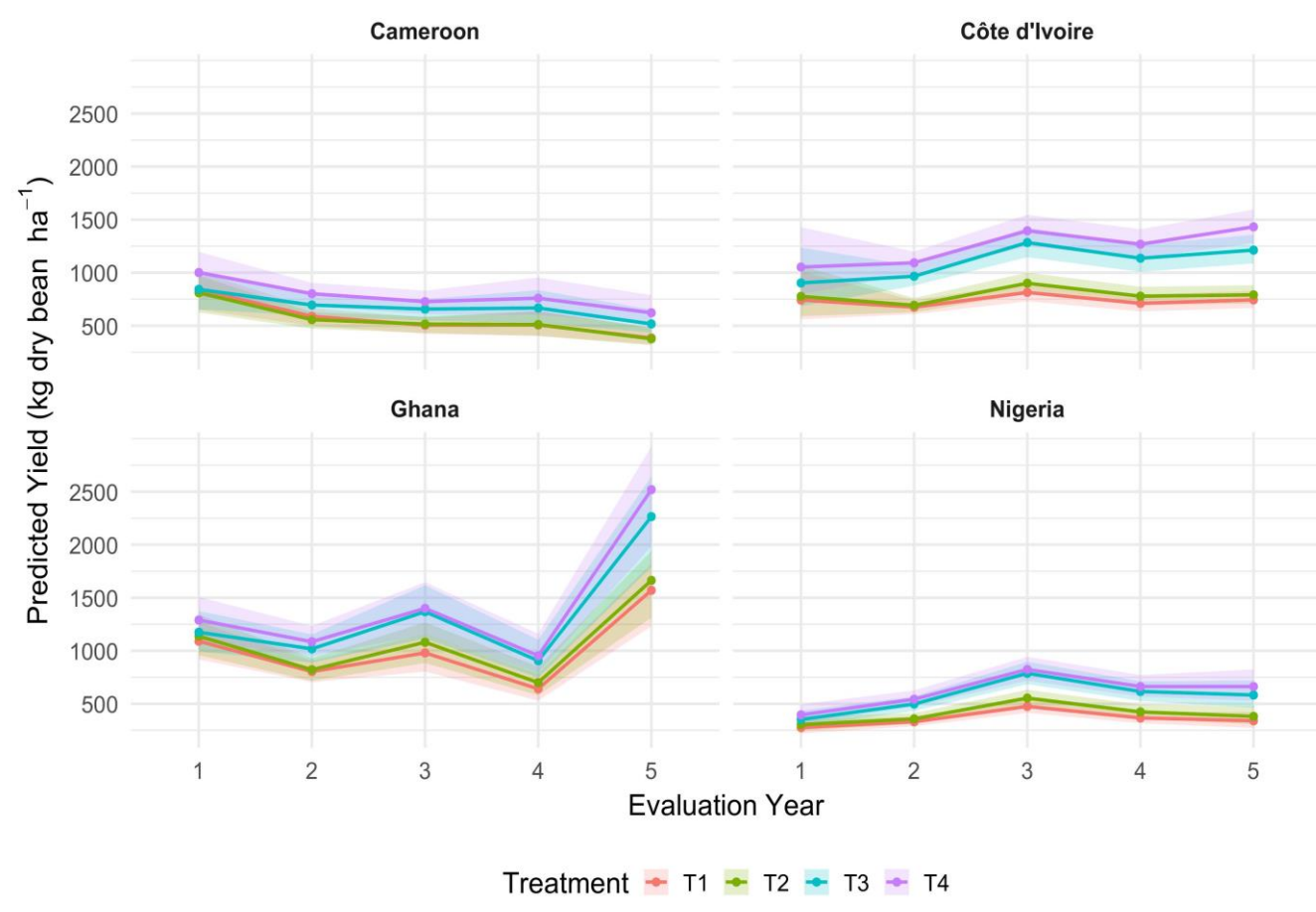


Figure 4. Predicted annual cocoa yield by country, treatment and evaluation year, with 95% confidence intervals.

Key findings

- Fertiliser increased yields in every country; offtake-based rates (T4) consistently outperformed national blanket recommendations (T3) by up to +461 kg ha⁻¹ in Côte d'Ivoire.
- Yields dipped across nearly all countries in evaluation year 4 — a pattern possibly linked to unmeasured climatic or environmental drivers, since these were not explicitly modelled.
- Standardisation sharpened treatment differences that were blurred in the raw, partial harvest data.

Conclusions & implications

Standardised annual yields can be reliably estimated from incomplete, irregular on-farm harvest records, turning a logistical limitation into usable data rather than discarding partial records. Internal cross-validation supports the method's ability to recover annual yield patterns from incomplete trial-years.

Because harvest methodology strongly shapes the yield values a study reports, we highlight the practical challenges of collecting consistent harvest data in cocoa production systems; challenges that should be addressed given the importance of reliable harvest recording for understanding yield trends, market dynamics, and the outcomes of crop improvement interventions.

