Title :

Cross-Origin AI Grading of Post-Harvest Crop Quality

From a Validated Thai Cocoa System Toward a Shared ASEAN Standard for Fair Smallholder Pricing

ASEAN IVO Forum 2026 · Topic 1: ICT for Food



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Project Title: Cross-Origin AI Grading of Post-Harvest Crop Quality

Background : Subtle differences, judged by eye, set the smallholder's price



(a) Normal bean (b) Germinated bean (c) Moldy Bean (d) Slaty Bean

What a grader must tell apart on every cut bean (Thai Trinitario cocoa, Nan Province)

Why this needs AI

Moldy and slaty halves differ from normal ones in subtle color and texture, and fatigue shifts judgement across a 100-bean sample. A vision model applies the same criteria to every bean, every time, and keeps the evidence.

Why ICT for Food

In the post-harvest supply chain, this check decides what is paid and what is downgraded or discarded — on evidence no party can audit. Coffee and cashew grading share the same pattern.

1 **Slow**

A bottleneck at collection centers: inspecting one 100-bean sample takes about half an hour.

2 **Subjective**

Judged by eye against ISO 2451 / ICCO criteria and national standards such as Thailand's TAS 5708-2566; results differ between graders and buyers.

3 **One-sided**

The farmer keeps no independent record of quality, so has little basis to negotiate the price.

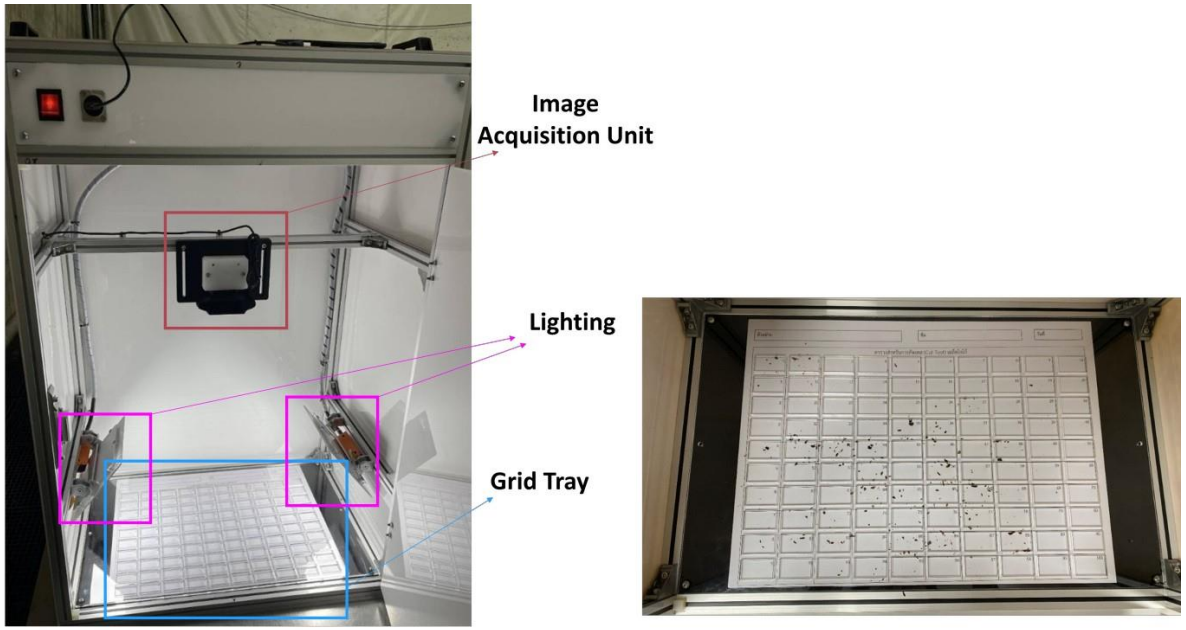
Project Title: Cross-Origin AI Grading of Post-Harvest Crop Quality

Targets: From one Thai origin to a grade that travels across ASEAN

TODAY	TARGET	STATUS
Visual cut test: about 30 min per 100-bean sample, and no stored record	Automated grading in about 5 min, with a stored record shown to farmer and buyer together	Done in Thailand
The grade depends on who inspects the beans	One reproducible machine measurement, checked against local expert graders in each country	Regional project
Model validated on Thai Trinitario cocoa from a single province	A new origin calibrated from a small, locally labeled sample instead of full retraining	Regional project
Each country grades to its own standard	One physical measurement mapped onto each national and ICCO-derived grade definition	Regional project

Proposed Method: Scientific and technological (1/3)

A working station: 30 minutes of inspection cut to 5



Imaging chamber with controlled LED lighting, and the grid tray that separates the half-beans

Controlled imaging

5000 K LED lighting, CRI ≥ 97; a grid tray keeps every half-bean apart.

Inference where grading happens

Runs on an edge computer — no internet needed at the collection center.

Annotated data

8,033 half-beans for fermentation color and 3,522 for defects, labeled to ICCO cut-test criteria; split by image 70/15/15.

Field partner

Built and tested with the Innovation Center for Research and Development of Sustainable Cocoa (ISTC), Nan.

30 → 5 min

end-to-end evaluation per 100-bean sample (–83%)

6×

throughput: 0.05 → 0.33 beans per second

28.2 s

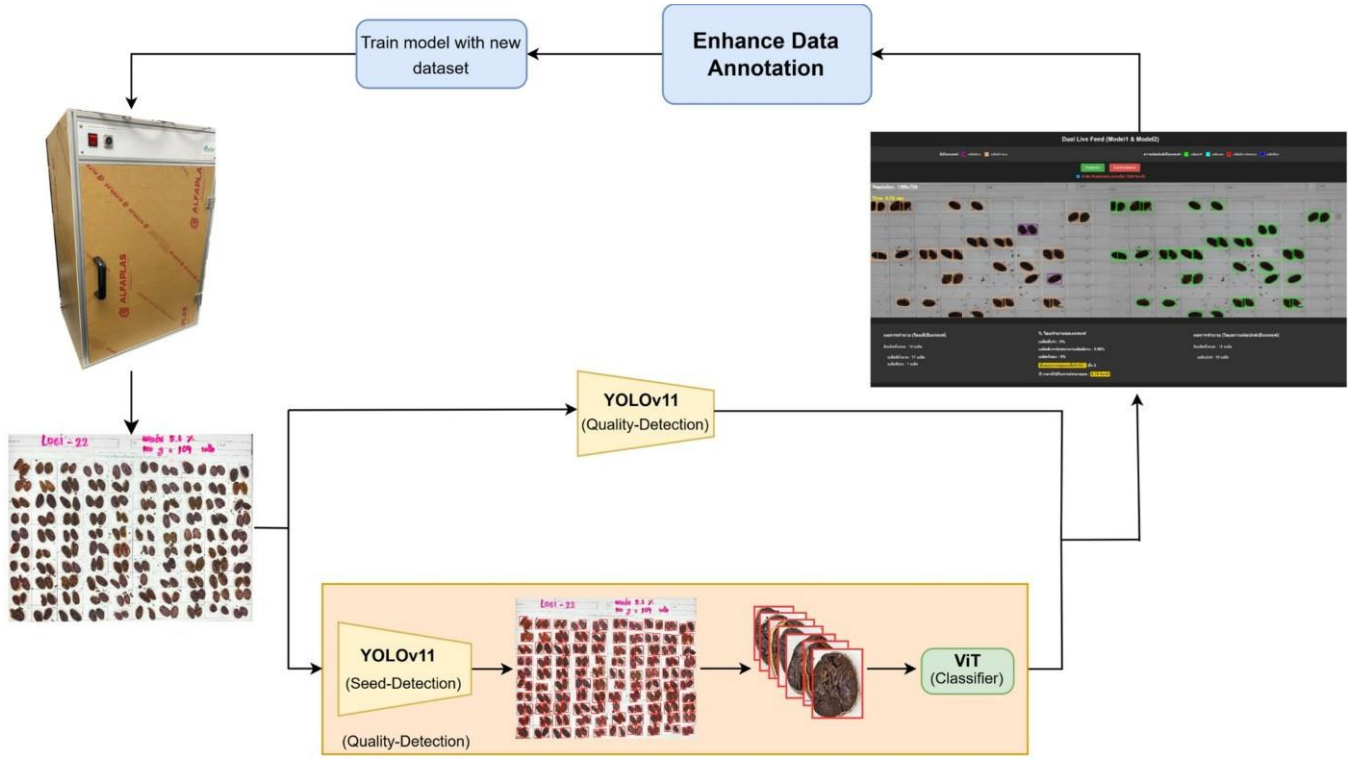
AI inference per 100 beans

4.53 min

mechanical cycle per 100 beans — now the limiting step

Proposed Method: Scientific and technological (2/3)

Fast detector first, transformer only when it is unsure



System pipeline: YOLOv11 detection, conditional ViT classification, and expert-corrected annotations fed back into training

1 **System 1 — every bean**

YOLO detects and grades each half-bean in real time.

2 **System 2 — only uncertain beans**

A crop goes to ViT-B/16 when the top class probability is below 0.75 or the top-2 margin is below 0.15: 14.3% of beans for color, 18.7% for defects.

3 **Experts in the loop**

Uncertain samples are queued for expert review in a web tool; annotation quality rose from 0.87 to 0.95 over three rounds.

Proposed Method: Implementation and field testing (3/3)

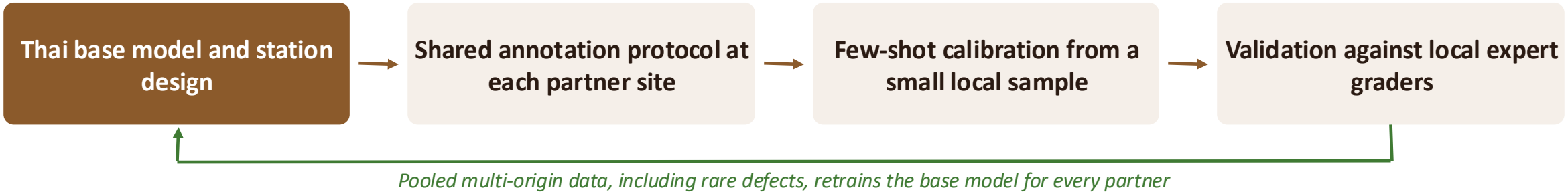
Extending the system to new origins with little new labeling

Why one country cannot do this alone

Origins differ
Genetics, fermentation and drying change what a bean looks like.

Rare defects are rare everywhere
Slaty and hard beans reach only AP50 0.231 on Thai data alone.

Standards differ
Each country grades to its own definitions.

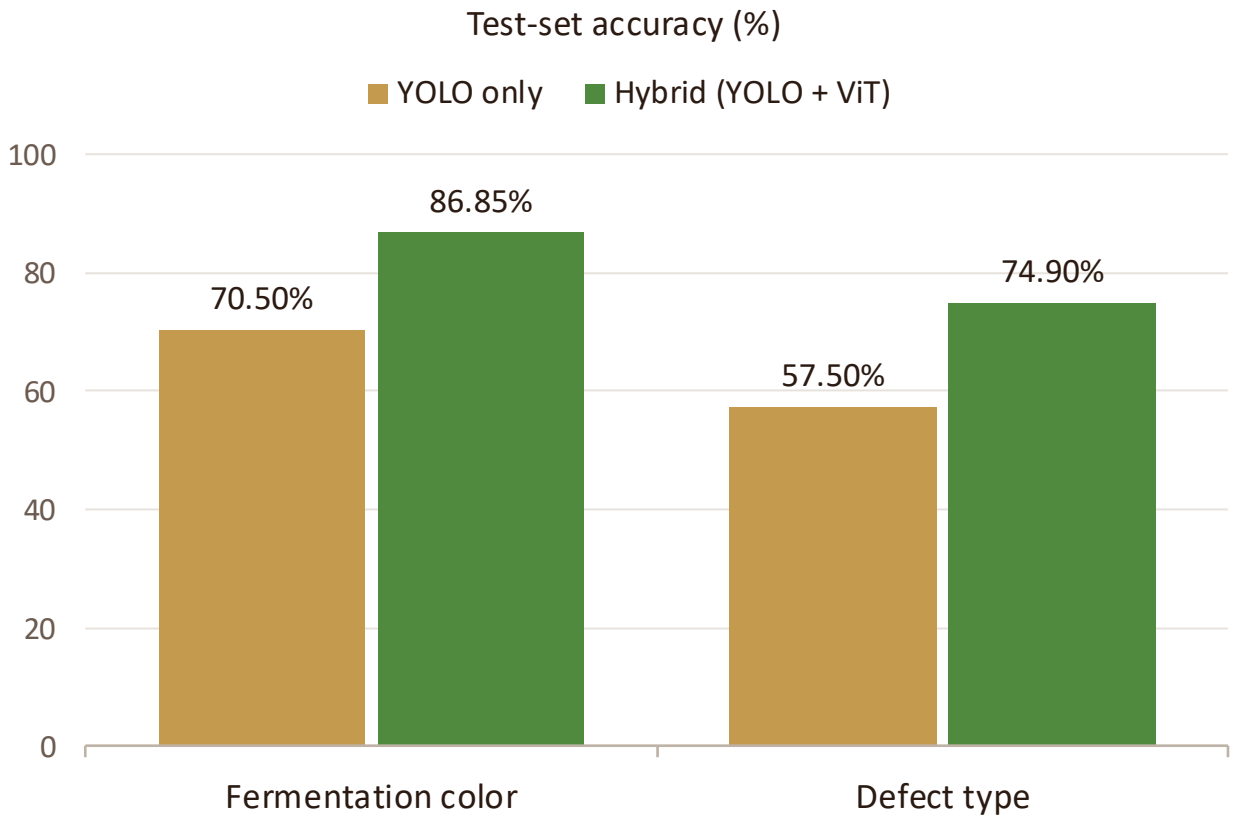


Proposed 24-month plan

Year 1	Annotation protocol and guide · station replicated from locally sourced parts (open bill of materials) · data collection at partner sites · co-supervised students start
Year 2	Calibration experiments (headline metric: labeled samples needed per new origin) · field validation with cooperatives · joint workshop · demonstration

Impact: Scientific and technological (1/3)

Hybrid grading adds 16–17 accuracy points over YOLO alone



Both gains significant at $p < 0.001$ (Cohen's $d = 2.14$ for color, 1.92 for defects). Source: Ruangsang, Na Nan & Aramvith, IEEE Access.

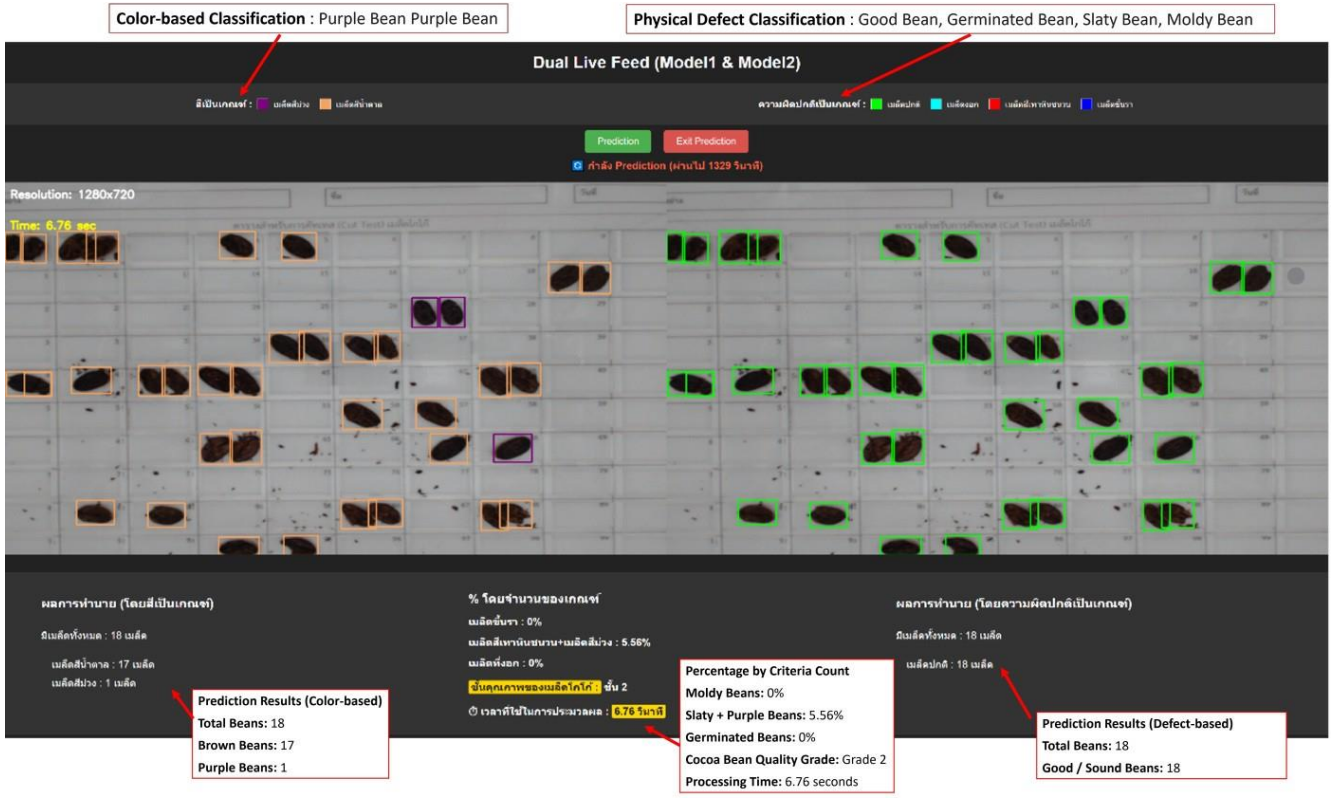
1. **A cross-origin benchmark for ASEAN**
   A shared multi-origin cut-test reference set, extending a Thai set that is, to our knowledge, the largest annotated to date.

2. **A known data budget per new origin**
   Few-shot calibration turns per-site retraining into a small, measured labeling effort — the project's headline metric.

3. **Rare defects become learnable**
   Pooling slaty and hard beans across countries targets the weakest class directly.

Impact: Societal (2/3)

Farmer and buyer see the same result at the point of sale



Live dashboard: per-bean color and defect results, batch grade and processing time on one screen

Contributes to SDG 1 · SDG 8 · SDG 9 · SDG 10

Price on evidence

An auditable third-party record gives smallholders a basis to negotiate.

Feedback that improves beans

Per-batch results show where fermentation falls short — a route to premium grades.

Less loss without evidence

Lots are downgraded or discarded on a measured, reviewable basis.

Shared, not owned

Viable at collection-center scale (projected 61% lower grading cost per batch; payback about 11 months at 100 t/year), so delivered through cooperatives or a mobile service.

Impact: Collaborative (3/3)

A consortium in formation across ASEAN and Japan

LEAD

Thailand

Chulalongkorn University

AI, edge hardware, coordination; ISTC field site, Nan

CORE TEAM

Thailand

KMUTT

Detection and super-resolution for fine-grained defects

IN FORMATION

Japan

Osaka

Embedded vision, model efficiency, co-supervision

IN FORMATION

Philippines

UP Diliman

Origin dataset and field validation

IN FORMATION

Lao PDR

National University of Laos

Coffee-origin validation, capacity building

IN FORMATION

Myanmar

UCS Yangon

Annotation and calibration for local origins

SEEKING PARTNER

Indonesia

Agricultural institution

Cocoa from a major producing country

SEEKING PARTNER

Cambodia

Agricultural institution

Cashew; adds a third CLM country

Adds: CLM participation (Lao PDR, Myanmar; Cambodia sought) · a jointly owned dataset · co-supervised students · cooperatives and collection centers involved from year 1

Output/Outcome: Scientific and societal (1/2)

What the project will leave behind

Scientific

1. Cross-origin calibration method, reported with its labeled-sample budget per new origin
2. Multi-origin reference image set and shared annotation protocol, open to ASEAN IVO members
3. Benchmark results including rare-defect classes; joint publications

Societal

1. Open bill of materials: a grading station built from locally sourced parts
2. Stations validated at cooperatives and collection centers in partner countries
3. Operator and annotation guides; a documented mapping to national and ICCO-derived grades for standards bodies

Indicators measurable within the project

Cohen's κ

machine-to-expert agreement at each site

Samples per origin

labeled data needed to reach target accuracy

Sites and users

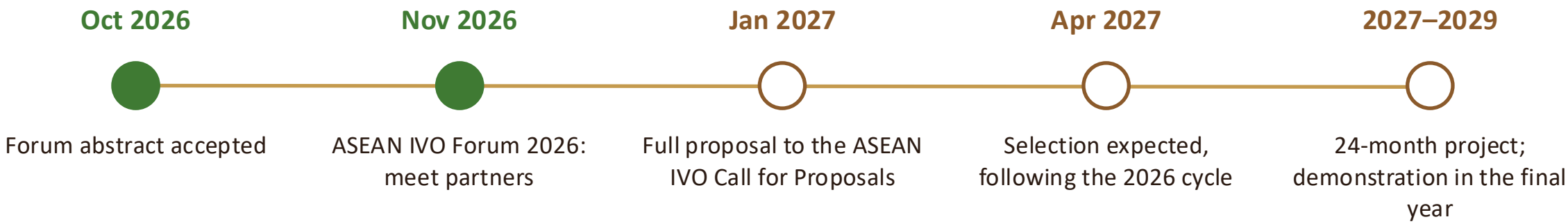
cooperatives and centers adopting the station

Rare-defect AP

gain from pooled multi-origin data

Output/Outcome: Collaborative (2/2)

Partners, people and a path to the 2027 proposal



1

New partnerships

Research links with institutions in at least three ASEAN countries plus Japan, built around shared data and a common protocol.

2

People

Co-supervised postgraduate researchers and a joint hands-on workshop on edge AI for agricultural quality assessment.

3

Existing support

Thailand Science Research and Innovation Fund (Chulalongkorn University) and a Chulalongkorn social-innovation program for the Thai prototype and field tests.

Conclusion:

An auditable grade, calibrated for every ASEAN origin

1

Targets

Replace the eye-based cut test with a machine measurement both sides can audit — one that works across origins and grade standards.

2

Method (idea)

A validated Thai station — YOLO with conditional ViT, experts in the loop, 30 → 5 min — extended by shared annotation and few-shot calibration at partner sites.

3

Scientific and societal impact

A multi-origin benchmark with a known data budget per new origin, and evidence-based pricing for smallholders through cooperative-owned stations.

Seeking partners in Indonesia and Cambodia — institutions working on cocoa, coffee or cashew quality. Contact: supavadee.a@chula.ac.th

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