XX Conferencia Internacional sobre PALMA DE ACEITE
20th International Oil Palm Conference

EL PODER TRANSFORMADOR DE LA PALMA DE ACEITE

A data-driven approach to close yield gaps in smallholder oil palm fields

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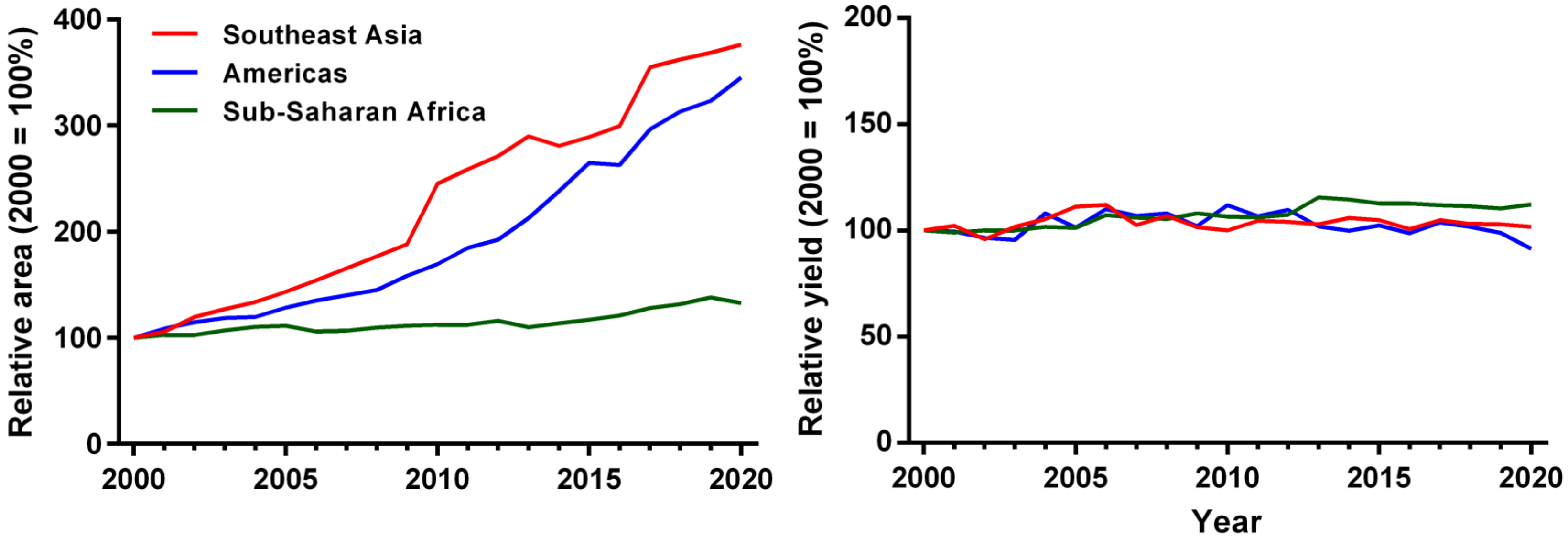
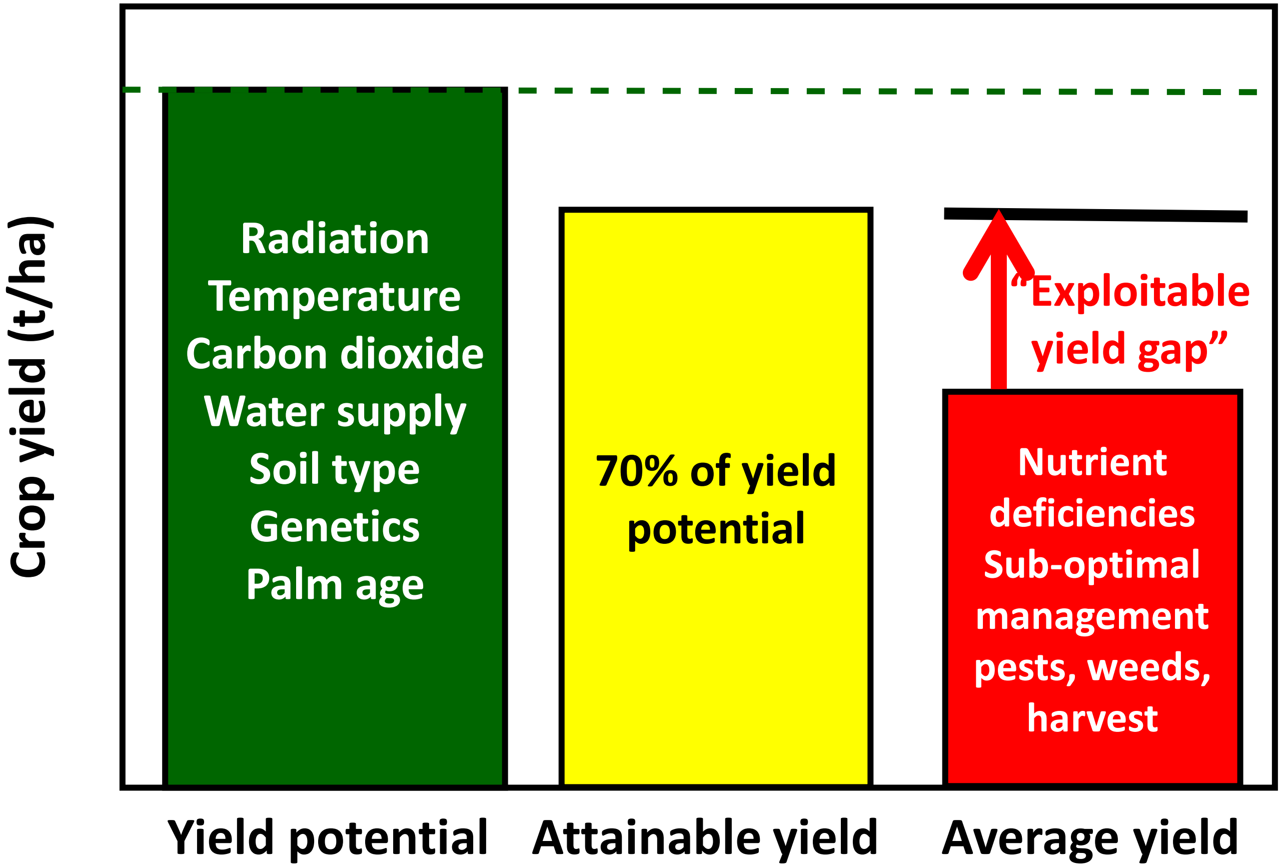
Intensification in oil palm: are we on the right track?

During the past 20 years, palm oil production has increased driven by area expansion, with average FFB yield remaining stable



Based on FAOSTAT (2000-2020)

Genetics is not all: good agronomy needed for high yields



Attaining 70% of the yield potential is a reasonable target for farmers with access to inputs, markets, and extension services. The <u>exploitable yield gap</u> is the difference between the attainable yield and average plantation yield

Adapted from van Ittersum *et al.*, Field Crops Research (2013)

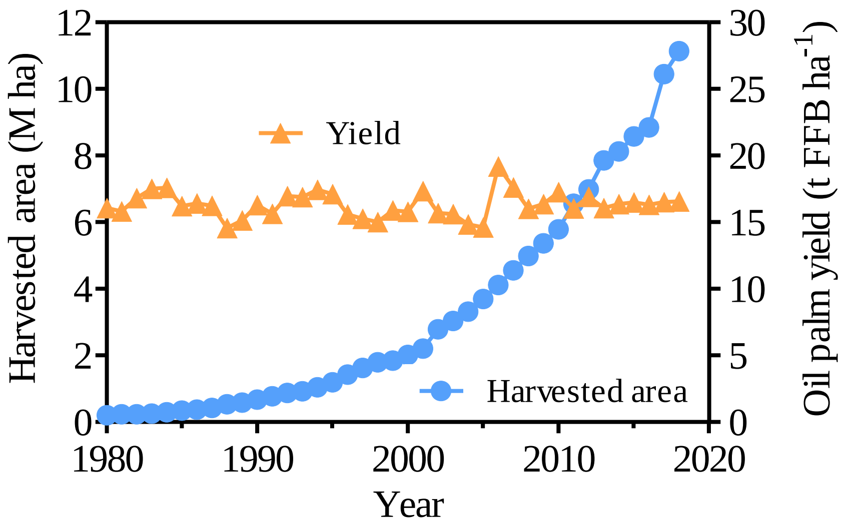
Limitations of on-farm field research to identify yield constrains

Photos: P. Grassini, K.G. Cassman, & J. Wendt

Analysis of farmer data can help identify suites of management practices that consistently lead to higher yields and/or input-use efficiencies for given climate and soil type

Case study: oil palm in Indonesia

- **During the past 25 years, crude palm oil (CPO) has increased driven by area expansion (+0.5 million ha per year), without increase in average yield.**

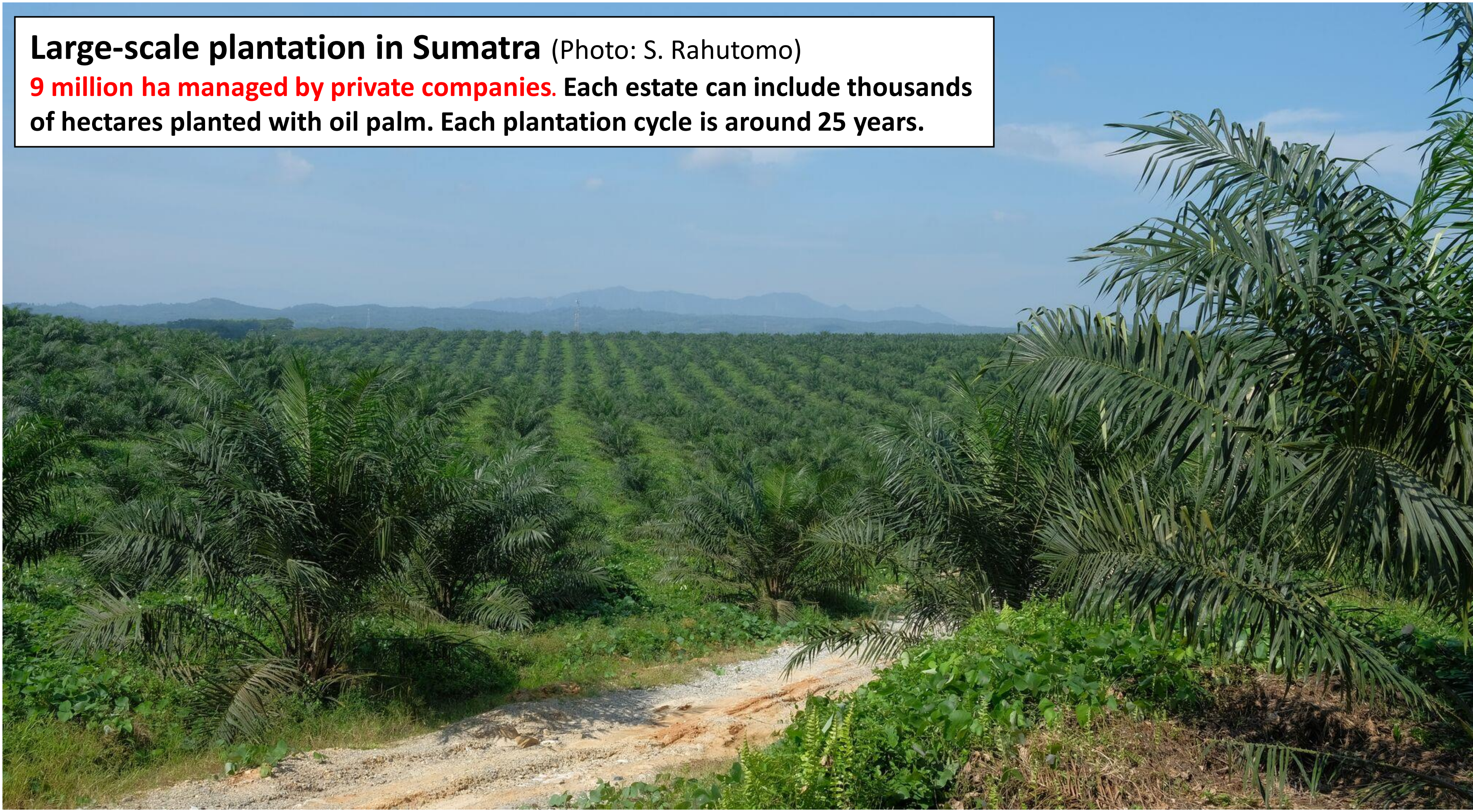


- **One third of past expansion at expense of forests & peatlands, with biodiversity loss and GHG emissions (Austin et al., 2019).**
- **Indonesia has made progress to slow down deforestation in recent years (UN-REDD, 2021).**
- **Oil demand and price projected to increase during the next decade (OECD-FAO Agricultural Outlook, 2020-2030)**

Can intensification on existing oil palm plantation area help Indonesia reconcile production and environmental goals?*

Achieving the required degree of intensification is only one piece of the challenge; it must be complemented with appropriate policies and institutions to ensure land sparing for nature

Norwegian Ministry
of Foreign Affairs



Large-scale plantation in Sumatra (Photo: S. Rahutomo)

9 million ha managed by private companies. Each estate can include thousands of hectares planted with oil palm. Each plantation cycle is around 25 years.

Smallholder plantation in Kalimantan/Borneo (Photos: P. Grassini).

6 million ha managed by smallholder farmers – **each managing around 2 hectares of oil palm – low productivity**

Efforts to increase yield focused on replanting programs – not much into agronomic management of current plantations

Project on oil palm intensification

- **Four-year project with focus on independent smallholder plantations located in mineral soils (started by mid 2019)**
- **Goal: identify causes for yield gaps and evaluate cost-effective management options to increase yield**
- **Partners from IOPRI/PPKS, IAARD, local Indonesian NGOs and farmer groups**
- **Inclusive approach involving Indonesian large plantations , farmer's associations, and universities.**

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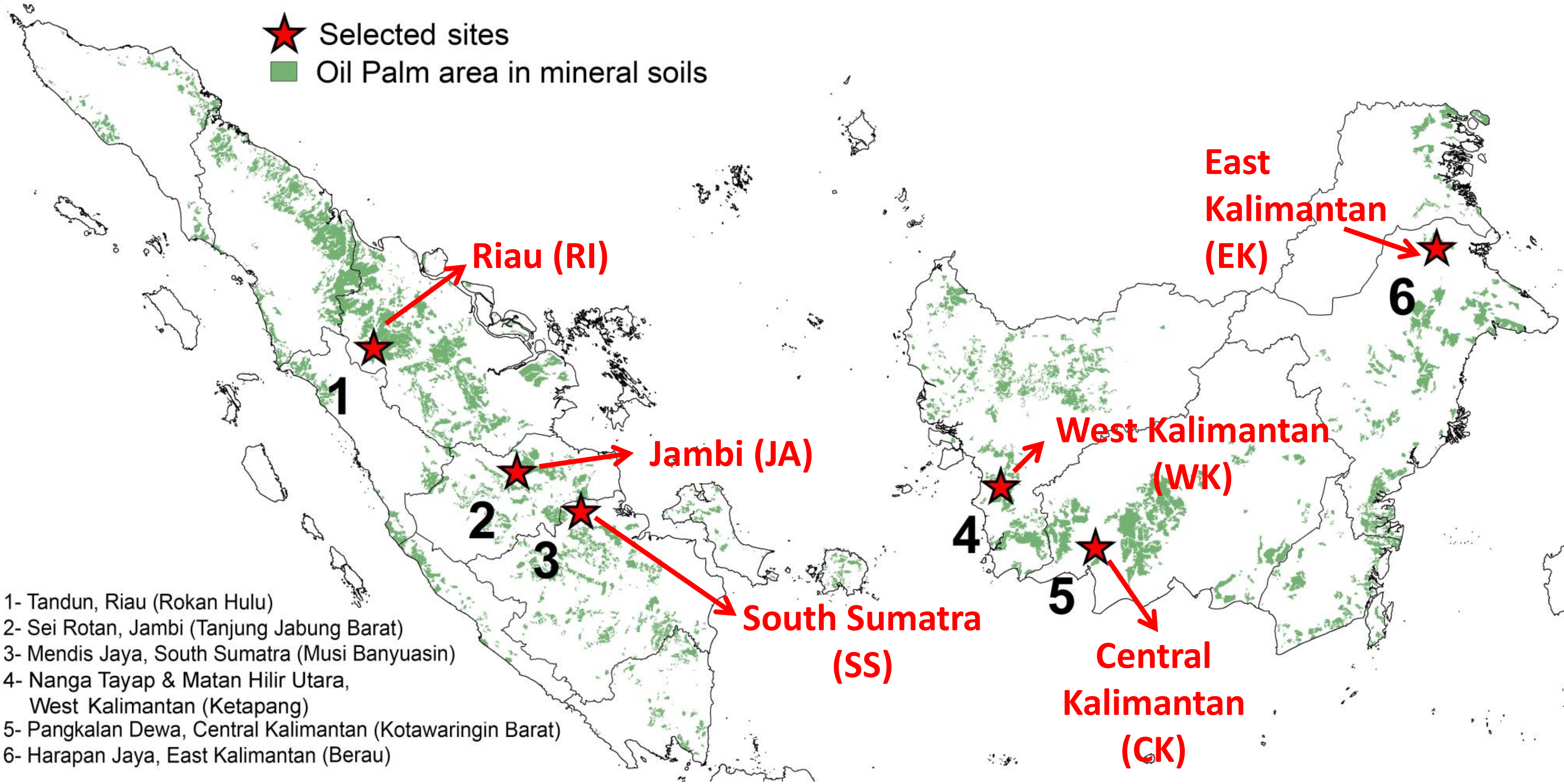
PLAN B Creating Sustainable Human Landscapes

Sites across six provinces



Monzon *et al.* (in preparation)

Main activities

- **Survey of 1200 farmers (200 per province)**

  → **Diagnosis of the socio-economic and agronomic causes for yield gaps**

- **Demonstration of best management practices (BMPs)**

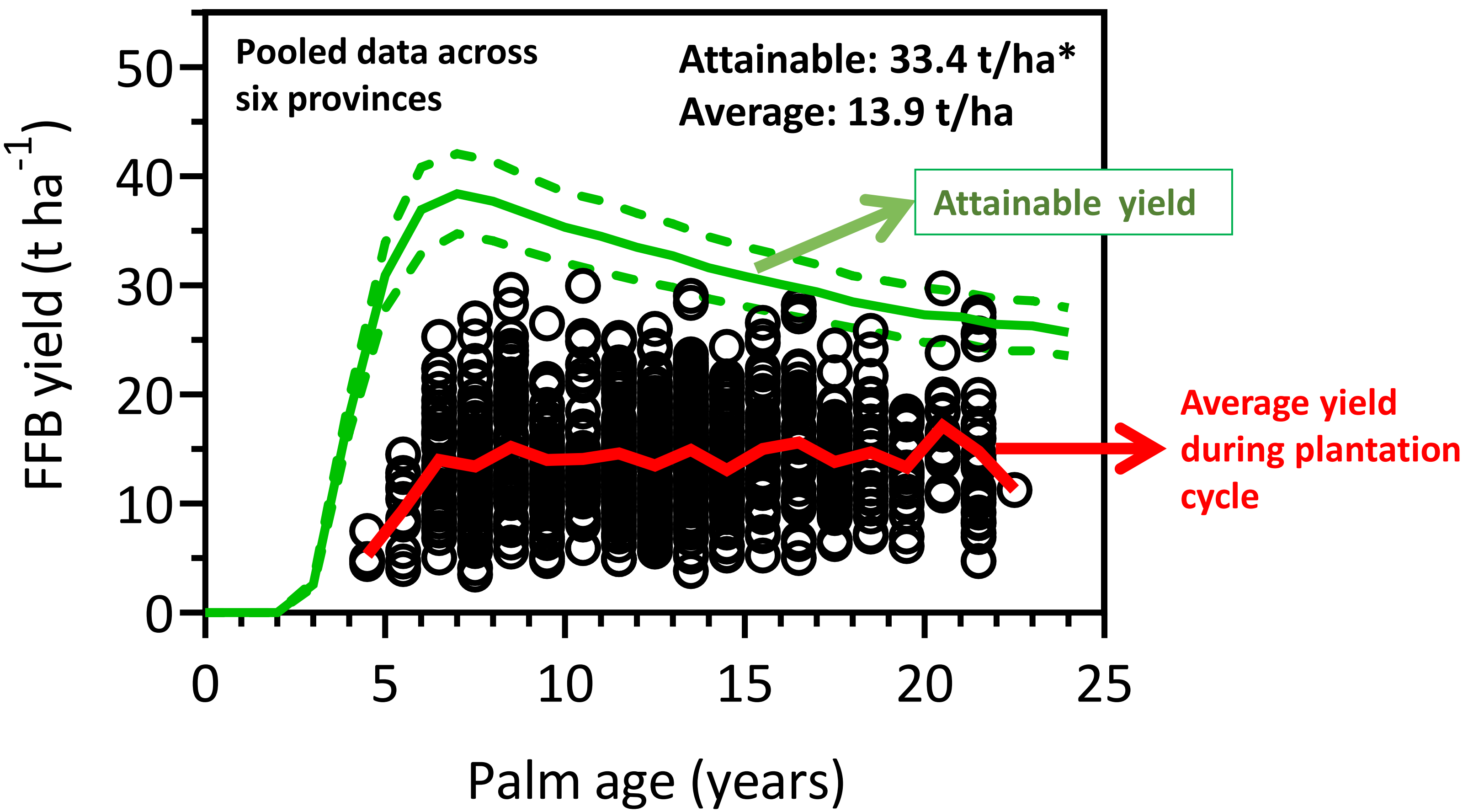
  → **Increasing yield & profit in smallholders farms**

- **Inform policy and orient investments on agricultural research and development (AR&D)**

  → **Contribute to the "solutions agenda" and scaling out**

Large yield gaps in smallholder fields

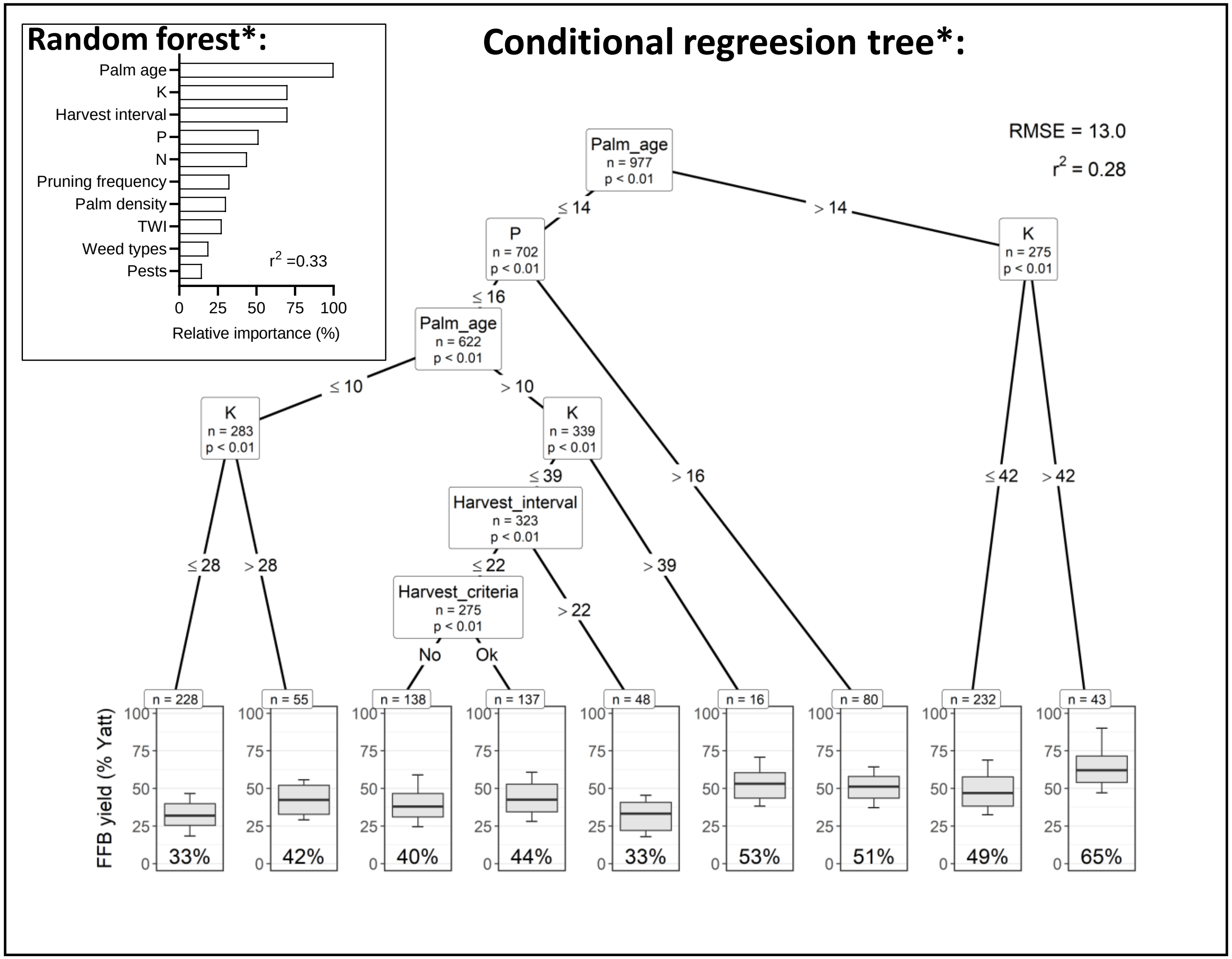
Average FFB yield (13.9 t FFB t/ha/y) represents only 42% of the attainable yield*
Large variation in yield at any palm age. Smallholder fields missed the productivity peak.



* Attainable yield estimated as 70% of the yield potential as determined using a well-calibrated crop model (PALMSIM, Hoffman et al., 2014) and based on local weather, soil type, and palm age. Average attainable yield across the seven provinces was 33.4 t FFB ha^{-1} y^{-1}. The analysis is based on two years of yield data (2020-2021) and 2-year averages are shown here.

Causes for yield gaps

Regression trees and random forest analyses identified agronomic practices explaining gaps

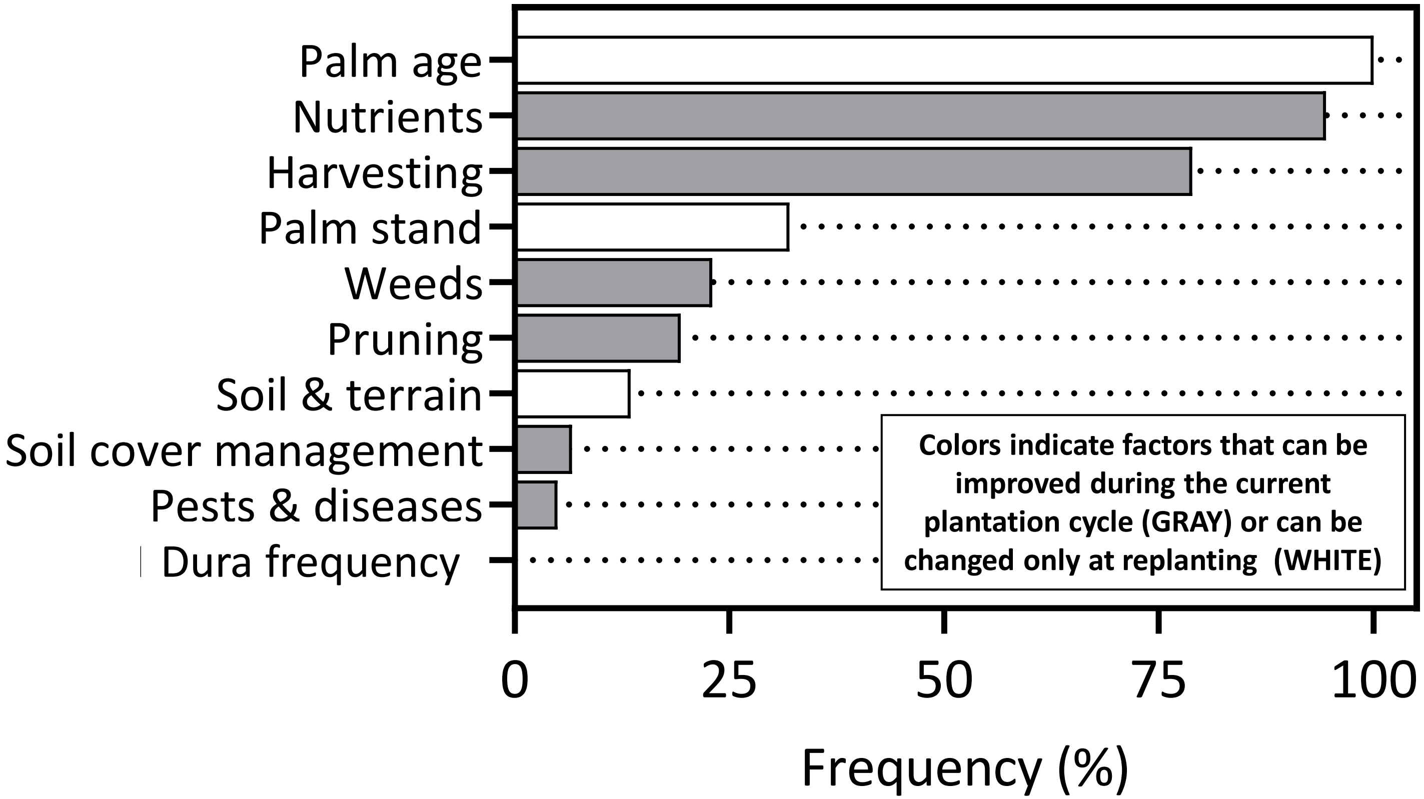


***Based on analysis of the pooled data across provinces. The analysis is based on two years of data (2020-2021), using 2-year average yields.**

Monzon *et al.*, in preparation

Causes for yield gaps

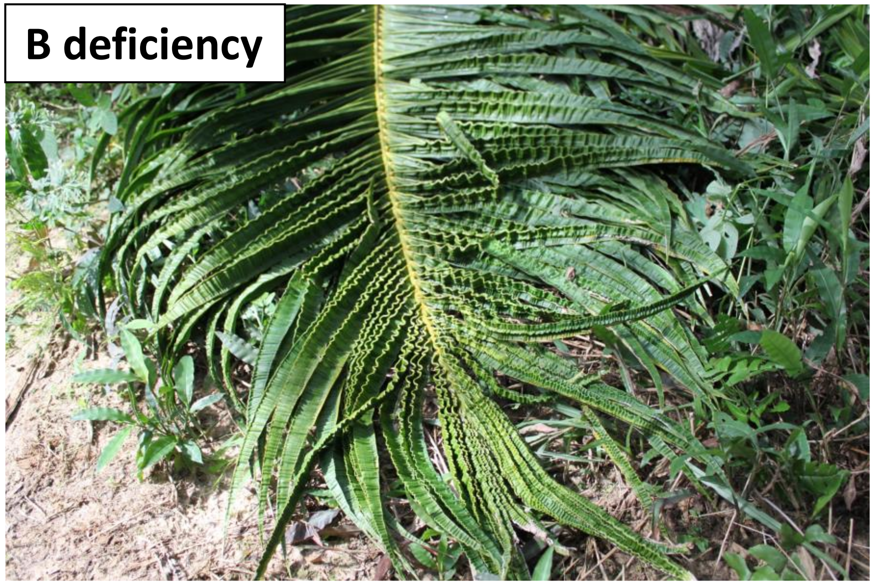
Nutrient, harvest, weed, and pruning management were key factors explaining yield gaps. Palm age and palm stand also explained gaps but cannot be modified within current cycle. Use of non-certified planting material reduces oil extraction rates and oil yields.



Monzon *et al.*, in preparation

Nutrient deficiencies

K deficiency



B deficiency

Mg deficiency

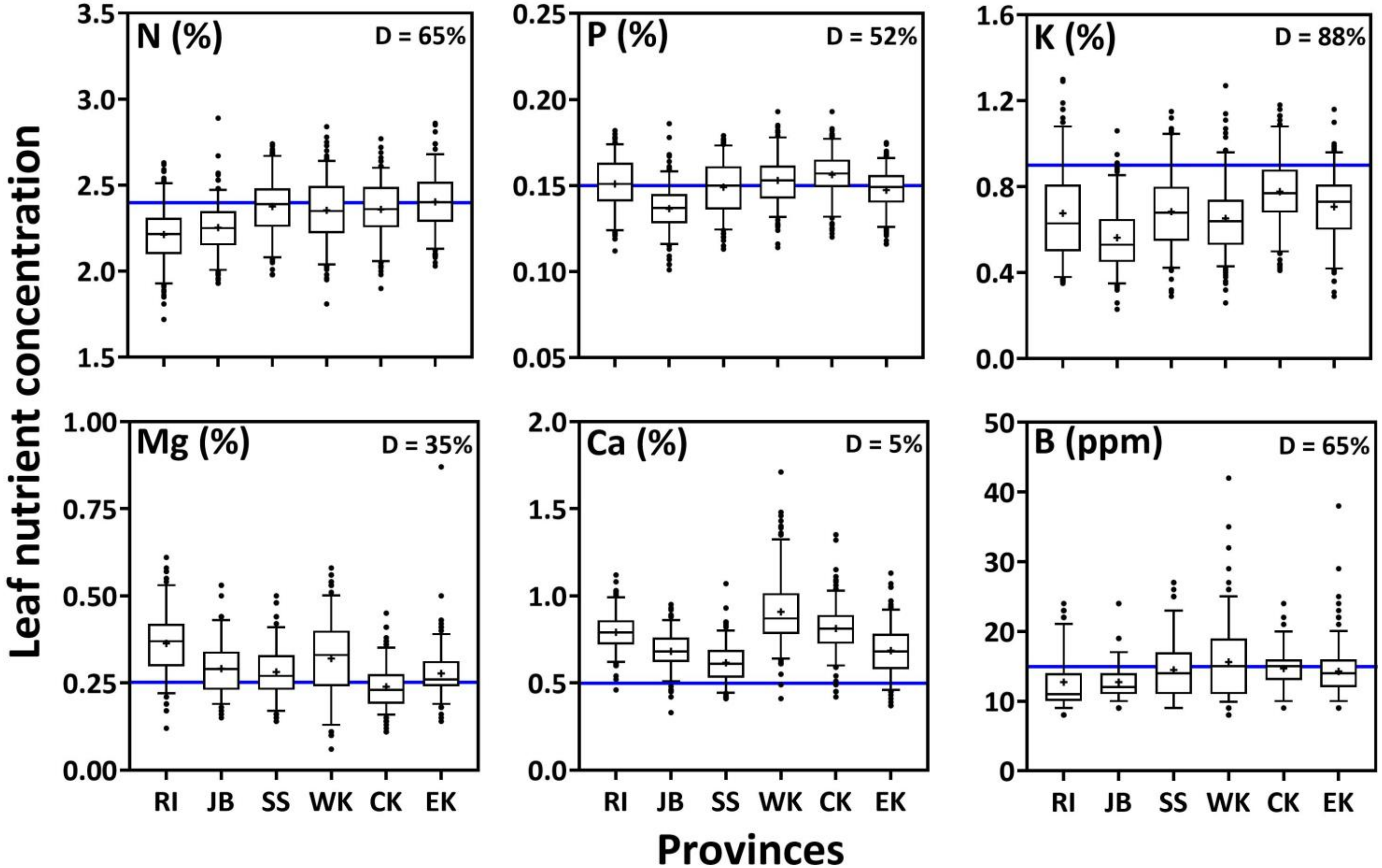
Photos: P Grassini, H Sugianto, C. Donough

Nutrient status*

Widespread nutrient deficiencies across independent smallholder fields. About 90% of fields exhibited K deficiencies whereas 60% of fields showed N, P, and B deficiencies.

Frequency of fields deficient (D) for each nutrient is shown.

Blue lines indicates the the nutrient sufficient leaf nutrient level (Rankine and Fairhurst, 1999)

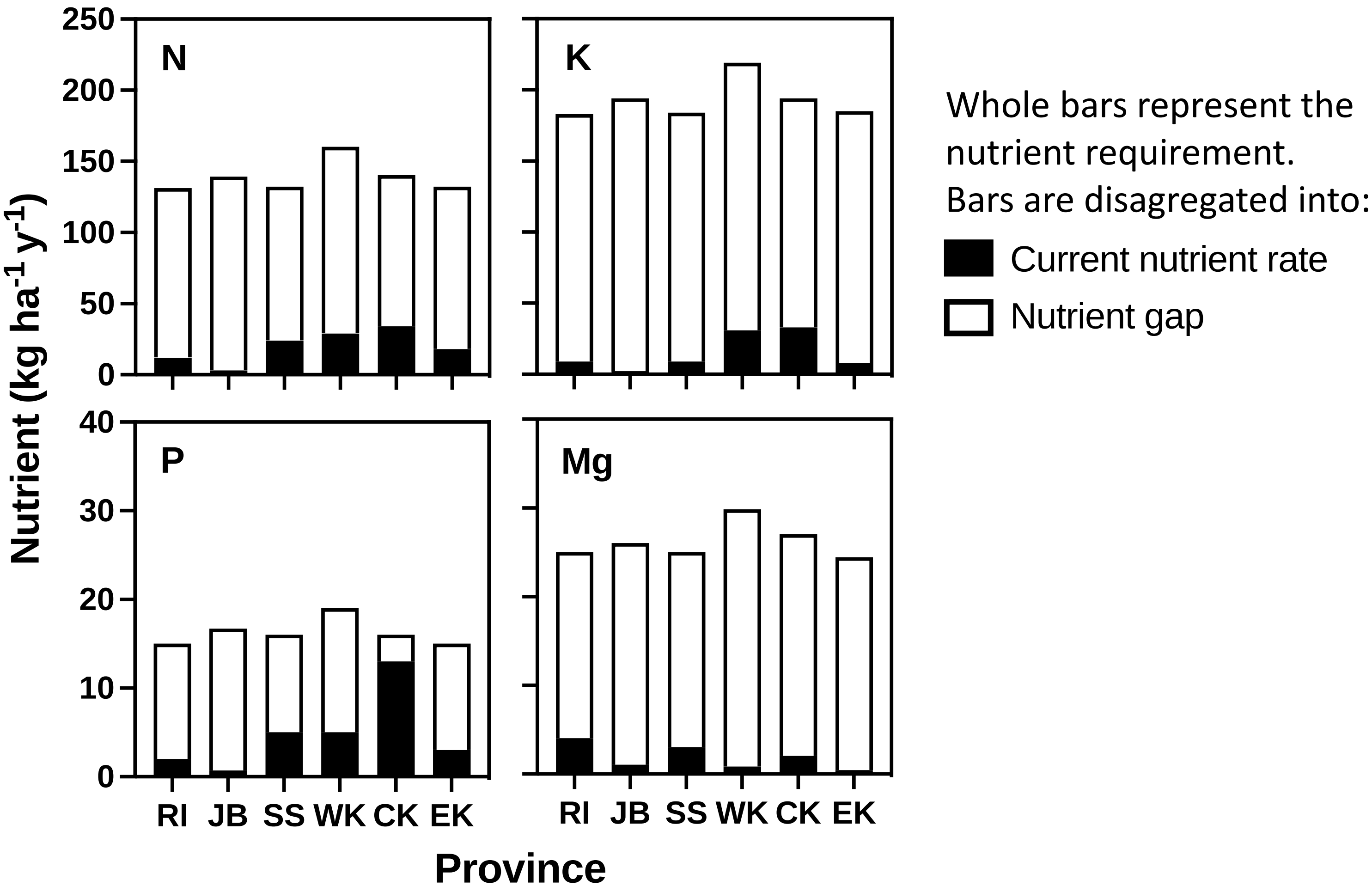


* Nutrient status determined based on ten sampled palms per field (average field size: 2 ha)

Sugianto *et al.*, in preparation

Nutrient balances

Nutrient uptake requirements associated with the attainable yield* are 6x (N), 2x (P), 11x (K), and 12x (Mg) higher than current nutrient rates.



*** Nutrient requirements were estimated based on the estimated attainable yield (70% of the simulated yield potential based on local weather, soil type, and palm age)) and average FFB nutrient removal (Lim et al., 2018), also accounting for trunk immobilization (Ng et al., 1968).**

Lim *et al.*, in preparation

Moving from diagnosis to yield gap closure

- **Selection of farmers in each province to demonstrate management options to narrow the existing yield gap**

- **Two fields per farmer (with same planting material, palm age, and soil):**

  → A reference (REF) field where we let farmers continue with their usual management practices

  → Another field where we provide technical support to the farmer to implement best management practices (BMP) to increase both yield AND farmer profit

- **Total of 31 REF-BMP paired fields located across five provinces (started in Jan 2020)**

Best management practices (BMPs)

Harvest criteria and frequency

Pruning and frond arrangement

Nutrient rate, source, timing, and placement

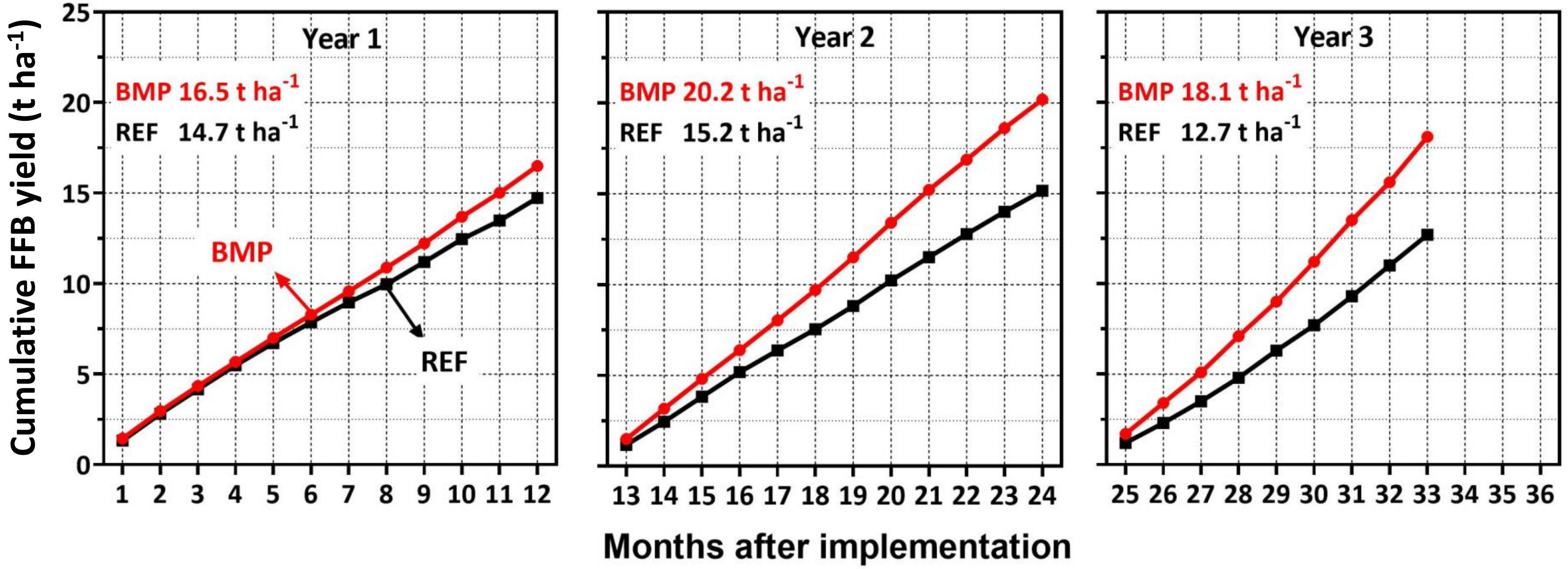
Management of weeds and beneficial vegetation


Economic analysis
Plant growth
Soil carbon and root density
Foliar nutrient analysis
Carbon stocks

Yield trends in BMP trials

Implementation of BMPs lead to higher yields in Year 1 (+12%), Year 2 (+32%), and Year 3 (+45%). The yield benefit increases over time as palms keep benefiting from the improved plant nutrition status.

Total of 31 paired BMP-REF comparisons across five provinces. Shown here are the average values.



Sugianto *et al.*, in preparation

Impact of BMPs on farmer yield and profit

Shown below is a side-by-side comparison of REF versus BMPs for a field in West Kalimantan. In this field, the BMPs increased yield by 52%, generating a comparable increase in profit.

REFERENCE ← → BMP

Photo taken by Hendra Sugianto

What factors influence (or not) BMPs impact?

- **Level of BMP implementation (p=0.001)**

  → **Lower impact with poor implementation**

  (due to knowledge gaps, lack of access to inputs, motivation, etc. Not necessarily related with farm size and/or household income)

- **Initial yield level (p=0.001)**

  → **Positive impact across the whole range of yield but quicker and larger when the initial yield is low.**

- **Planting material (p = 0.70)**

  → **Positive impact occurs with any type of planting material.**

Economic impact of intensification

Implementation of Best Management Practices (BMPs) resulted in +20% increase in net profit. The economic benefit will be larger in subsequent years as yield keeps increasing.

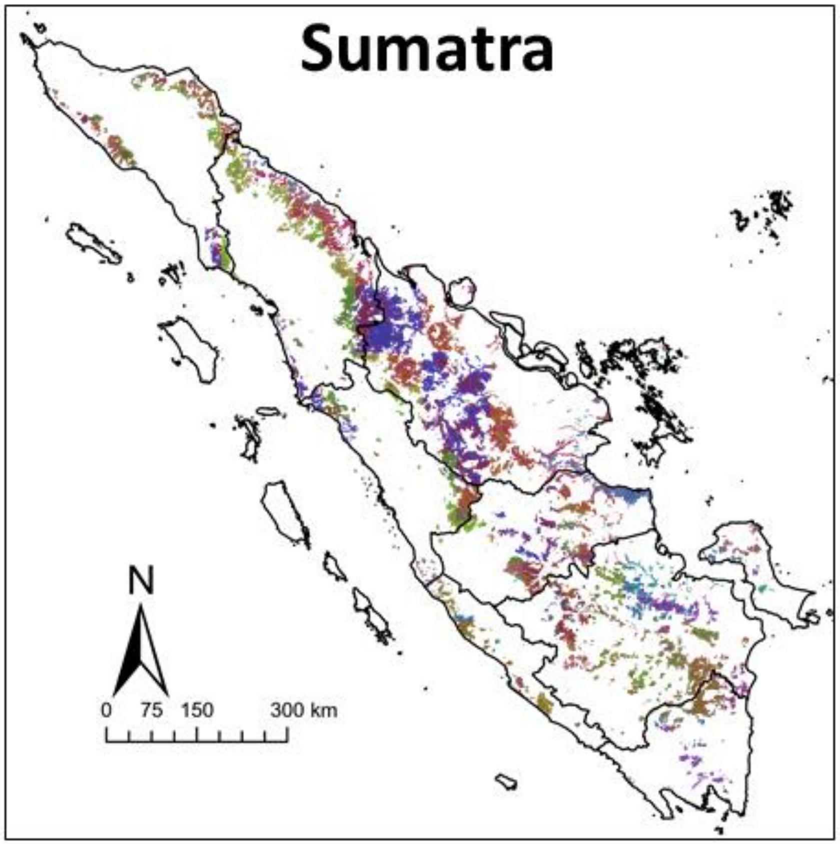
MANAGEMENT		Total production costs* (M IDR ha^{-1})		Gross income** (M IDR ha^{-1})		Net income*** (M IDR ha^{-1})
REFERENCE		10		68		42
BMPs		20		52		48
DIFFERENCE		+10		+16		+6 (+20%)

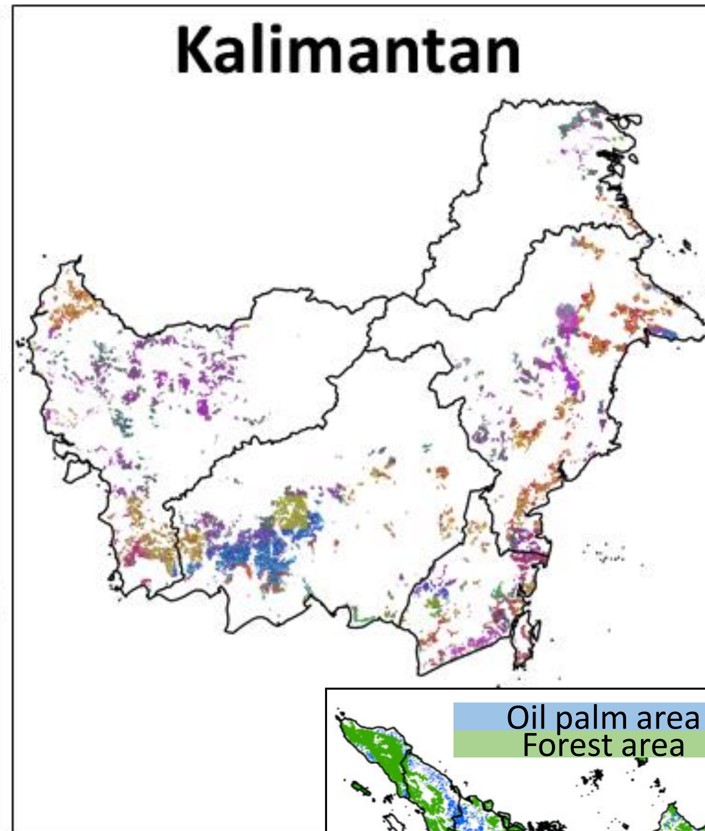
* Includes all total inputs and labor costs during the first two years of the project
** Based on FFB yield and actual FFB price received by farmers during the first two years of the project
*** Estimated as the difference between gross income and total costs during the first two years of the project

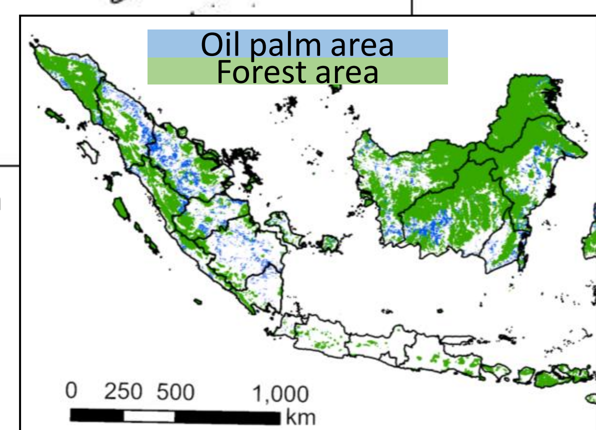
Sugianto *et al.*, in preparation

Where to scale out intensification?

Desirable criteria: areas with climate and soil comparable to those where BMPs were evaluated, far from forested areas and peatlands, including large number of smallholders





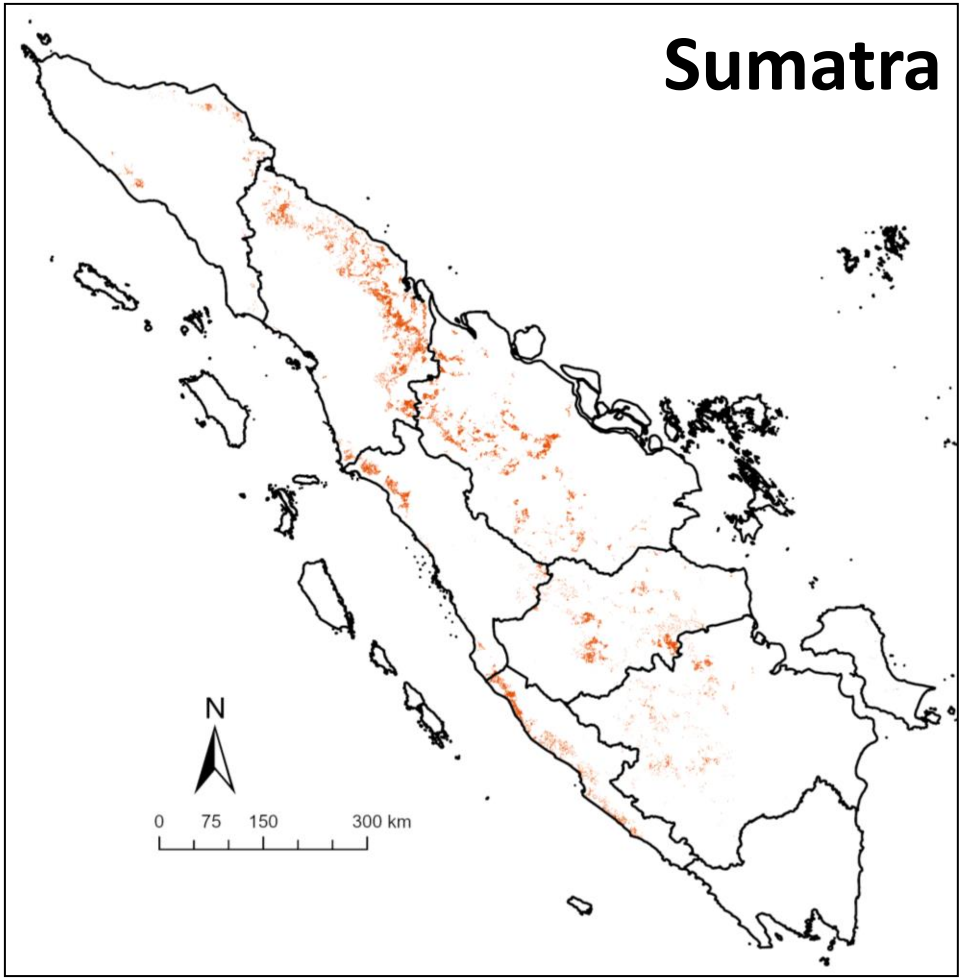


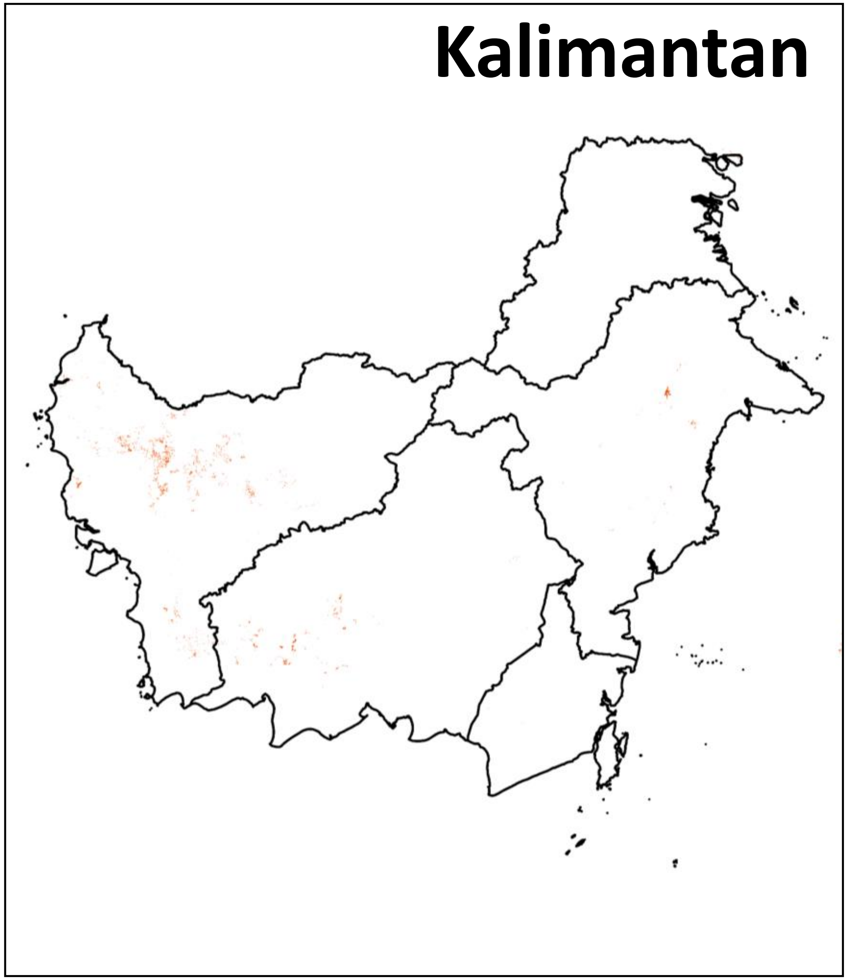
Each color in the maps represents a combination of climate & soil wherein the response to a given technological package is expected to be similar

Agus, Tenorio *et al.*, in preparation

Target areas for intensification

One million hectares of oil palm managed by independent smallholders





Agus, Tenorio *et al.*, in preparation

Scaling out potential benefits of intensification

Implementation of BMPs in the target area (1 million ha) would lead to a positive socio-economic and environmental impact

Variable	Baseline	BMPs
CPO Production (MMT)	2.8	4.2
CPO Revenue (billion USD)	2.3	3.4
Potential Land Saving (million ha)	0	0.5

Assumptions: full adoption across all mature independent smallholders' oil palm area in mineral soils in Indonesia, and current CPO price (800 USD per t CPO). Also assumed is average OER of 20%% of dura and tenera type and current 50% dura contamination based on measurements performed in our field trials. Impact calculated based on 45% FFB yield increase due to BMP adoption after three years based on our field trials data. Independent smallholders assumed to account for 2/3 smallholder area.

Agus, Tenorio *et al.*, in preparation

Main messages + thoughts

- There is a large exploitable yield gap in current plantations, with larger gaps in smallholder farms
- First is first - better agronomic management is needed to close the yield gap of existing plantations
  - Strong evidence of nutrient deficiencies and poor field upkeep
  - +45% yield and +20% profit increase three years of BMP implementation
- Need to complement technologies, knowledge, and policy
  - Access to proper inputs and strong extension services
  - Policy needs to focus on yield constrains in farmer fields (e.g., potassium deficiency)
- Genetics and certification programs are important but intensification on existing plantation area *via* better agronomy is also essential to reconcile economic & environmental goals.

EFFICIENT MANAGEMENT OF THE CROPLAND AREA TO INCREASE PRODUCTIVITY

SEPT 30 2022

8 A.M. - 12:30 P.M.

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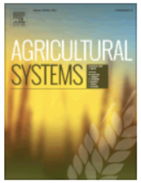
Deadline for submission: Dec 1, 2022



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Sustainable oil palm intensification

February 2022

Meeting future demand for agricultural production without further encroachment of fragile natural ecosystems, such as forests, savannahs, and peatlands, is one the biggest challenges that humanity has ever faced. Oil palm production illustrates the intense pressure that exists worldwide to convert natural ecosystems to agricultural production. Global oil palm area has tripled during the past 20 years, in many cases at expense of rainforests and peatlands. In contrast, yield gains in main producing countries have been small or even negligible, with productivity remaining well below its potential. A focus on increasing oil palm production on existing plantation area via crop sustainable intensification, instead of land expansion, can help reconcile environmental and production goals.

This Special Issue on sustainable oil palm intensification will cover aspects related to intensification in smallholders' fields and large plantations, with focus on the diagnosis and closure of yield gaps, addressing both agronomic and socio-economic dimensions at different spatial scales, integration with other crops and livestock, and adding value via use of palm residues as a way to mitigate land conversion for oil palm production. Likewise, it will discuss impacts on land sparing, production, and profit, barriers for adoption of sustainable intensification on oil palm production (e.g., knowledge gaps for farmers, lack of tools available to stimulate learning, supply chain barriers, lack of services), and indicators to monitor the process of intensification and its outcomes. We will welcome articles from oil palm producing areas around the world, including those in South East Asia, Sub-Saharan Africa, and South & Central America.

Guest editors: Patricio Grassini (University of Nebraska-Lincoln) & Maja Slingerland (Wageningen University)

Thank you!   Questions?