On the palm oil - biodiversity tradeoff: Environmental performance of smallholder producers

Bernhard Dalheimer, Fabian Brambach, Juanita Mirawati, Holger Kreft, Bernhard Brümmer
bernhard.dalheimer@uni-goettingen.de

University of Goettingen
Department of Agricultural Economics and Rural Development

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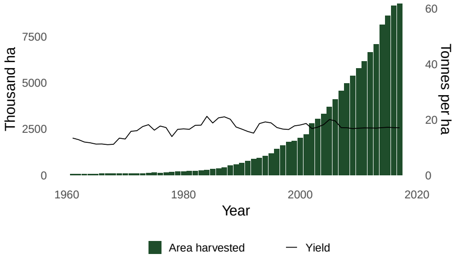
Palm oil boom: Economic success and ecological desaster



Palm oil in Indonesia: Developmental success & ecological disaster

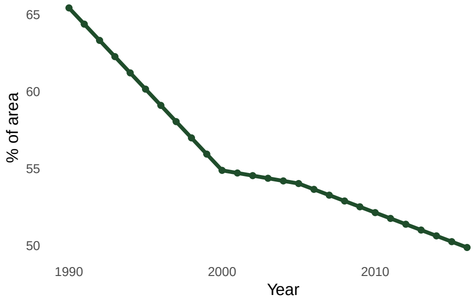


Figure 1: Forest area over time

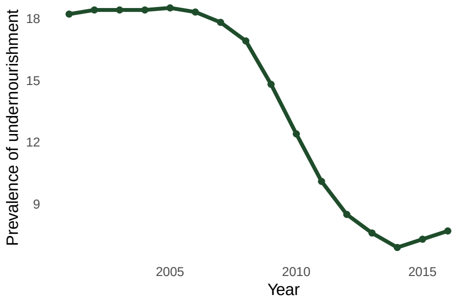


Figure 2: Food insecurity over time

(FAOSTAT, 2020)

Research gaps & questions

What we do know...

- Biodiversity threatened in Indonesia
- Macro relationships
- Trade-offs in large estates
- mosaic-type spatial arrangements of smallholders: exceptional opportunities for biodiversity conservation
- Smallholders provide 40% of palm oil output
- Yields are low, expansion driven

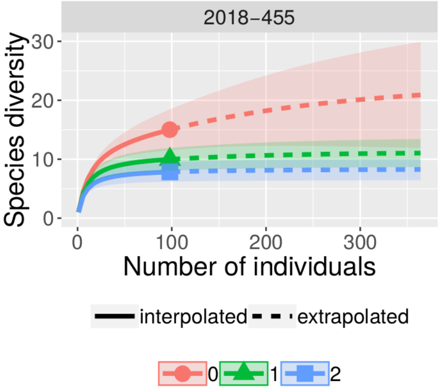
What we do not know...

- **Micro-level** trade-offs
- **Smallholders'** environmental performance

- How to conserve biodiversity during commodity booms?

Data

- Ongoing oil palm farm survey in Jambi province of Sumatra, Indonesia
- Short unbalanced panel of 3 waves (2012, 2015, 2018)
- 123 observations
- Conventional input-output, socio economics, agricultural practices, **plot plant species abundance and richness data**



Restricted (hybrid) hyperbolic distance function

- Environmental **restricted** hyperbolic distance function

$$D_R(\bar{\mathbf{x}}, \mathbf{x}, \mathbf{y}, \mathbf{b}) = min\left\{\theta : \left(\bar{\mathbf{x}}, \mathbf{x}\theta, \frac{\mathbf{y}}{\theta}, \mathbf{b}\theta\right) \in T\right\}, \quad (1)$$

hybrid of enhanced hyperbolic and hyperbolic functions

- $\bar{\mathbf{x}}$ Fixed inputs $(\cdot)$
- $\mathbf{x}$ Variable inputs $(\downarrow)$
- $\mathbf{y}$ Good output $(\uparrow)$
- $\mathbf{b}$ Bad output$(\downarrow)$

- **Shadow price** of biodiversity conservation

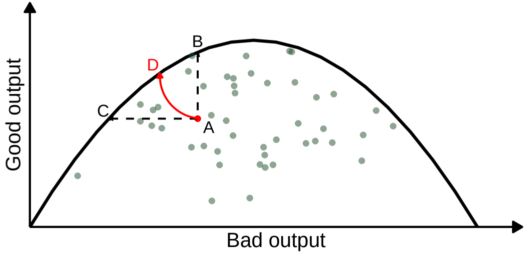
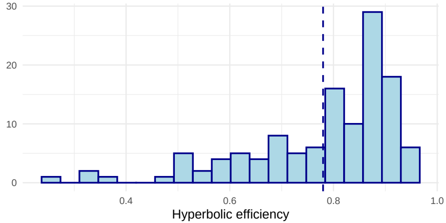


Figure 3: Environmental hyperbolic distance function

Environmental (In)efficiency



Mean efficiency:	0.78
Potential good output expansion:	28%
Potential bad output contraction:	22%

Manual and chemical weeding among drivers

Policy scenarios & Shadow prices

- Eliminating weeding: **3% (19) more species and 2,4% more palm oil** (practice based PES)
- Abating biodiversity loss by one species amounts to **340$ per farm**, **173$ per ha** or **16% of annual farm palm oil income**, on average
- Design PES to target
  (i) Social inclusivity of conservation
  (ii) Uniform biodiversity
  (iii) Cost minimizing

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- **Practice based PES** to lower abatement cost without trade-off
- **Outcome-PES** to incentivize conservation require target dimension

Thank you for your attention!

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References I

FAOSTAT (2020). FAOSTAT statistical database. Data retrieved online at http://www.fao.org/faostat/en/.

Back up

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- **Restricted hyperbolic** distance function

$$-lny_i = \alpha_0 + \sum_{k=1}^{3} \alpha_k ln(x_{ki}) + \alpha_4 ln(x^*_{4i}) + \beta_1 ln(b^*_i) + \sum_{k=1}^{3} \beta_{1k} ln(b^*_i) ln(x_i)$$
$$+\beta_{14} ln(b^*_i) ln(x^*_{4i}) + \frac{1}{2} \sum_{k=1}^{3} \sum_{l=1}^{3} \alpha_{kl} ln(x_{ki}) ln(x_{li}) + \frac{1}{2} \sum_{k=1}^{3} \alpha_{k4} ln(x^*_k) ln(x_4) +$$
$$+\frac{1}{2} \alpha_{44} ln(x_i)^2 + \frac{1}{2} \beta_{11} ln(b^*_i)^2 + \rho_0 t_i + u_i + v_i, \quad (2)$$

- $\mathbf{y}_i$: Oil palm, $\mathbf{b}_i$: Biodiversity loss, $\mathbf{x}_i$: Inputs, $\mathbf{b}^*_i = \mathbf{y}_i * \mathbf{b}_i$, $\mathbf{x}^*_i = \frac{\mathbf{x}_i}{\mathbf{y}_i}$

Empirical specification (Inefficiency model)

For the error component $u_i + v_i$ we assume

- Homoskedastic symmetric noise:

$$v_i \sim N(0, \sigma_v^2) \tag{3}$$

- Heteroskedastic one sided inefficiency:

$$u_i \sim N^+(\mu, \sigma_{u,i}^2) \tag{4}$$

and

$$\sigma_{u,i}^2 = exp(\tau\prime \mathbf{z}_i) \tag{5}$$