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Impact of rainforest transformation into oil-palm plantations on Si pools in soils

Britta Greenshields[1], Barbara von der Lühe[1], Harold J. Hughes[1]
Aiyen B. Tjoa[2], Daniela Sauer[1]

[1] University of Göttingen, Physical Geography Unit, Göttingen
[2] Tadulako University, Faculty of Agriculture, Palu, Indonesia

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Contact: britta.greenshields@uni-goettingen.de

Silicon (Si) & Oil palms:

- High loss of lowland rainforest due to rapid expansion of oil-palm monocultures
- Oil palms: Si accumulators [1]

  → Si uptake through soil solution [2]

  → Silica precipitation in biomass[3]
- Silicon (Si): beneficial to plant's health

  (I) mitigating biotic and abiotic stresses [2,4]

  (II) sustaining a high crop yield [1,2,4]

"Quantifying Si pools and fluxes under oil-palm plantations may contribute to a better understanding of Si-cycling after landuse transformation. This knowledge may be incorporated into oil-palm management practices to reduce environmental impacts for the long-term."

[1] Munevar and Romero, Expl. Agric. (2014) 1.
[2] Liang et al. Silicon in agriculture: From theory to practice. Springer, 2015.
[3] Clymans et al., Ecology, 97 (2016) 3044-3057
[4] Najihah et al., Crop Protection, 67 (2015) 151-159.

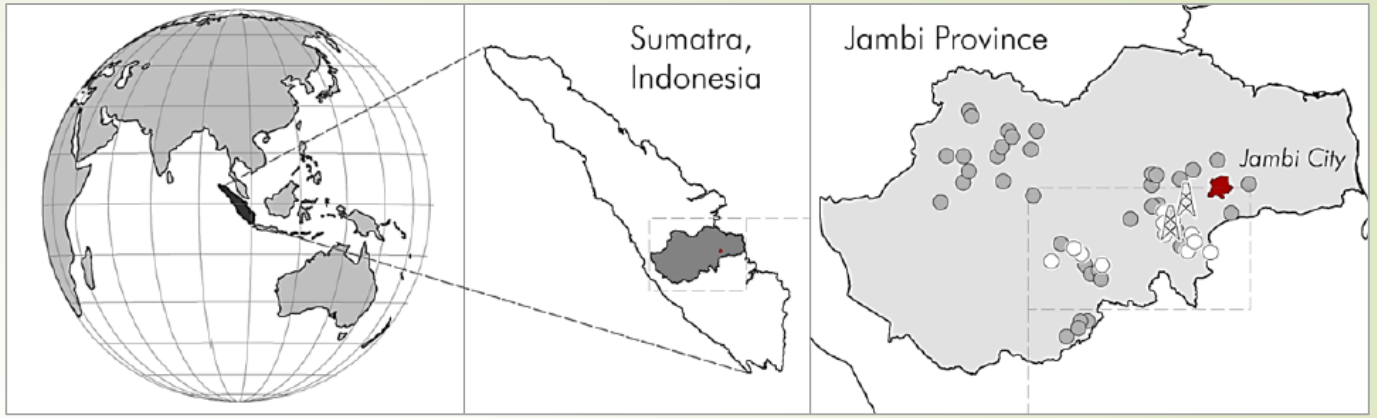
Study Area & Fieldwork

Study area:

- Jambi Province, Sumatra, Indonesia
- Humid-tropical climate:
  - Ø temperature: ~ 27 ° C
  - Ø rainfall: ~ 2200 mm/y
  - rainy season October – April
    dry season May – September
- Acrisols

Sampling design:

- Soil profiles: 1 x 1 x 1 m
  n = 6, rainforest
  n = 8, oil palm
  - horizon-wise sampling



Acrisol
oil-palm plantation

Acrisol
lowland rainforest

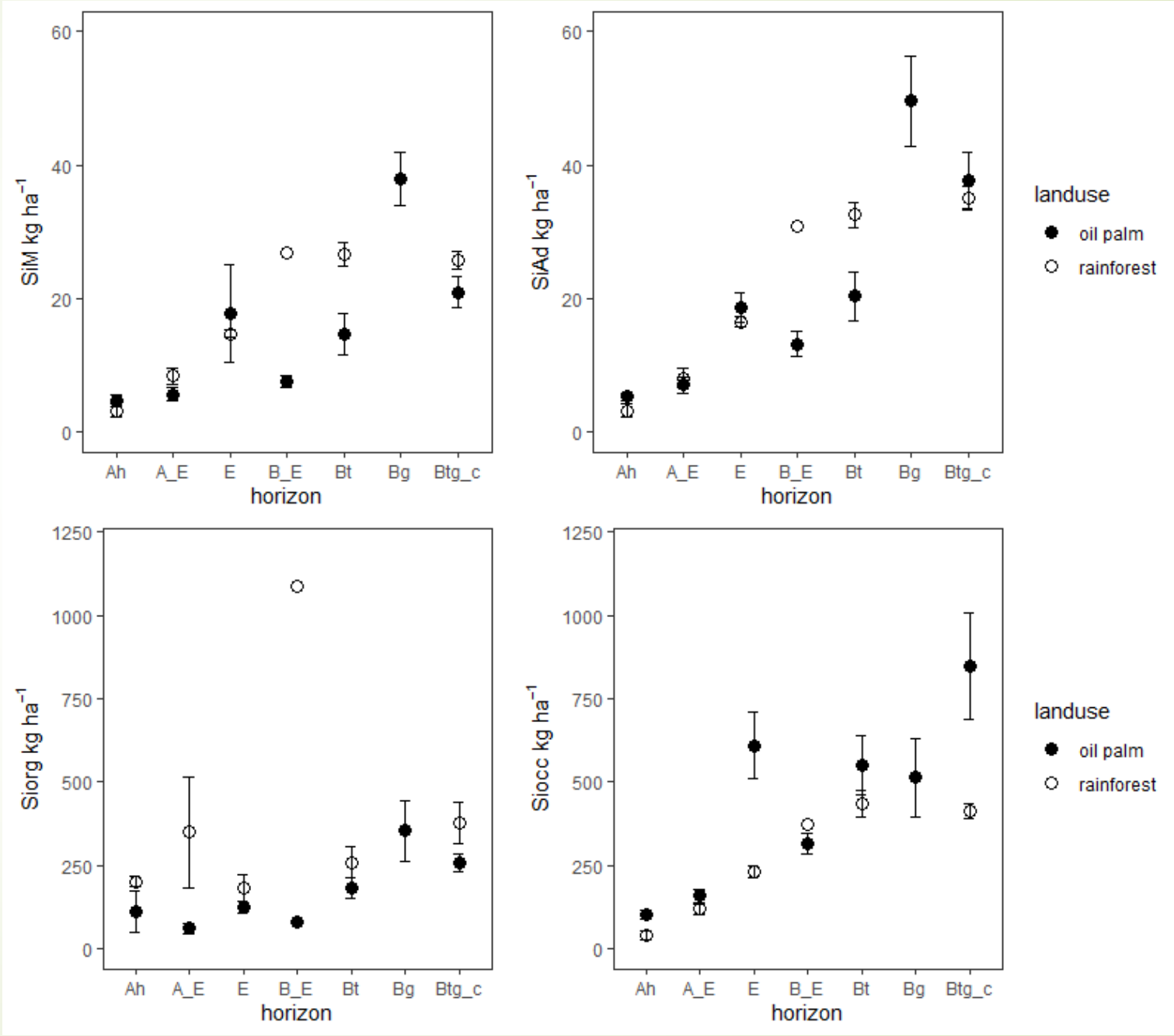
Reference: Project Map © K. Darras
Photographs: © B. Greenshields

Research objective – to the following hypothesis:

"Oil palms are Si accumulators. Thus they deplete Si pools – mobile Si (Si_M), adsorbed Si (Si_{Ad}), Si bound in organic matter (Si_{org}) and Si occluded in pedogenic oxides (Si_{occ}) – in Acrisols."

Result 1:

- organic Si stock (Ah – E horizon) is decreased in Acrisols under oil-palm plantations
- Topsoil erosion as main process of organic Si stock losses



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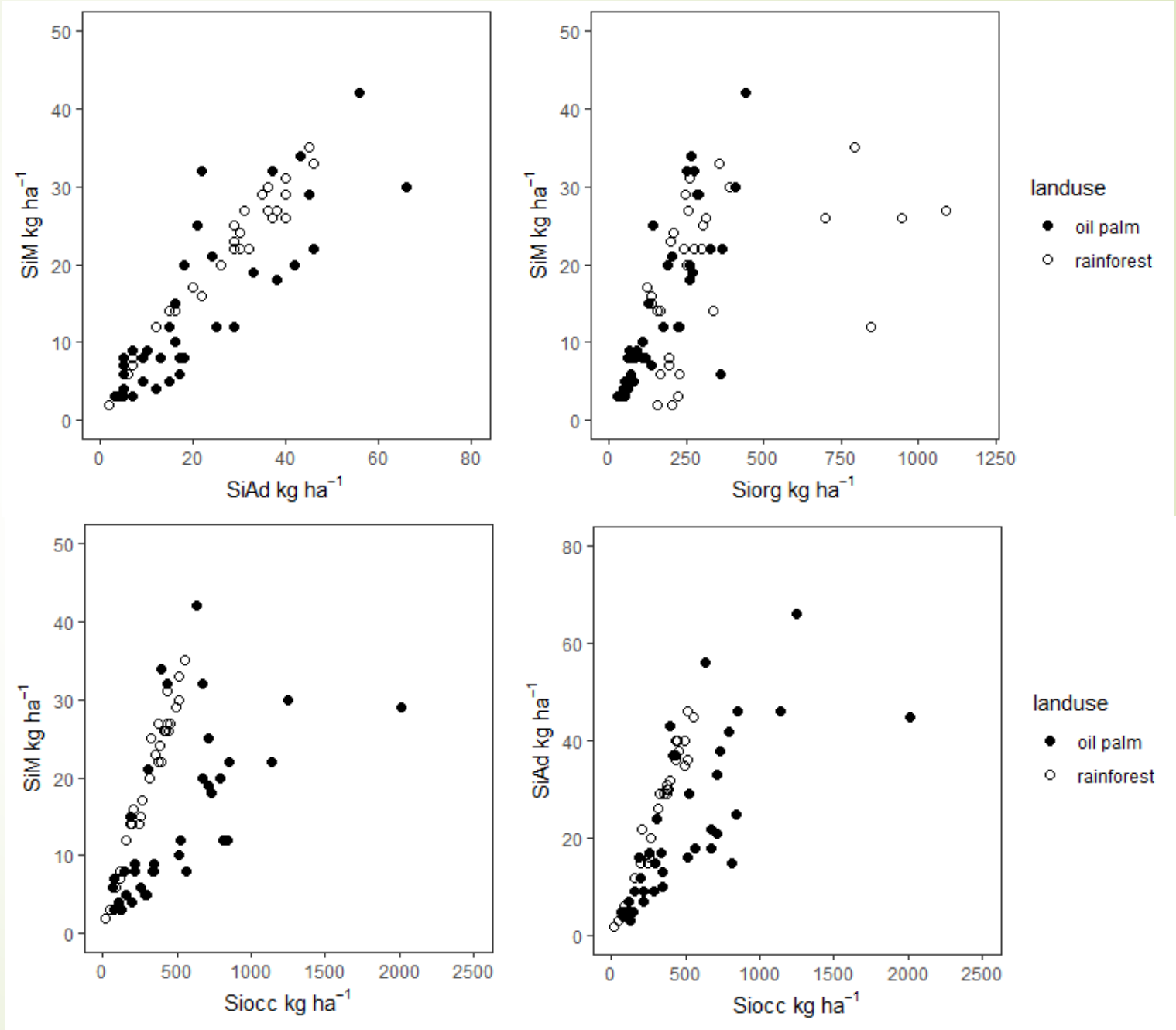
Results 2:

- Si_M vs. Si_{Ad} ; Si_M vs. Si_{occ} and Si_{Ad} vs. Si_{occ} show interdependencies in soils under rainforest, but are less related to each other in soils under oil-palm plantations.
- Pearson's correlation: $R^2 > 0.8$ in Acrisols under rainforest
- Rainforest transformation into oil-palm plantations disturbs quantities and natural distribution of Si stocks in Acrisols



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Preliminary conclusions and outlook

- Rainforest transformation into oil-palm plantations only seems to decrease the organic soil Si stock within a 1 m soil profile
- Stocks of mobile Si, adsorbed Si and Si occluded in pedogenic oxides are not decreased under oil-palm monocultures in soil profiles analyzed so far
- mobile Si, adsorbed Si and Si occluded in pedogenic oxides show a strong correlation ($R^2 > 0.8$) in Acrisols under rainforest
  - Silicon dynamics seem to be controlled more directly by soil-forming processes (illuvial accumulation of clay) than by land-use change
- Land-use transformation to oil-palm plantations may disturb dynamics between Si stocks
  - similar trends between Si stocks are seen but with a higher variability in oil-palm plantations
- Research is currently on-going by further investigating the effect of landscape position on Si stocks in soils and characterizing the biogenic Si stock

Acknowledgements

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