Oil Palm and Land Cover Change Dynamics in Indonesian Peatlands

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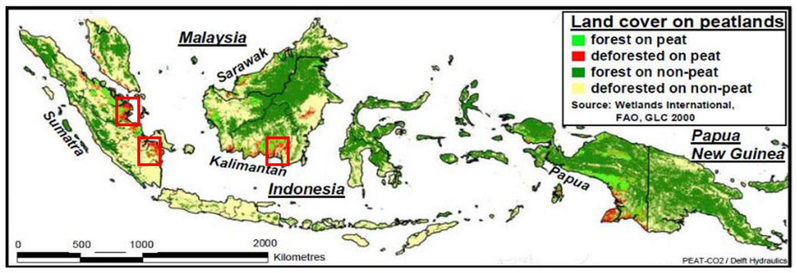
Background

Reducing carbon emissions from Indonesia's tropical peatlands is essential for stabilizing global climate and conserving biodiversity. These peatlands are biodiversity hotspots that cover approximately 200,000 km^2 and contain a 57 Gt C reservoir of carbon.

Smallholder agricultural systems, especially smallholding oil palm plantations, have become increasingly important in reshaping landscapes and exacerbating carbon emissions. It is often overlooked that smallholder farmers manage half of the oil palm area in Indonesia, with a greater annual rate of expansion (11%) than large-scale plantations (5%).

Research Components

- **Characterize the land-cover and land-use changes (LCLUC)**
- **Identify major drivers and impacts of those changes**
- **Develop strategies for managing the landscape sustainably**



Spatial patterns and drivers of smallholder oil palm expansion within peat swamp forests of Riau, Indonesia

Backgrounds

- More than half of peat swamp forests in Riau have been lost since 1990(Fig.1a).
- It is challenging to govern and manage the rising smallholder oil palm expansion on peat soils due to numerous farmers and fragmented nature.
- It is imperative to understand spatial distribution and drivers of smallholder oil palm-related conversion of peat swamp forests.

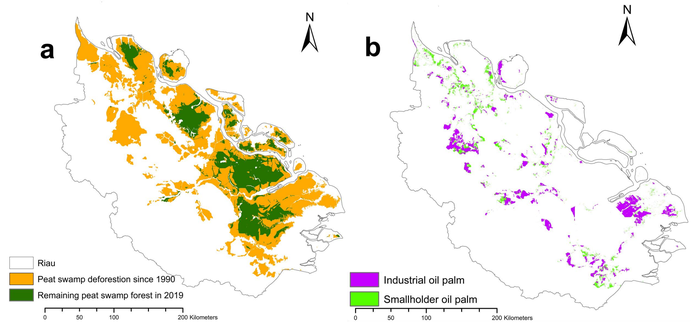


Fig.1 Maps of Riau, Indonesia showing (a) Peat swamp forest in 1990 and 2019 and (b) industrial and smallholder oil palm in 2019.

Major findings

- The distribution of smallholder oil palms was strongly related to road proximity. 75% of smallholder oil palm expansion over peat swamp forests was located within 1km of roads and 90% was within 2 km of roads(Fig.2).
- Comparing to smallholders, industrial oil palm plantations located closer to processing mills. 90% of smallholder oil palms over the peat swamp forests are located within 25 km of mills(Fig.2).
- In addition to roads, land use zones (e.g., the setting of concessions and migration settlements) and other environmental factors (e.g., precipitation and elevation) were identified as important drivers of smallholder oil palm expansion on peatland(Fig.3).

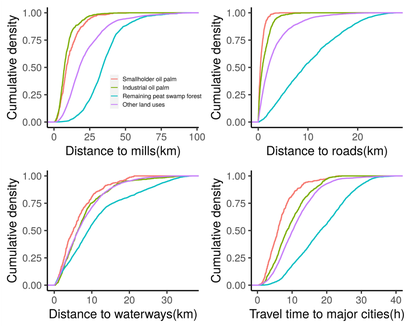


Fig.2 Cumulative density plots for smallholder oil palm, industrial oil palm, remaining peat swamp forests and other land uses in 2019 within the area covered by peat swamp forest in 1990 in Riau

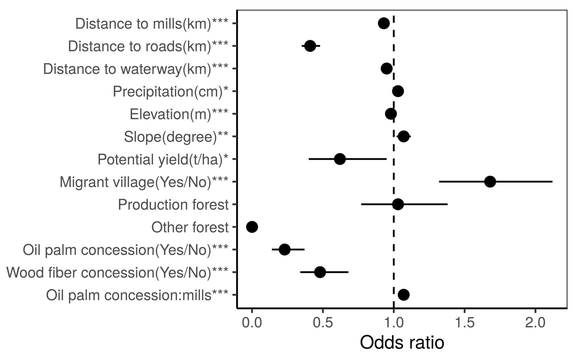


Fig.3 Relative influences of major variables on smallholder oil palm expansion into peat swamp forest in Riau.

References

- Zhao et al. 2022 Environ. Res. Lett. 17 044015
- Zhao et al. 2022 Agricultural Systems, in Review

Potential decline in palm oil production in Indonesia and replanting strategies for alleviating the decline

Backgrounds

- Maintaining stable and high levels of palm oil production within the current oil palm extents could relieve deforestation pressure.
- Recent exponential growth of oil palm plantation area has led to significant carbon emissions and biodiversity loss, and may face productivity decline.
- It is critical to identify effective replanting strategies for current oil palm extents to alleviate the potential decline in palm oil production.

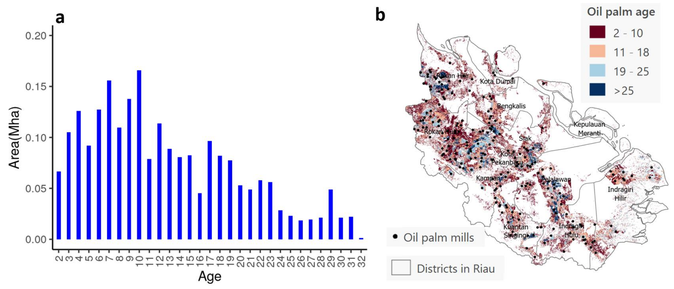


Fig.4 Oil palm area by age in Riau in 2017(Panel a) and spatial distribution of oil palm by age stage(Panel b).

Major findings

- The age distribution of oil palms in Riau is spatially heterogeneous, which may pose challenges for effective replanting(Fig.4).
- The production of fresh fruit bunches (FFB) from oil palm would peak in 2023 at 49 million metric tons (MMT) and drop to 40 MMT by 2036, if all current oil palm was replanted at 25 years old with no further planted-area expansion(Fig.5).
- If the oldest existing oil palm is replanted at the annual rate of 4%, FFB production would peak at 48 MMT in 2019 and then slowly decrease and stabilize around 45 MMT by 2035(Fig.5).
- Replanting 4% annually, with or without yield improvements, would achieve the highest and most stable landscape-level production(Fig.6).
- Collaborations among government officials, local extension specialists, mill owners, private plantations and smallholder farmers will be critical for maintaining steady high levels of palm oil production in Riau.

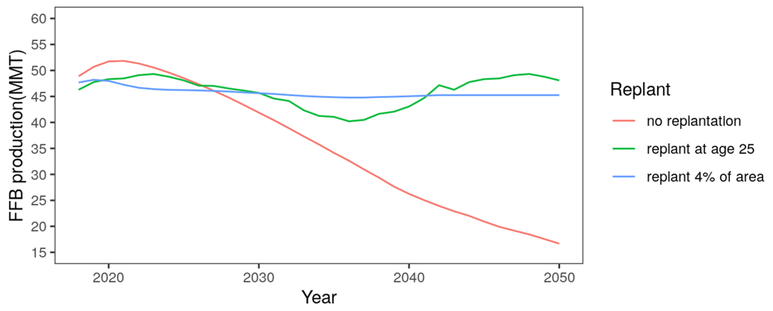


Fig.5 The production trend under different replanting strategies. It shows the production trend under 3 different replanting scenarios, including no replantation, replant at age 25, replant 4% of area each year. Under the scenario of no replantation, from age 35 to age 50, the yield is 10 tons per hectare, and become 0 after age 50 due to difficulties in harvesting

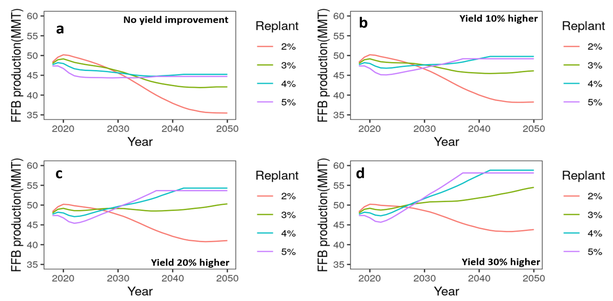


Fig.6 Projection of fresh fruit bunch (FFB) production (million metric ton, MMT) by year. Panel (a) shows the production trend under current yields for different replanting rates without yield improvement. Panels (b-d), respectively, show the production trends for 10%, 20% and 30% yield improvements for replanted trees.

Managing sustainable expansion of smallholder oil palms in Central Kalimantan

Backgrounds

- Central Kalimantan is the province with the largest peatland area in Indonesia.
- Smallholder oil palm is only 10% of total oil palm area in Central Kalimantan in 2019, comparing to 45% in Riau(Fig.7).
- Expansion of smallholder oil palm needs to be guided to minimize the deforestation pressure over peatland area.

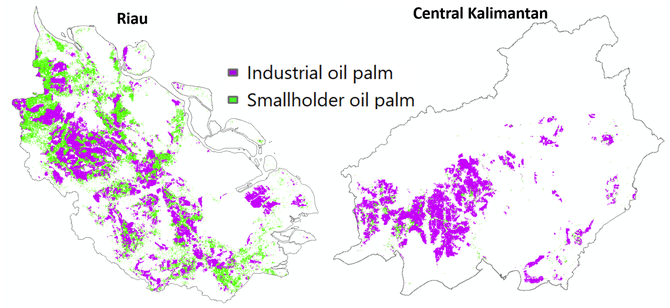


Fig.7 Industrial and smallholder oil palm distribution in Riau and Central Kalimantan in 2019

Major findings

- In Central Kalimantan, 90% of oil palms are within 20 km of mills and 2 km of roads. Additionally, 95% of oil palms are in locations with potential yields greater than 3.8 ton/ha and elevations less than 100 m, which we treat as the criteria of biophysical suitability of oil palm.
- In 2019, the biophysically suitable area for oil palm was 7.48 million ha, of which 1.5 million ha was within 20 km of mills and 2 km of roads. However, only 0.69 million ha is on non-forest land (APL), which is allowed to be converted by smallholder farmers. Among these non forest lands, ~0.37 million ha could be converted to oil palm while preserving current food production and forests (Fig.8).
- If further expansion of smallholder oil palm is unavoidable, we identify the spatial locations where mills or roads need to be added to guide the expansion to regions with relatively low environmental impacts (Fig.8)

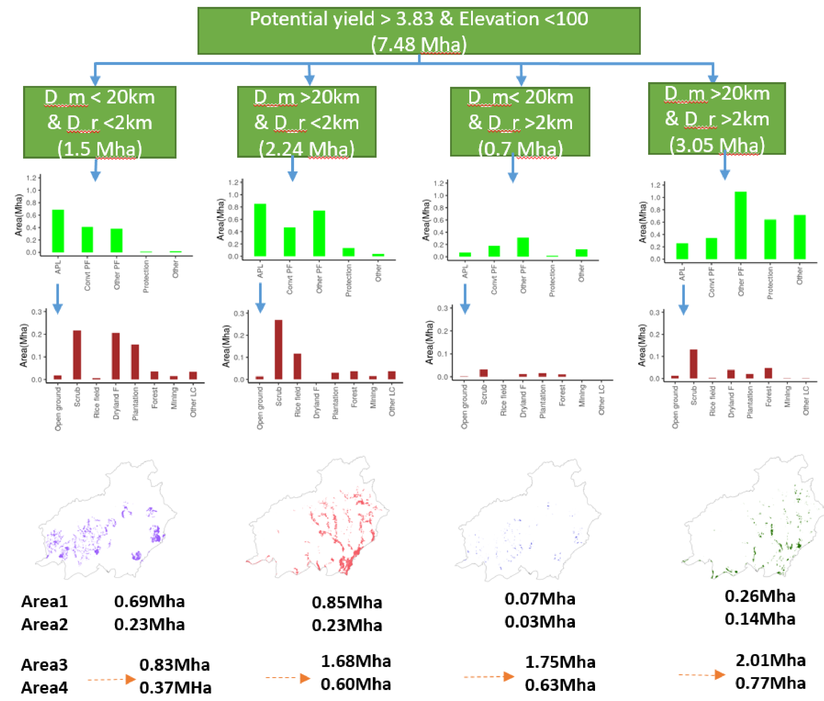


Fig.8 Accessibility of areas (Mha-million hectares) biophysically suitable for oil palm under different land legal status/land cover type(2019). Accessibility: Distance to mills(**D_m**), Distances to roads(**D_r**). Land type/status: non-forest land(**APL**), convertible production forest(**Convt PF**), total production and limited production forest(**Other PF**), conservation and protection forest (**Protection**), dryland farming(**dryland F**), settlement/transmigration/pond/airport(**Other LC**).Area 1: total non-forest land(APL), Area 2: sum of open ground and scrub, Area 3: current smallholder oil palm area + APL area, Area4 : current smallholder oil palm area + Area 2.