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Refined past, current and future greenhouse gas footprints of palm oil production

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Oil palm (Elaeis guineensis) is the most important oil crop in the world, with more than 85% of the global production coming from Indonesia and Malaysia. However, knowledge of country-wide past, current and likely future greenhouse gas (GHG) footprints from palm oil production remains largely incomplete. Over the past year, first studies reporting measurements of net ecosystem carbon dioxide (CO_2) fluxes in oil palm plantations of different ages and on different soil types became available. Combining the recent CO_2 flux estimates with existing measurements on methane and nitrous oxide fluxes allows for a refined quantification of the GHG footprint of palm oil production over the whole plantation life cycle.

To derive country-wide GHG emissions from palm oil production for both Indonesia and Malaysia, we applied the refined GHG footprint estimates to oil palm area extents. Therein, we differentiated between mineral and peat soils, second- and first-generation plantations and within the latter category also among previous land-use systems from which conversion to oil palm likely occurred. For deriving the current (2020) proportions for each category, we combined FAO data with existing remotely sensed maps on oil palm extent and tree density as well as peatland and intact forest layers. These area proportions were then applied to available historic (1970 – 2010) and future (2030 – 2050) oil palm extent estimates as a business-as-usual scenario (BAU), complemented by alternative scenarios. GHG footprint estimates comprise all GHG emissions from palm oil production, i.e. from land-use change, cultivation, milling and use.

Our refined approach estimates the 2020 GHG emissions from palm oil production at 1011 Tg CO_2-eq. yr^{-1} for Indonesia and at 261 Tg CO_2-eq. yr^{-1} for Malaysia. Our results show that while plantations on peatland only represented 17% and 15% of the total plantation area in 2020 for Indonesia and Malaysia, they accounted for 73% and 72% of the total GHG emissions from palm oil production. Emissions in 1980 and 2000 were estimated to be only 1% and 14% of the 2020 palm oil emissions for Indonesia, but already 24% and 96% for Malaysia due to the earlier oil palm expansion. Projected emissions for 2050, assuming further oil palm expansion on suitable land

and constant yields from 2020 on, represent 64% of the 2020 value for Indonesia and 97% for Malaysia under a BAU expansion scenario. These lower or constant GHG emissions for future scenarios despite assumed increases in cultivated area are the consequence of lower GHG emissions in second and subsequent rotation cycles. For both countries, the 2050 BAU emissions could be reduced by more than 50% by halting all conversion of peatlands and forests to oil palm from 2020 on, and by more than 75% when additionally restoring all peatlands currently under oil palm to forest until 2050. Closing yield gaps could potentially lead to further emissions savings.