frontiers | Frontiers in Forests and Global Change

TYPE Editorial
PUBLISHED 09 July 2024
DOI 10.3389/ffgc.2024.1441266

OPEN ACCESS

EDITED AND REVIEWED BY
Geertje M. F. Van Der Heijden,
University of Nottingham, United Kingdom

*CORRESPONDENCE
Selva Dhandapani
✉ selvakumar.dhadnapani@afbini.gov.uk;
✉ sccalva@gmail.com

RECEIVED 30 May 2024
ACCEPTED 28 June 2024
PUBLISHED 09 July 2024

CITATION
Dhandapani S, Yule CM and Drewer J (2024) Editorial: Biogeochemical and biodiversity impacts of oil palm land-use in Southeast Asia. *Front. For. Glob. Change* 7:1441266.
doi: 10.3389/ffgc.2024.1441266

Editorial: Biogeochemical and biodiversity impacts of oil palm land-use in Southeast Asia

Selva Dhandapani[1]*, Catherine M. Yule[2] and Julia Drewer[3]

[1]Soil Biogeochemistry and Terrestrial Ecology Research Programme, Agri-Food Biosciences Institute (AFBI), Belfast, United Kingdom, [2]School of Science, Technology and Engineering, University of the Sunshine Coast, Maroochydore, QLD, Australia, [3]Biosphere Atmosphere Exchange and Effects (BAEE) Group, UK Centre for Ecology and Hydrology, Penicuik, United Kingdom

KEYWORDS

tropical agro-ecology, tropical peatlands, greenhouse gas emissions, peat fire, riparian buffers, understorey vegetation, sustainable agriculture, land-use change

Editorial on the Research Topic
Biogeochemical and biodiversity impacts of oil palm land-use in Southeast Asia

Rationale

Southeast Asia is home to one of the oldest and most consistent rainforests in the world, with high endemic biodiversity and carbon storage, and the largest cover of carbon-rich tropical peat swamp forests (Yule, 2010; Xu et al., 2018). However, these tropical forests are becoming increasingly disturbed by anthropogenic land-use changes, particularly the expansion of oil palm agriculture (Miettinen et al., 2016; Dhandapani et al., 2023). Oil palm currently stands as the fastest expanding equatorial crop and the most traded vegetable oil in the world (USDA, 2023), and 85% of the world's oil palm production comes from Malaysia and Indonesia (USDA, 2023). The rapid expansion of oil palm plantations in the last few decades has directly coincided with rapid deforestation (Hansen et al., 2013; Shevade and Loboda, 2019). Between 1990 and 2010, forest cover in the region reduced from 268 to 236 million ha (Stibig et al., 2014), and is predicted to shrink a further 5.2 million ha by 2050 (Estoque et al., 2019), which has been disastrous for global biodiversity and climate (Sodhi et al., 2004; Dhandapani, 2015; Cooper et al., 2020).

A greater understanding of the environmental impacts of forest conversion and different oil palm management practices would support improved management of oil palm plantations that already cover large areas of Southeast Asia. It is a crucial time to understand their impacts in detail, considering the further expansion of oil palm in its native Africa, and other tropical regions such as South America and Papua New Guinea (Sayer et al., 2012; Pashkevich et al., 2024). For example, there are some indications that oil palm intercropping ameliorates the impact of oil palm plantations on both biodiversity and biogeochemical cycling in Southeast Asia (Dhandapani et al., 2020, 2022), however, research has been lacking on the environmental impacts of different oil palm cropping systems and management practices. This Research Topic therefore brings together a diverse and wide range of new research on subjects from soil microbial communities, soil physics and biogeochemistry, greenhouse gas emissions, terrestrial and semiaquatic invertebrate biodiversity in oil palm plantations on peat and mineral soils. There is a common thematic focus on oil palm management practices to mitigate GHG emissions and biodiversity loss, such as soil compaction to reduce impact of fire disturbance (Samuel and Evers), management of diverse habitat features (Manning et al.) such as understorey vegetation (Reiss-Woolever et al.; Drewer et al.) and riparian buffers (Drewer et al.; Harianja et al.).

Novel findings

An important disturbance in Southeast Asian tropical peatlands is fire which follows draining and clearing for oil palm cropping. Fires dramatically increase greenhouse gas (GHG) emissions and reduce air quality even past incidence of the fire event (Dhandapani and Evers, 2020). There is a lack of evidence based mitigation strategies for controlling and reducing carbon (C) losses from fire. Samuel and Evers suggest that in the absence of groundwater influence, compaction could be one of the solutions in mitigating carbon loss from fire in their controlled study, however they acknowledge the complexity in the field and the vital role groundwater level plays in tropical peatland management. Nevertheless, it is a first step in understanding the influence of compaction on GHG emissions and potential for mitigation of C emissions from fire related disturbances. The degradation in soil health of already established oil palm plantations (Guillaume et al., 2016; Woittiez et al., 2018) will result in farmers moving to productive soil necessitating further forest encroachments and deforestation (Pramudya et al., 2018).

Soil microbes play an important role in soil functions, particularly in nutrient cycling and decomposition of organic matter, hence in maintaining soil health, however soil microbial communities in oil palm plantations are understudied (Drewer et al., 2021). Azizan et al. found significant differences between microbial communities on peat in oil palm plantations and forest with respect to notable changes in specific bacterial groups in the deeper layers which are likely to influence carbon sequestration and nitrogen cycling.

The preparation of oil palm planting sites negatively impacts soil and particularly peat properties with increased heterotrophic carbon dioxide (CO_2) emissions, resulting in increased carbon loss and accelerating climate change (Tonks et al., 2017). Manning et al. showed significant spatial variation and the difference between autotrophic and heterotrophic regions, adding new findings to previous research on this subject (Dhandapani et al., 2022). Manning et al. further presented a more accurate way of estimating plantation level CO_2 emissions from soil, by performing area-weighted upscaling and accounting for variations in soil CO_2 emissions from different spatial features. Accurate estimations of the impacts are critical to develop effective solutions.

Reiss-Woolever et al. and Harianja et al. showed the importance of enhancing habitat complexity to mitigate biodiversity loss with no significant negative impact on GHG emissions (Drewer et al.). The management features that benefit biodiversity also generally benefit biogeochemistry of peat and biogeochemical cycles, similar to what is observed in intercropping systems (Dhandapani et al., 2019). Considering the large cover of oil palm plantations in Southeast Asia, and importance of oil palm in serving global food and energy needs as well as improving local economies, there is a need to investigate sustainable management practices for biodiversity conservation, in addition to protecting forests. Reiss-Woolever et al. emphasize the importance of limiting vegetation clearance in oil palm plantations to maintain habitat complexity and conserve biodiversity. Despite finding 55 species of Lepidoptera in this study, no forest specialist species were found in oil palm plantations with or without intensive management of ground vegetation, emphasizing the relative importance of forest habitats for biodiversity conservation. Further, no pest species were found in less intensive understorey management, indicating minimal risks for farm productivity. Drewer et al. add to this by showing no difference in GHG emissions with increased ground vegetation. So, the current studies show no negative impact from less intensive management of ground vegetation, but many proven benefits for biodiversity (Hood et al., 2020; Reiss-Woolever et al.) and biogeochemistry (Ashton-Butt et al., 2018).

Conclusions

To reduce the adverse impacts of the continued expansion of oil palm plantations in Southeast Asia, and more recently into Central and South America, and West Africa, it is crucial to draw on the lessons learned from over a century of oil palm cultivation in Malaysia and Indonesia. By implementing sustainable practices such as limiting forest loss and less intensive management, biodiversity loss and greenhouse gas emissions can be mitigated.

Author contributions

SD: Conceptualization, Writing – original draft, Writing – review & editing. CY: Writing – original draft, Writing – review & editing. JD: Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

Ashton-Butt, A., Aryawan, A. K., Hood, A. S. C., Naim, M., Purnomo, D., Suhardi., et al. (2018). Understory vegetation in oil palm plantations benefits soil biodiversity and decomposition rates. *Front. For. Glob. Change* 1:10. doi: 10.3389/ffgc.2018.00010

Cooper, H. V., Evers, S., Aplin, P., Crout, N., Dahalan, M. P. B., and Sjogersten, S. (2020). Greenhouse gas emissions resulting from conversion of peat swamp forest to oil palm plantation. *Nat. Commun.* 11:407. doi: 10.1038/s41467-020-14298-w

Dhandapani, S. (2015). "Biodiversity loss associated with oil palm plantations in Malaysia: serving the need versus saving the nature," in *4th International Conference on Biodiversity* (Las Vegas, CA: Journal of Ecosystem and Ecography).

Dhandapani, S., and Evers, S. (2020). Oil palm 'slash-and-burn' practice increases post-fire greenhouse gas emissions and nutrient concentrations in burnt regions of an agricultural tropical peatland. *Sci. Total Environ.* 742:140648. doi: 10.1016/j.scitotenv.2020.140648

Dhandapani, S., Evers, S., Boyd, D., Evans, C. D., Page, S., Parish, F., et al. (2023). Assessment of differences in peat physico-chemical properties, surface subsidence and GHG emissions between the major land-uses of Selangor peatlands. *CATENA* 230:107255. doi: 10.1016/j.catena.2023.107255

Dhandapani, S., Girkin, N. T., Ever, S., Ritz, K., and Sjogersten, S. (2022). Immediate environmental impacts of transformation of an oil palm intercropping to a monocropping system in a tropical peatland. *Mires Peat* 28:17. doi: 10.19189/MaP.2021.GDC.StA.2290

Dhandapani, S., Girkin, N. T., Evers, S., Ritz, K., and Sjögersten, S. (2020). Is intercropping an environmentally-wise alternative to established oil palm monoculture in tropical peatlands? *Front. For. Glob. Change* 3:70. doi: 10.3389/ffgc.2020.00070

Dhandapani, S., Ritz, K., Evers, S., and Sjögersten, S. (2019). Environmental impacts as affected by different oil palm cropping systems in tropical peatlands. *Agric. Ecosyst. Environ.* 276, 8–20. doi: 10.1016/j.agee.2019.02.012

Drewer, J., Leduning, M. M., Griffiths, R. I., Goodall, T., Levy, P. E., Cowan, N., et al. (2021). Comparison of greenhouse gas fluxes from tropical forests and oil palm plantations on mineral soil. *Biogeosciences* 18, 1559–1575. doi: 10.5194/bg-18-1559-2021

Estoque, R. C., Ooba, M., Avitabile, V., Hijioka, Y., Dasgupta, R., Togawa, T., et al. (2019). The future of Southeast Asia's forests. *Nat. Commun.* 10:1829. doi: 10.1038/s41467-019-09646-4

Guillaume, T., Holtkamp, A. M., Damris, M., Brümmer, B., and Kuzyakov, Y. (2016). Soil degradation in oil palm and rubber plantations under land resource scarcity. *Agric. Ecosyst. Environ.* 232, 110–118. doi: 10.1016/j.agee.2016.07.002

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., et al. (2013). High-resolution global maps of 21st-century forest cover change. *Science* 342, 850–853. doi: 10.1126/science.1244693

Hood, A. S. C., Advento, A. D., Stone, J., Fayle, T. M., Fairnie, A. L. M., Waters, H. S., et al. (2020). Removing understory vegetation in oil palm agroforestry reduces ground-foraging ant abundance but not species richness. *Basic Appl. Ecol.* 48, 26–36. doi: 10.1016/j.baae.2020.07.002

Miettinen, J., Shi, C. H., and Liew, S. C. (2016). Land cover distribution in the peatlands of Peninsular Malaysia, Sumatra and Borneo in 2015 with changes since 1990. *Glob. Ecol. Conserv.* 6, 67–78. doi: 10.1016/j.gecco.2016.02.004

Pashkevich, M. D., Marshall, C. A. M., Freeman, B., Reiss-Woolever, V. J., Caliman, J.-P., Drewer, J., et al. (2024). The socioecological benefits and consequences of oil palm cultivation in its native range: The Sustainable Oil Palm in West Africa (SOPWA) Project. *Sci. Total Environ.* 926:171850. doi: 10.1016/j.scitotenv.2024.171850

Pramudya, E. P., Hospes, O., and Termeer, C. J. M. (2018). The disciplining of illegal palm oil plantations in Sumatra. *Third World Q.* 39, 920–940. doi: 10.1080/01436597.2017.1401462

Sayer, J., Ghazoul, J., Nelson, P., and Boedhihartono, A. K. (2012). Oil palm expansion transforms tropical landscapes and livelihoods. *Glob. Food Sec. Agric. Policy Econ. Environ.* 1, 114–119. doi: 10.1016/j.gfs.2012.10.003

Shevade, V. S., and Loboda, T. V. (2019). Oil palm plantations in Peninsular Malaysia: determinants and constraints on expansion. *PLoS ONE* 14:e0210628. doi: 10.1371/journal.pone.0210628

Sodhi, N. S., Koh, L. P., Brook, B. W., and Ng, P. K. L. (2004). Southeast Asian biodiversity: an impending disaster. *Trends Ecol. Evol.* 19, 654–660. doi: 10.1016/j.tree.2004.09.006

Stibig, H. J., Achard, F., Carboni, S., Raši, R., and Miettinen, J. (2014). Change in tropical forest cover of Southeast Asia from 1990 to 2010. *Biogeosciences* 11, 247–258. doi: 10.5194/bg-11-247-2014

Tonks, A. J., Aplin, P., Beriro, D. J., Cooper, H., Evers, S., Vane, C. H., et al. (2017). Impacts of conversion of tropical peat swamp forest to oil palm plantation on peat organic chemistry, physical properties and carbon stocks. *Geoderma* 289, 36–45. doi: 10.1016/j.geoderma.2016.11.018

USDA (2023). *Oilseeds: World Markets and Trade.* United States Department of Agriculture Foreign Agricultural Service. Available online at: https://fas.usda.gov/data/oilseeds-world-markets-and-trade-05102024

Woittiez, L. S., Slingerland, M., Rafik, R., and Giller, K. E. (2018). Nutritional imbalance in smallholder oil palm plantations in Indonesia. *Nutr. Cycl. Agroecosyst.* 111, 73–86. doi: 10.1007/s10705-018-9919-5

Xu, J. R., Morris, P. J., Liu, J. G., and Holden, J. (2018). PEATMAP: refining estimates of global peatland distribution based on a meta-analysis. *Catena* 160, 134–140. doi: 10.1016/j.catena.2017.09.010

Yule, C. M. (2010). Loss of biodiversity and ecosystem functioning in Indo-Malayan peat swamp forests. *Biodivers. Conserv.* 19, 393–409. doi: 10.1007/s10531-008-9510-5