The Global Environmental Consequences of Palm Oil Production:
The Role of Industrial Polyculture in Sustainable Solutions

Callie A. Deines
Political Science & Public Affairs
Environmental Science

Abstract

- With the rise of the world's population, the necessity of global agricultural markets, and mass cultivation methods such as monoculture plantations have also drastically increased throughout countries of various socioeconomic statuses.
- This implies that a single plot of land be used to grow a single crop at a time which not only reduces the quality of produce, but also surrounding soil and water quality, and ecosystem biodiversity.
- Particularly focusing on palm oil production, the pollution resulting from these monocultures spreads across various countries including regions throughout southeast Asia, and some tropical countries in Africa and South America.
- In many cases, areas where oil palm is farmed were originally peatlands which act as carbon sinks but are then drained to be used as plantations which converts them to a carbon source.
- An alternative method to this would be the incorporation of large-scale polyculture plantations that involve intercropping multiple species in one area to promote both environmental and economic benefits.
- Utilizing a case study analysis of Malaysia, further investigations of the causes, criticisms, and possible global scale implementations of large-scale polyculture farms in replacement of monocultures will be analyzed and discussed within the targeted area.

Distribution of Peatlands in the World

Figure 1. Distribution of peatlands in the world, map from Renou-Wilson, F., Bolger, T., Bullock, C., Convery, F., Curry, J., Ward, S., Wilson, D., & Müller, C. (2011). *BOGLAND - Sustainable management of peatlands in Ireland.* Environmental Protection Agency.

Importance of Oil Palm and Peatlands

- The African oil palm (*Elaeis guineensis*), is cultivated in plantations where it yields 3 to 8 times more oil per area than any other oil-producing crop in tropical or temperate regions (Sheil et. al., 2009).
- Palm oil derivatives are common in products such as soap, shampoo, and lotion, food stuffs, and biofuels (Teoh, 2010).
- The process of draining peatlands makes them more susceptible to fire, therefore leading to increased greenhouse gas emissions, widespread environmental damage, and significant socioeconomic and health impacts (Dhandapani & Evers, 2020).
- Peatlands can hold up to two times as much carbon as all of the earth's forests combined (United Nations Environment Programme, 2019).

2000-2023 Average Production of Palm Oil by Country

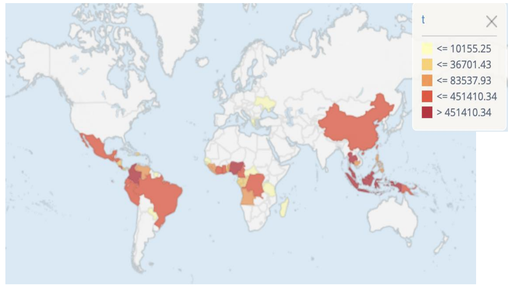

Figure 2. 2000-2023 Average production quantities of palm oil by country graph from FAOSTAT. (2000-2023). https://www.fao.org/faostat/en/#data/QCL/visualize

Palm Oil in Malaysia

- Due to this study aiming to eventually implement the proposed practices on a global scale, Malaysia was selected based on their overall palm oil production rates, country GDP, as well as global peace and rule of law rankings to ensure the adaptability to countries of both the global north and global south.
- Malaysia's commercial cropping has led to the country having the highest deforestation rate globally within the 21st century (Hansen et al., 2013).

Average Production of Top 10 Oil Palm Producers: 2000-2023

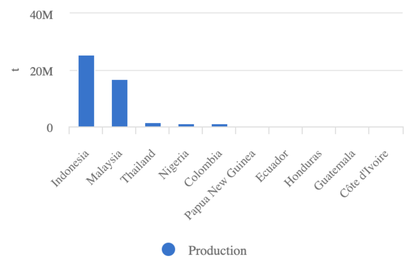

*Figure 3. P*roduction of palm oil in metric tons per country of top 10 globally, graph from FAOSTAT. (2000-2023). https://www.fao.org/faostat/en/#data/QCL/visualize

Figure 4. Peatland and cleared oil palm plantation.

Malaysia Palm Oil Production

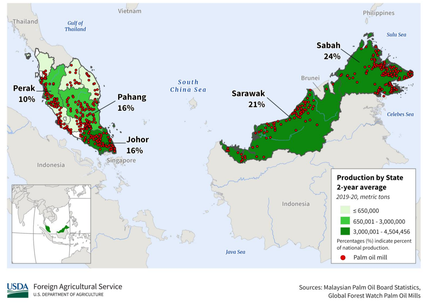

Figure 5. Palm oil production percentages and averages per state in Malaysia, map from United States Department of Agriculture. (2024). *Production - Palm Oil*. Palm Oil | USDA Foreign Agricultural Service. https://fas.usda.gov/data/production/commodity/4243000

Results

- Polyculture oil palm plantations could provide alternative livelihoods, reduce dependency, and diversify the country's incomes while also helping improve biodiversity, and overall resiliencies (Namanji, et. al., 2021).
- Oil palms can be planted in double rows with 6-meter spacing within each row and 15-meter-wide avenues in between which provides space for intercropping with high-value crops like cacao, coffee, vanilla, fruit, or timber trees. It ensures adequate light, water, and nutrients for these crops throughout the 25-year cycle while minimizing negative impacts on oil palm yields and expanding crop options (Namanji, et. al., 2021).
- Despite that it is unclear how strong the correlation between oil palm intercropping plantations and their overall improvement of environmental impacts on an industrial scale, a broader exploration of diverse management and cropping methods could yield viable alternatives that support both ecosystem integrity and the global market

Intercropping Oil Palm with Other Species

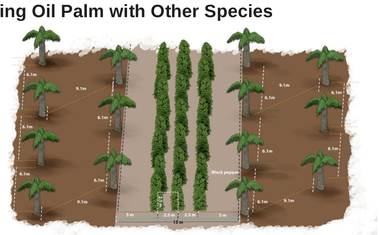

Figure 6. Explanation of oil palm intercropping methods, diagram from Namanji, S., Ssekyewa, C., & Slingerland, M. (2021). Intercropping food and cash crops with oil palm–Experiences in Uganda and why it makes sense.

Figure 7. Double row alley intercropping in Malaysia, with cassava, photo from Namanji, S., Ssekyewa, C., & Slingerland, M. (2021). Intercropping food and cash crops with oil palm–Experiences in Uganda and why it makes sense

Conclusion

By diversifying crops grown alongside oil palm through industrial scale plantations, farming has the potential to restore ecosystem services, improve soil health, and increase biodiversity without compromising economic yields. Successful implementation will provide a leading example in progress for other countries. Implementing this requires:

- Introducing of a few industrial scale polyculture plantations in one country to observe impacts, particularly in peatlands.
- Observing local and global environmental and societal impacts.
- Monitoring any fluctuations to decide further investigations in producing countries

This solution offers the potential for various benefits including socioeconomic progress and environmental restoration. The transition from monoculture to polyculture farming represents a significant step toward addressing the environmental and social challenges associated with palm oil production.

References

Beyer, R. M., Durán, A. P., Rademacher, T. T., Martin, P., Tayleur, C., Brooks, S. E., ... & Sanderson, F. J. (2020). The environmental impacts of palm oil and its alternatives. *Biorxiv*, 2020-02.
Central Intelligence Agency. (2023). *Real GDP per capita*. The World Factbook. https://www.cia.gov/the-world-factbook/field/real-gdp-per-capita/country-comparison/
Dhandapani, S. (2014, September). Biodiversity loss associated with oil palm plantations in Malaysia: Serving the need versus saving the nature. In Conference: Crops for the future.
Dhandapani, S., Ritz, K., Evers, S., & Sjögersten, S. (2019). Environmental impacts as affected by different oil palm cropping systems in tropical peatlands. Agriculture, Ecosystems & Environment, 276, 8-20.
Dhandapani, S., Girkin, N. T., Evers, S., Ritz, K., & Sjögersten, S. (2020). Is intercropping an environmentally-wise alternative to established oil palm monoculture in tropical peatlands?. Frontiers in Forests and Global Change, 3, 70.
Dhandapani, S., Girkin, N. T., Evers, S., Ritz, K., & Sjögersten, S. (2022). Immediate environmental impacts of transformation of an oil palm intercropping to a monocropping system in a tropical peatland. Mires and Peat, 28(07).
Dhandapani, S., & 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. Science of the Total Environment, 742, 140648.
Crop explorer for major crop regions - united states department of agriculture. International Production Assessment Division (IPAD) - Home Page. (n.d.). https://ipad.fas.usda.gov/cropexplorer/cropview/commodityView.aspx?cropid=4243000
FAOSTAT. (2000-2023). https://www.fao.org/faostat/en/#data/QCL/visualize
Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., ... & Townshend, J. R. (2013). High-resolution global maps of 21st-century forest cover change. *science*, *342*(6160), 850-853.
Hosseini, S. E., & Abdul Wahid, M. (2015). Pollutant in palm oil production process. *Journal of the Air & Waste Management Association*, 65(7), 773-781.
Institute for Economics & Peace. Global Peace Index 2023: Measuring Peace in a Complex World, Sydney, June 2023. Available from: http://visionofhumanity.org/resources (accessed 17 November 2024).
Kadir, A. P. G. (2023). Overview of the Malaysian oil palm industry 2022.
Muhammad, K. I., Sharaai, A. H., Ismail, M. M., Harun, R., & Yien, W. S. (2019). Social implications of palm oil production through social life cycle perspectives in Johor, Malaysia. The International Journal of Life Cycle Assessment, 24, 935-944.
Namanji, S., Ssekyewa, C., & Slingerland, M. (2021). Intercropping food and cash crops with oil palm–Experiences in Uganda and why it makes sense.
Orsato, R. J., Clegg, S. R., & Falcão, H. (2013). The political ecology of palm oil production. *Journal of Change Management*, *13*(4), 444-459.
Padfield, R., Varkkey, H., Manzo, K., & Ganesan, V. (2023). Time bomb or gold mine? Policy, sustainability and media representations of tropical peatlands in Malaysia. Land Use Policy, 131, 106628.
Pelaez, R. D. R., Oliveira, M. E. C., Miller, R. N. G., de Almeida, J. R. M., & de Siqueira, F. G. (2024). Biotechnological valorization of lignocellulosic residues from the oil palm industry: status and perspectives. *Biomass Conversion and Biorefinery*, *14*(3), 3077-3099.
Raihan, A., Begum, R. A., Mohd Said, M. N., & Pereira, J. J. (2021). Assessment of carbon stock in forest biomass and emission reduction potential in Malaysia. Forests, 12(10), 1294.
Santika, T., Wilson, K. A., Budiharta, S., Law, E. A., Poh, T. M., Ancrenaz, M., ... & Meijaard, E. (2019). Does oil palm agriculture help alleviate poverty? A multidimensional counterfactual assessment of oil palm development in Indonesia. *World Development*, *120*, 105-117.
Sheil, D., Casson, A., Meijaard, E., Noordwijk, M. V., Gaskell, J., Sunderland-Groves, J., ... & Kanninen, M. (2009). The impacts and opportunities of oil palm in Southeast Asia: What do we know and what do we need to know?.
Teoh, C. H. (2010). Key sustainability issues in the palm oil sector. International Finance Corporation, World Bank Group, 1-44.
United Nations Environment Programme. (2019, March 11). *Peatlands store twice as much carbon as all the world's forests*. United Nations Environment Programme. https://www.unep.org/news-and-stories/story/peatlands-store-twice-much-carbon-all-worlds-forests
United States Department of Agriculture. (2024). *Production - Palm Oil*. Palm Oil | USDA Foreign Agricultural Service. https://fas.usda.gov/data/production/commodity/4243000
World Justice Project. (2024). *Rule of law index 2024*. World Justice Project. https://worldjusticeproject.org/
Yusoff, S. (2006). Renewable energy from palm oil–innovation on effective utilization of waste. Journal of cleaner production, 14(1), 87-93.