

Tracing embodied deforestation in global supply chains: a full-resolution MRIO analysis for policy-resilient climate mitigation

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Deforestation remains one of the largest sources of land-use carbon emissions. Consequently, reducing forest loss is key to mitigating climate change and is at the core of nationally determined contributions (NDCs) and nature-based climate strategies. Progress towards mitigation targets is typically evaluated using territorial indicators, such as domestic forest cover change and national land-use emissions. In a globalised economy, these measures could be misleading—apparent domestic gains may coincide with the displacement of deforestation and associated carbon emissions to other regions through trade. By focusing primarily on within-border outcomes, current accounting approaches risk overlooking consumption-driven pressures embedded in global supply chains. A fair evaluation of mitigation progress therefore requires consideration of deforestation emissions embodied in international consumption alongside territorial indicators.

Here, we used a spatially explicit framework to quantify consumption-driven deforestation emissions. We combined forest loss data with sectoral driver probability maps to allocate deforestation to economic activities. The integration with full Eora multi-regional input output (MRIO) database to trace deforestation through international production networks allowed us to attribute embodied forest loss to final consumer countries. Then, we estimated climate impacts by overlaying spatial carbon stock data with consumption-attributed deforestation to quantify embodied land-use emissions associated with global trade. This approach also allowed for re-adjustments to the NDCs in the land use, land-use change and forestry (LULUCF) categories.

Overall, our results suggest substantial differences between territorial deforestation and consumption-based responsibility for different countries. This is exemplified by Singapore, a tropical island country largely reliant on trade for consumer goods, and China, a central player in global commodity trade alongside substantial domestic afforestation efforts. Despite net gains in forest cover domestically, our findings reveal that Chinese consumption is associated with considerable deforestation emissions abroad, contributing to approximately 0.78 million hectares of forest loss (roughly the size of Hong Kong Island) and estimated 220 million tons of embodied carbon emissions in 2015 alone. Compared to the magnitude of its total local emissions as 11550 million tons, its territorial responsibility is more evident. In contrast, Singapore, with relatively low domestic deforestation, is shown to exert significant pressures on forest ecosystems abroad through imports of agricultural and resource-intensive goods. Its deforestation footprint is estimated to be around fifty thousand hectares, three hundred times larger than its domestic deforestation area in 2015. Therefore, accounting for supply-chain land-use impacts is crucial for countries like Singapore.

From a policy perspective, our approach allows both producer- and consumer-side perspectives to be assessed within a consistent accounting structure. There is never a one-size-fits-all policy that ensures the equitable responsibilities of countries. The framework is explicitly oriented toward policy resilience, showing how consumption-based indicators can complement territorial metrics in NDCs, inform trade-related climate policies, and reduce the risk of carbon and deforestation leakage, especially for nations whose economies are largely dependent on trade. By advancing the application of input-output economics to land-use and climate mitigation challenges, this study contributes to the conference theme of enhancing policy resilience from global to local perspectives.