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"Towards multi-functional agro-ecosystems
promoting climate resilient futures"

Which countries and income groups are responsible for the environmental footprints of global food trade?

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Abstract

Understanding the environmental implications of global food trade is essential for effective climate change mitigation and equitable resource governance. Agricultural production not only deploys resources at the point of origin but also embeds virtual flows of water, land, greenhouse gas emissions (GHG), and biomass in traded commodities, flows that are ultimately driven by the consumption decisions of importing countries. Attributing these environmental costs to final consumers, rather than producers alone, is central to a fair accounting of global sustainability responsibilities.

Building on a multi-regional input-output framework (FABIO), we compile a comprehensive dataset of virtual water, land, GHG, and biomass flows covering 192 countries, 125 crop sectors, and the period 1990–2022. A novel crop-specific GHG emission factor panel, interpolated from benchmark datasets and scaled by country-level production intensity, enables temporally resolved accounting of agricultural emissions embedded in trade for the first time at this resolution.

Aggregating results by income group reveals stark structural asymmetries. Virtual flows across all four resources have expanded dramatically since 1990, with middle-income countries, many located in the Global South, driving the growth in agricultural exports. High-income countries (HICs), despite being relatively resource-rich, consistently run environmental deficits, as they are net importers of virtual water, land, and GHG-intensive production. This dynamic implies that the ecological burden of feeding wealthy nations is increasingly borne by countries with lower adaptive capacity and often more fragile ecosystems.

These findings have direct implications for climate adaptation and mitigation policy. Consumption-based environmental accounting exposes the hidden transfer of environmental pressure from high-income consumers to lower-income producers, undermining the sustainability of agricultural systems in the Global South. We argue that trade-linked environmental accountability must be incorporated into both national climate strategies and international sustainability frameworks if multifunctional, resilient food systems are to be achieved globally.

Keywords: Environmental accountability, food trade, footprints, income groups, responsibility, virtual resources

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