Modeling the supply sheds of cocoa cooperatives in Côte d'Ivoire

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Extended abstract

Globally traded commodities sourced in the tropics are commonly labeled with unsustainable supply conditions such as deforestation, human rights abuses and poverty (Pendrill et al., 2022; Sellare et al., 2022). Consequently, companies trading, manufacturing or retailing these commodities have made sustainability pledges. Furthermore, consumer countries' governments are passing supply chain due-diligence regulations, such as the European Union Deforestation Regulation (EUDR) which will require trading companies to demonstrate, as of 2025, that imported products are sourced from legal and deforestation-free plots.

However, in global value chains with large and diffused supply bases, sustainable sourcing is challenging to both implement effectively, and monitor and assess accurately. Upstream collection points in commodity supply chains – like farmer cooperatives, slaughterhouses, mills or silos – are pivotal for both aspects: deploying effective sustainable sourcing schemes (Grabs et al., 2024; Heine et al., 2020; Sellare et al., 2020), and assessing the spatially related socio-environmental risks embedded in supply (Godar et al., 2015). Hence, knowing their upstream and downstream connections in the supply chain is critical to the governance of sustainable sourcing (zu Ermgassen et al., 2022). However, in many cases, connections with spatially identified suppliers upstream these points, i.e. their supply sheds, are unknown – even to supply chain actors.

The supply shed of cocoa farmer cooperatives in Côte d'Ivoire is a case in point regarding this knowledge gap. With 40% of global cocoa bean supply, Côte d'Ivoire is the largest producer country. The more than 2 million tonnes of beans produced in the country (ICCO 2024) are sourced by a handful of multinational trading companies, from an estimated two million smallholder farmers[1]. While this trade is worth USD 5 billion (Guye et al., 2024), a majority of farmers still do not receive a living income, which entails further human rights and environmental harms (Fountain and Hütz-Adams, 2020). In particular, cocoa has replaced an estimated 1.5 million hectares of tropical moist forest since 2000 (0.36 mil. in protected areas), which is 45% of territorial tropical moist forest loss (Kalischek et al., 2023; Renier et al., 2023).

[1] Own estimate, using production per farmer provided in (Bymolt et al., 2018).

In this study, we build a spatial model of the supply sheds of cocoa cooperatives across Côte d'Ivoire – i.e., the geographic space over which a given cooperative is likely to source cocoa. The output of this model can unravel empirical analyses addressing at least four research questions.

First, knowing the country's overall supply shed of cooperatives can be insightful in the context of the European Union Deforestation Regulation (EUDR) coming into force. To comply with the EUDR's first-mile traceability requirement, companies are likely to invest first and foremost in supply chains that involve a cooperative. Yet, as cooperatives supply no more than an estimated 40% of cocoa beans sourced in Côte d'Ivoire (Guye et al., 2024), myriad producer communities are on the verge of losing access to the EU. Localizing producer communities outside the cooperatives' supply shed, and documenting the factors of larger supply sheds, would allow better targeting support for compliance capacity building and market inclusion.

Second, knowing the cooperatives' supply sheds also increases the accuracy with which researchers and civil society can track how cocoa sourcing companies restructure their supply chains in reaction to the EUDR – and in particular, the extent to which they tailor non-compliant supplies to non-EU markets instead of working towards compliance across the board.

Third, to lend credibility to their claimed performances on sustainability – pursued through their own sustainable sourcing programs – cocoa sourcing companies disclose the list of the supplier cooperatives participating in the programs. However, properly verifying these claims requires, among other things, to know the location of the farms supplying cooperatives – i.e., their supply sheds.

Fourth, the ability of measuring spatially explicit outcomes within cooperative supply sheds can facilitate the impact analysis of other relevant differences existing between cooperatives, such as in their governance models.

In addition to helping address these research questions, our empirical analysis can provide practical guidance to actors of sustainable cocoa supply chain governance. Specifically, we provide an assessment of the predictive performances of heuristic supply sheds, like administrative boundaries or catchment radiuses, compared to models demanding more data or structure. Further, we document what correlates with these performances, i.e. in what conditions heuristics do and do not work.

We build on three data sets primarily collected by academic partners through surveys of cocoa farmers and their buyers. In addition, we use scraped and privately shared data from cocoa sourcing companies and certification bodies, on the spatially explicit location of cooperatives and their members. We combine these primary data with novel secondary data on the universe of geolocated cooperatives (Guye, 2024) and with other spatially explicit open data found to be relevant in stakeholder interviews.

The model follows a likelihood approach whereby we attribute to every land pixel a probability that a potential cocoa farm in this pixel supplies (i.e. is a member of) a given cooperative. Typical potential determinants of this probability are distance, terrain, motorized travel time, and the local density of other cocoa plots and cooperatives. We use random forest algorithms to predict cooperative membership likelihood and learn which variables are most predictive. Further, in our survey data, we analyse the marginal predictive power of richer information with respect to the more systematically observable determinants aforementioned.

To answer the two first research questions outlined above, we use descriptive statistics on remotely sensed land use metrics in modeled supply sheds, and on a merge with customs declarations using a supply chain mapping model (Trase, 2024). To answer the two next research questions, we aim to use credible causal econometrics.

This research is led by Dr. Valentin Guye, an applied economics researcher studying the interactions of land use systems and commodity trade, in collaboration between UCLouvain (Belgium), IIASA (Austria), the JRC of the European Commission, and Wageningen University & Research (the Netherlands). This project is funded under two larger research projects, Sustain-Cocoa and Transparent Monitoring, and its results will feed into their research agendas. The end goal is to formulate high-level, independent, science-based recommendations to the relevant actors of sustainability in the corporate, institutional and civil society spheres.

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