Supply chain structures shape governance options and outcomes for deforestation-risk commodities across the tropics

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Supplementary Information (at end of this document):

- Supporting text: Additional detail for Results and Methods
- Table S1: Numbers of interviews and focus groups with each actor group in each commodity value chain
- Table S2: Criteria to assess values taken by GVC governance and other variables
- Interview guides

Abstract

Demand for agricultural commodities is a major driver of tropical deforestation, contributing to climate change and biodiversity loss and eroding forest-based livelihoods. In response, hundreds of multinational firms have adopted policies to end deforestation in their supply chains. Impact evaluations to assess the additionality of these forest-focused supply chain policies (FSPs) have proliferated. However, the influence of underlying contextual factors, such as supply chain structures, on FSPs' effectiveness and equity remains poorly understood. Here, we present the first pan-tropical comparative analysis of the four leading forest-risk commodities – Brazilian cattle and soy, Indonesian palm oil, and West African cocoa – to examine how supply chain structures influence FSPs' adoption, implementation, and outcomes. Drawing on 268 semi-structured interviews and focus groups with supply chain actors, our analysis enables us to improve middle-range theory about the influence of supply chain structures on policy outcomes. Specifically, we identify that by increasing the complexity of commodity transactions, FSPs necessitate that firms establish close supply chain linkages with suppliers. If suppliers have high capabilities to comply, these linkages are straightforward to establish. However, if suppliers have low compliance capabilities – as is common among smallholder farmers – and FSP firms have low market share, close linkages are difficult to develop. In these cases, firms often vertically integrate their supply chains. This improves control over deforestation-free production but disempowers farmers, undermining equity. Collectively, these empirical and theoretical contributions show that to overcome effectiveness-equity tensions and achieve transformative change, firms must invest in building smallholders' compliance capabilities across their supply bases.

Introduction

Tropical deforestation contributes to climate change and biodiversity loss, and affects the livelihoods of a billion people.[1,2] A quarter of tropical deforestation can be attributed to international demand for only a few agricultural commodities including cattle, palm oil, soy, and cocoa.[3] This has led to the proliferation of "forest-focused supply chain policies" (FSPs): policies by multinational firms to eliminate deforestation from their supply chains.[4]

FSPs include sectoral standards through which firms collectively apply incentives or sanctions to encourage producers to avoid deforestation.[5] For example, in the Amazon Soy Moratorium, signatory firms collectively agreed to not to buy soy from deforested properties in the Brazilian Amazon.[6] FSPs also include unilateral pledges by firms, such as Indonesian palm oil companies' "No Deforestation, no Peat, no Exploitation" (NDPE) commitments.[7] Other FSPs involve public actors; the *Termo de Ajustamento de Conduta* (Terms of Adjustment of Conduct, TAC) is a state-enforced agreement by slaughterhouses in the Brazilian Amazon to avoid sourcing cattle from illegally deforested properties.[8] The TAC is complemented by a private commitment, the *Compromisso Público da Pecuária* (Public Livestock Commitment, or G4), by Brazil's four largest meatpacking firms to avoid sourcing cattle from properties with any deforestation. In West Africa, the Cocoa and Forests Initiative is a public-private partnership between the governments of Côte d'Ivoire and Ghana and 35 firms to end deforestation in cocoa supply chains.[9] Some importing jurisdictions including the European Union (EU) have also introduced regulations that harden FSPs in public law, such as the EU Deforestation Regulation (EUDR).[10] The EUDR requires firms selling forest-risk commodities in the EU to demonstrate they were not produced on land that was deforested after 2020.

Extensive research has analyzed the design,[11–13] implementation,[7,14,15] and coverage of individual FSPs.[16–22] Numerous studies have examined their effectiveness within supply chains[23–25] and at regional and global scales.[4,26–30] Researchers have also investigated FSPs' social equity in terms of producers' access to, or exclusion from, markets.[8,12] Market exclusion is a particular concern for smallholder farmers whose livelihoods depend on producing forest-risk commodities. Research on market access equity has been complemented by studies on producers' participation in FSP design (procedural equity), distribution of benefits (distributive equity), and recognition of pre-existing political, economic, and social conditions (recognitional equity).[24,31,32] Equity is also important for FSPs' legitimacy:[33,34] their acceptance as being justified, desirable, or appropriate by a given community of producers.[35–37]

Some research has also examined how different contextual factors – namely public governance, historical land-use trends, producers' values, and supply chain structures – explain the adoption,

design, and implementation of FSPs.[7,16,38–40] Among these contextual factors, supply chain structures are particularly important: "lead" firms are often located far from production, and implementation is often delegated along complex supply chains with many intermediaries.[7,9,41,42] Yet despite the potential influence of supply chain structures, relatively little is understood about how they affect FSPs. A cross-commodity understanding of the interplay between supply chain structures and the governance of deforestation-free production is crucial to build theory about what underpins the success, failures, and challenges encountered by not only FSPs, but market approaches to agricultural sustainability more generally.

Gaps in understanding about how supply chain structures influence FSPs also pose practical problems for firms, which are exposed to deforestation across diverse commodities and regions but often apply FSPs in undifferentiated ways. A lack of awareness about the influence of varying supply chain structures also threatens to undermine frameworks for best practice, including the Accountability Framework Initiative and Science Based Targets Network, which provide generic guidance on mitigating deforestation but do not address differences between commodities and regions.

Here, we present a pan-tropical, cross-commodity comparative analysis drawing on 268 semi-structured interviews and focus groups to examine how different supply chain structures influence firms' governance of deforestation-free production using FSPs. Our aim was to develop a "middle-range" theory of the relationships between supply chain structures and FSP outcomes. Middle-range theories are descriptions of causal chains of mechanisms for well-bounded sets of phenomena;[43] they are more generalizable than *ad hoc* explanations of individual cases, but more specific than universal systems theories. We defined governance as the steps taken by firms to coordinate and control deforestation-free production,[44] including the adoption, design, and implementation of FSPs. Given our interest in governance, we adopted a Global Value Chain (GVC) perspective, which shifts focus from the transfer of goods between firms in a supply chain to the series of activities involved with producing and adding value to a commodity.[44–46] Accordingly, we defined value chain structures in terms of their length (number of activity stages or "tiers"), complexity (interconnections between actors), relative positions and collective leverage (market share) of lead firms, and the types of linkages connecting firms to suppliers.[7,44,47]

We examined the most prominent FSPs for the four most important forest-risk commodities, which account for over half of agriculture-driven tropical deforestation.[48] These FSPs were the Soy Moratorium and cattle slaughterhouses' TAC agreements in the Brazilian Amazon; palm oil firms' NDPE policies in Indonesia; and the Cocoa & Forests Initiative in West Africa (Côte d'Ivoire and Ghana; **Figure 1** and **Table 1**). We interviewed actors along each commodity value chain from

producers to manufacturers, as well as governments, non-government organizations (NGOs), and other relevant stakeholders (**Table S1**). We also incorporated insights from the FSP literature.

For each commodity, we first characterized the overall structure of the value chain, including its main actors, length, and complexity. Next, we identified the polarity of governance, i.e., where firms that drive deforestation-free production are positioned, and their market share. We then asked: how is firms' governance of deforestation-free production related to value chain structures, specifically in terms of the linkages between firms and suppliers? And how do different structures influence FSPs' adoption, design, implementation, and outcomes? For outcomes, we examined FSPs' effectiveness in reducing deforestation at regional scales. We also examined FSPs' equity in terms of market access for both smallholder farmers and larger producers.[12] As equity is relative, we considered how it manifests for producers compared to their peers who are not subject to FSPs.

We begin by presenting the analytical framework. We then present our findings for each commodity separately. In the Discussion, we compare our findings across the commodities to develop and discuss a middle-range theory of deforestation-free value chain governance.

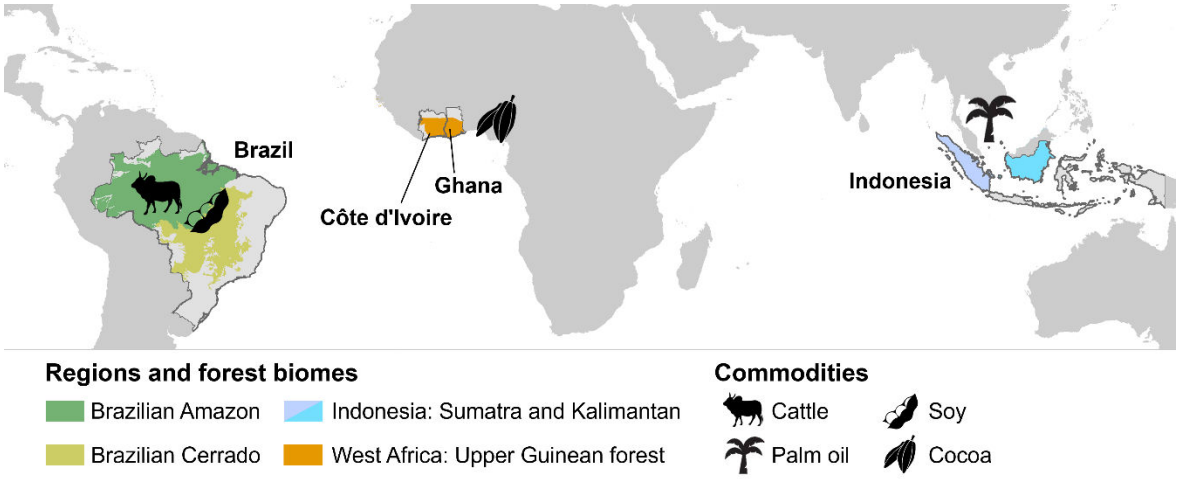


Figure 1. The most important producing regions for the four agricultural commodities associated with the most tropical deforestation,[49] which are investigated in this study. The map shows the forest biomes within each country that have been the most deforested by the commodities' expansion.

Table 1. Design features of the four FSPs investigated in this study. FSP types were identified from Lambin et al.[5] Other design features were identified from criteria for effective and equitable FSPs developed by Garrett et al.,[11] Grabs et al.,[12] Grabs and Garrett,[15] and Addoah et al.[24] Only those design features deemed most important for understanding a policy's overall design and implementation are presented.

Commodity and region	Brazilian Amazon soy	Brazilian Amazon cattle	Indonesian palm oil	West African cocoa
FSP investigated	Amazon Soy Moratorium (ASM)	Terms of Adjustment of Conduct (TAC)	No Deforestation, no Peat, no Exploitation (NDPE) policies	Cocoa and Forests Initiative (CFI) and firms' in-house sustainability programmes
Policy adoption date	July 2006[3]	July 2009[1]	From 2010	March 2017[2]
Type	Sanction-based sectoral standard: sectoral agreement based on market exclusion of noncompliant producers	Sanction-based sectoral standard: state-led standard based on market exclusion of noncompliant producers	Individual company pledges	Collective aspiration / public-private partnership and individual company pledges
Scope: actors	Soy producers	Cattle producers, although TAC agreements are signed by slaughterhouses	Firm's own plantations and independent palm oil producers and suppliers	Smallholder cocoa farmers, cooperatives, and traders; initially, direct suppliers only
Scope: region or biome	Legal Amazon	Cattle-producing Amazon states incl. Pará, Acre, Rondônia, Amazonas, Mato Grosso[1]	NDPE policies cover the entire (global) supply chains of committed companies	Côte d'Ivoire and Ghana
Deforestation reduction target and/or definition	Zero gross deforestation	Zero illegal deforestation	Zero gross deforestation: no conversion of forests identified as High Conservation Value (HCV) or High Carbon Stock (HCS)	In theory, zero gross deforestation (no HCV or HCS, no sourcing from protected areas)[2]; in practice, zero illegal deforestation
Cut-off date	22 July 2008[3]	22 July 2008[1,4]	Dates vary by firm, type of forest assessment (HCV or HCS), and application to firms' own or suppliers' operations	Ghana: 1 Jan 2018 (National Parks), 31 Dec 2019 (Category 1 Forest Reserves)[2]; Côte d'Ivoire: 31 Dec 2018 (National Parks and Reserves);[5] firms mostly 2025 or 2030[6]
Monitoring approach	Deforestation monitored within property boundaries using Brazilian National Space Agency (INPE) PRODES satellite monitoring and Rural Environmental Registry (CAR)	Deforestation monitored using INPE's PRODES and property boundaries in CAR	Deforestation risk assessment and satellite monitoring by individual firms; collective investments in forest disturbance alert system (Radar for Detecting Deforestation, RADD)	Deforestation risk assessment and satellite monitoring by individual firms; national satellite monitoring systems being developed by each country
Traceability approach	Property-level identification of soy producers	Cattle purchase documents incl. Animal Transport Permits (GTA), CAR certificates, environmental production licenses (LAR)*	Use of supplier and mill lists and supply sheds; extensive mapping of plantations but limited mapping of smallholder farms by firms; RSPO or ISCC certification	Mapping of individual farms by firms; certification (mostly Rainforest Alliance or Fairtrade); national traceability systems in development
Enforcement approach	Exclusion of noncompliant farms based on list published annually by Soy Moratorium Working Group (GTS)[3]	Exclusion of non-compliant direct suppliers by slaughterhouses, enforced using state audits of slaughterhouses' purchase documents[7]	Implementation of HCV and HCS approaches in firms' own plantations; grievance, engagement, and suspension or exclusion procedures with suppliers	Exclusion of farmers with farms in protected areas and surrounding buffer zones, as identified by individual firms and cooperatives through risk assessments
Benefit sharing and/or capability building by firms	Capability building undertaken by GTS to educate producers about the ASM[8]	Limited and company-specific, e.g. JBS' Green Offices initiative	Some capability building with scheme (contract) smallholder farmers by individual firms; some firm-to-firm capability building; sharing of certification premiums	Mass sensitization programmes by firms on environmental conservation, agroforestry, productivity, and livelihoods, but only to farmers within firms' value chains
Coordination with public and private actors	Government and NGOs were members of GTS[3]	TAC developed and enforced by the Brazilian Federal Prosecutor's Office (MPF)	Some coordination through e.g., Consumer Goods Forum, Palm Oil Collaboration Group, Palm Oil Innovation Group, and HCS Approach Steering Group, and jurisdictional or landscape approaches	CFI is a public-private partnership involving 35 firms and the Governments of Côte d'Ivoire and Ghana

1. Gibbs et al.;[25]; 2. CFI;[50] 3. Heilmayr et al.;[29] 4. Alix-Garcia and Gibbs;[26] 5. CFI;[51] 6. Addoah et al.;[24] 7. Levy et al.;[18] 8. Brannstrom et al.[52] Definitions (Portuguese initialisms defined in English): ASM, Amazon Soy Moratorium; CAR, Rural Environmental Registry; CFI, Cocoa & Forests Initiative; GTS, Soy Moratorium Working Group; HCS, High Carbon Stock; HCV, High Conservation Value; ISCC, International Sustainability & Carbon Certification; MPF, Brazilian Federal Prosecutor's Office; NDPE, No Deforestation, no Peat, no Exploitation; RSPO, Roundtable on Sustainable Palm Oil. * Larger properties in Pará only.

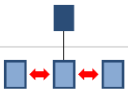
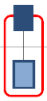
188 ***Analytical framework***

189 Several frameworks exist to analyze the governance of global value chains (GVCs)[53] and global
190 production networks.[54] To examine the relationship between value chain governance and structures,
191 we selected a GVC framework that focuses on the linkages lead firms use to coordinate and control
192 their suppliers.[44] We also considered whether lead firms were located at a single tier (unipolar
193 governance), or at two (bipolar) or more (multipolar) tiers.[47]

194

195 According to our selected framework, three variables determine the linkages that firms use to
196 coordinate and control deforestation-free production by their suppliers.[44] These are: 1) the
197 complexity of information required for transactions (i.e., evidence that commodities were produced
198 without deforestation); 2) the ability to codify (i.e., explicitly and precisely characterize) that
199 information, for example by using a standard; and 3) the capabilities of suppliers to execute
200 transactions (i.e., demonstrate FSP compliance). Each variable can take a value of either high or
201 low. Their combinations produce five observable types of governance and associated linkages:
202 market, modular, relational, captive, and hierarchical (**Figure 2**). These linkage types fall along a
203 spectrum of intensity. At one end of the spectrum, firms make no attempt to coordinate production
204 and exert little control over suppliers through market linkages. Here, firms buy commodities from
205 whichever supplier offers the lowest price. At the other end of the spectrum, firms directly control
206 and coordinate production through vertically integrated hierarchical value chains, in which they
207 undertake production, processing, manufacturing, and possibly marketing activities. By examining
208 the complexity and codifiability of FSPs, and suppliers' capabilities, it should thus be possible to
209 identify the types of linkages firms use with their suppliers. We used this framework to identify the
210 value chain structures through which firms govern deforestation-free production.

211

Variable					
Complexity of transactions	Low	High	High	High	High
Ability to codify transactions	High	High	Low	High	Low
Capabilities of suppliers	High	High	High	Low	Low
Resulting linkage / governance type	**Market linkages**	**Modular linkages**	**Relational linkages**	**Captive linkages**	**Hierarchy** (vertical integration)
Lead firm(s)					
Supplier(s)					
Intensity of governance	Least intense				Most intense
Definition and key features	No explicit coordination of suppliers by lead firms; buyers respond to prices set by sellers and costs of switching to new partners are low	Little explicit coordination of suppliers by lead firms, but complex information still exchanged through e.g. technical standards	Strong relationships between lead firms and suppliers to achieve close coordination and exchange complex information	Suppliers transactionally dependent on buyers and face high costs to switch to new partners	Lead firms take ownership of production, processing, and manufacturing through vertical integration
Potential market share of lead firms	Lower				Higher

Key

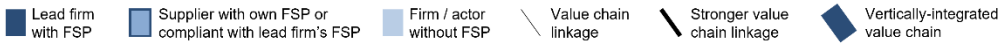


Figure 2. Five types of value chain linkages used by firms to govern deforestation-free production by suppliers (adapted from Gereffi et al., 2005).[44] In theory, linkage types are determined by the values (high or low) taken by three variables: the complexity of transactions, codifiability of transactions, and capabilities of suppliers to execute transactions. In practice, low complexity is not found with low codifiability or low supplier capabilities. Linkage types are shown lying along a spectrum of governance intensity, from least (market) to most intense (hierarchical). Lead firms that practice the most intense forms of governance (hierarchical or captive) can also be expected to hold higher market share.[46]

GVCs often consolidate power among large firms, which can come to dominate a market by vertically integrating their value chains.[44,46,55,56] Concentrated markets dominated by a few large firms can reduce environmental externalities if, for example, those firms limit production to drive up sale prices.[57,58] In the case of FSPs, firms attempt to exert control over deforestation through their purchasing rather than sales. Nonetheless, the collective market share of firms with FSPs is an important determinant of policy effectiveness,[11,18,22] although this is not simply a function of market concentration. Even in a fragmented market with many actors, FSPs can achieve high market share if they are adopted by most firms. However, if the collective market share of firms with FSPs is low, or market share is high but FSPs' stringency varies widely (i.e., codification is low), deforestation can "leak" to buyers with no or weak FSPs.[43]

Vertical integration and market share can also be expected to influence FSPs' equity.[12,59] Vertical integration can provide less-capable producers with more secure income, credit, market access, off-farm employment, and extension services.[56,60,61] However, it can also enable firms to drive down prices, exclude farmers that fail to meet production standards, and dispossess less-competitive smallholders of their lands.[59,62,62] If firms with FSPs collectively achieve high market share, this could lead to the exclusion of noncompliant suppliers.[12,18] To examine the impacts of market share

as well as vertical integration, we therefore augmented the GVC analysis framework to include market share (**Figure 2**).

We applied this framework to code our interview data. We summarized and interpreted the coded data using a framework matrix (**Supplementary Information**, **SI**) that cross-tabulated the most salient codes (themes) with the four commodities. We assessed the values taken by GVC governance and other variables using pre-defined criteria (**Table S2**). Noting the diversity of actors, FSPs, and outcomes across commodities and within value chains, we allowed each variable to take an intermediate value as well as "high" or "low". We present our findings as a narrative synthesis for each commodity, structured as follows: 1) overall value chain structure; 2) polarity of governance and market share; 3) complexity and codification of FSPs, and capabilities in the supply base; 4) resulting value chain linkages; and 5) outcomes. The adoption, design, and implementation of FSPs are discussed throughout.

Results

All statements are based on interview data unless a literature reference is cited. Supporting evidence is provided in participant quotations, which are linked to interviews using pseudonyms (**Table S1**).

Soy in the Brazilian Amazon

Overall structure: Brazilian soy value chains have comparatively few tiers (**Figure 3**). Farmers sell soybeans to traders, occasionally via intermediaries or cooperatives. Four firms – Archer Daniels Midland, Bunge, Cargill, and Dreyfus – have historically dominated exports, although new market entrants are increasingly driving export growth.[63] Vertical integration is limited, with Brazilian trader Amaggi being an outlier in owning farms.[64]

Polarity of governance and market share: The Amazon Soy Moratorium emerged from pressure by Greenpeace on traders and retailers including Cargill and McDonald's. The reputational risk associated with deforestation motivated both firms to drive FSP adoption by seeking support from other companies. This revealed two governance poles – downstream and midstream – in initial negotiations over a zero-deforestation agreement. While McDonalds "*brought companies together*" downstream (BRS03-NGO), Cargill's dominance in the Brazilian Association of Vegetable Oil Industries (Portuguese initialism ABIOVE) gave it influence over the midstream. The Moratorium was adopted in 2006 and designed as a pre-competitive sectoral agreement to exclude noncompliant producers. To implement the Moratorium, a Soy Moratorium Working Group (Portuguese initialism GTS) was established by ABIOVE with Greenpeace, and included traders, NGOs, and later the government. Implementation was thus driven from the midstream. With the

participation of ABIOVE, the Moratorium achieved high market share at the midstream, covering 95% of Amazon soy exports by 2018.[28]

Complexity and codification of FSPs, and capabilities in the supply base: The Soy Moratorium is highly codified: it involves precisely characterized and standardized technical requirements for zero deforestation. Implementation is moderately complex. Farmers must register their property boundaries on the national Rural Environmental Registry (Portuguese acronym CAR). Compliance is then assessed by traders using deforestation data from the Brazilian National Space Agency's (INPE) PRODES satellite monitoring system and a list of noncompliant farms published annually by the GTS.[6,29] However, as CAR registration is legally required, complying with the Moratorium is no more complex for producers than meeting their statutory obligations.

Farmers generally have high capabilities to comply with the Moratorium. Soy farmers in Brazil are often well capitalized, particularly compared to "family" farmers.[65] They have become highly organized into a national lobby, the Brazilian Association of Soy Producers (Aprosoja), which assists producers with understanding regulatory changes.[16,66] Meanwhile, the availability of previously cleared cattle pastures in the Amazon made compliance relatively easy for producers seeking to expand soy cropland.[16,67] Yet, to the extent that the Moratorium disincentivized new agribusinesses investment in the Amazon, it likely increased transaction and input costs for farmers compared to places where economies of scale had been achieved such as the Cerrado, Brazil's highly biodiverse savannah biome.[68]

Value chain linkages: The Moratorium's moderate complexity, high codification, and farmers' high compliance capabilities, alongside the comparatively short soy value chain, produced modular linkages between individual producers and traders. However, the high market share of Moratorium signatories meant farmers had limited opportunities to find non-FSP buyers. Consequently, these modular linkages collectively took on a captive resemblance at the biome scale. In one extreme case, Cargill established actual captive linkages with producers through a near-monopsony around its Amazon River port of Santarém, before the Moratorium was established.[68] These linkages enabled Cargill to enforce the Moratorium directly among producers. Elsewhere, non-Moratorium signatories could be found but offered reduced prices, signaling high costs for farmers to switch to non-FSP buyers: "*Those guys who specialized in sourcing blocked soya from the Moratorium, they already knew the producer had to sell, and they would drive the price down*" (BRS02-IND). Still, farmers' high capabilities prevented linkages from becoming hierarchical. The captive resemblance of modular linkages at the biome scale became more evident when comparing farmers in the

311 Amazon with the Cerrado, where producers' relatively higher capabilities enabled them to maintain
312 market linkages with non-FSP buyers and resist the Moratorium's expansion (further details in **SI**).
313
314 **Outcomes:** With a short value chain, high producer capabilities, and high market share (95%),[28]
315 the Soy Moratorium achieved high regional effectiveness (**Table 2, Figure 4**), reducing soy-driven
316 deforestation in the Amazon by 57% between 2006–2015 and preventing 18,000 km^2 of forest loss
317 by 2016.[28,29] However, 43–50% of this avoided deforestation was offset by clearance elsewhere in
318 Brazil.[30] The high market share of Moratorium signatories also limited Amazonian farmer's options
319 for non-FSP buyers. Modular linkages took on a captive resemblance at the biome scale, despite
320 farmers being well-capitalized and highly capable. With weaker public and political support for
321 conservation outside the Amazon,[66] producers' organizations were able to resist the Moratorium's
322 expansion to the Cerrado.[16]

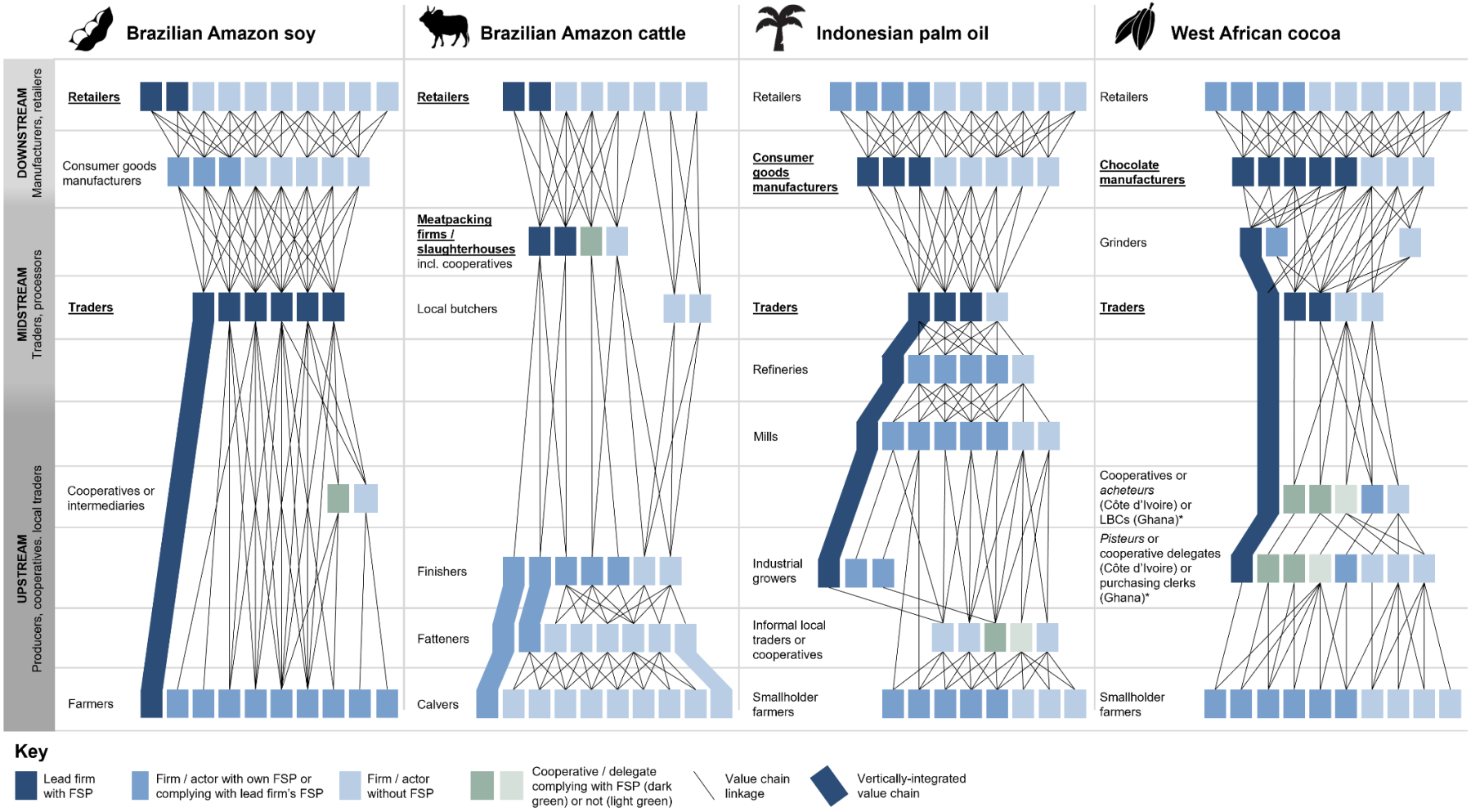


Figure 3. Schematic representation of the four commodity value chains illustrating the positions of lead firms that drive FSPs (bold underlined text) and coverage of policies among their suppliers. The numbers of actors depicted in each tier are indicative rather than representative of actual numbers or proportions of market share. These schematics show how FSP adoption by relatively few midstream actors in hourglass-shaped supply chains can lead to high market share. Incomplete adoption at a given tier can lead to a bifurcated value chain with FSP-compliant (dark blue) and conventional (light blue) streams.

329 ***Cattle in the Brazilian Amazon***

330 **Overall structure:** Cattle value chains in the Brazilian Amazon are complex and involve
331 numerous producers managing and trading cattle through one or more lifecycle stages of calving,
332 rearing, and fattening/finishing. Some larger farmers have vertically integrated their value chains
333 by adopting "full cycle" management. Few slaughterhouses have integrated cattle production into
334 their operations. Four meatpacking firms – JBS, Marfrig, Minerva, and Bertin (later acquired by
335 JBS) – dominate the sector. JBS alone accounts for 50% of cattle slaughtered in the Legal
336 Amazon.[26]
337
338 **Polarity of governance and market share:** The TAC was adopted in 2009 following pressure
339 from the Federal Public Prosecutor's Office (Portuguese initialism MPF) and NGOs including
340 Greenpeace[25] on the most prominent meatpacking firms and manufacturers and retailers
341 downstream. However, the TAC's design was ultimately negotiated between the MPF, the
342 Association of Brazilian Cattle Exporters (ABIEC), and the four largest meatpacking firms,
343 signifying midstream governance.[8] The TAC requires slaughterhouses with a record of sourcing
344 cattle from illegally deforested areas to sign agreements not to buy cattle from illegally deforested
345 properties.[18] The first agreements were signed in July 2009.[25] In October 2009, a private zero
346 deforestation agreement, the G4, was signed by JBS, Marfrig, Minerva, and Bertin, again under
347 pressure from Greenpeace.[18] Through the G4 signatories' substantial market share, the two cattle
348 agreements came to cover 75% of slaughterhouses' cattle purchases in Pará, Rondônia and Mato
349 Grosso by 2018, of which 26% was accounted for by the TAC alone.[18]
350
351 **Complexity and codification of FSPs, and capabilities in the supply base:** TAC agreements
352 require slaughterhouses to ensure producers provide complex but highly codified evidence of
353 compliance. This includes an Animal Transport Permit (Portuguese initialism GTA), CAR
354 certificate and, for larger properties in Pará, an environmental production license (LAR).
355 Slaughterhouses use these documents together with PRODES, embargo lists, polygons of
356 indigenous lands and protected areas, and productivity indices to verify no illegal deforestation has
357 taken place. Some slaughterhouses reported initially having limited capabilities to implement these
358 procedures, even if they ultimately completed monitoring: "*We don't have the structure to deal*
359 *with the public prosecutor's office, that's the truth... TAC is a headache*" (BRC44-SLA). Producers
360 had varying capabilities to execute TAC-compliant transactions. While larger finishers found
361 meeting requirements expensive but feasible, most small- and medium-sized producers we
362 interviewed were not even aware of the TAC, with only two of 15 mentioning buyers'
363 environmental requirements. In addition, most cleared land in the Brazilian Amazon is occupied by
364 pasture, much of which is degraded. Unlike soy, the low profitability of cattle makes renovating

pastures unattractive unless management intensity is increased [69]. For producers who lack the capital to intensify, low yields create incentives to expand into forests.

Value chain linkages: Theoretically, complex TAC requirements and low capabilities among producers would be expected to produce captive or hierarchical linkages, with vertically integrated operations appearing or smaller producers becoming trapped into dependence on slaughterhouses. Indeed, four finishers we interviewed had adopted full-cycle operations. Yet we also found that market linkages persisted between producers and non-TAC signatory slaughterhouses, with price and timely payment being the most important factors. Two TAC-signatory slaughterhouses described the importance of developing strong relationships with suppliers, signaling that when TAC is implemented, this is through relational linkages.

What explains the persistence of market linkages despite the high complexity of the TAC and low capabilities in the supply base? First, not all slaughterhouses have to sign TAC agreements.[18] Second, seven of the eight slaughterhouses we interviewed were unable to meet their processing capacities due to insufficient supply and high prices. The moderate coverage of TAC agreements and high demand for cattle in the study region led to the value chain bifurcating between TAC slaughterhouses, which require complex proof of compliance, and local butchers and non-TAC slaughterhouses that make no such demands. A meatpacker's union official described the problem of trying to implement an FSP in this situation: "*It's like trying to separate beans and rice, it's difficult. You discard the beans, and then someone else comes along and eats the rice and beans as well as your beans*" (BRC07-UNI).

Outcomes: Early analyses of the TAC and G4 found no impact on forests in areas surrounding slaughterhouses.[26] The G4 was later found to have reduced cattle-driven deforestation by 15% in Pará, Rondônia, and Mato Grosso between 2010–2018.[18] The TAC also reduced deforestation on farms in Pará by 0.57% per year between 2009–2018, saving 6.7 ha of forest per property per year, although this impact declined by 89% due to deregulation under the Bolsonaro administration.[70] Nonetheless, producers and slaughterhouses claimed "*TAC is succeeding*" (BRC39-SLA) by limiting where producers can clear. From an equity perspective, smaller producers with lower capabilities were excluded from selling to TAC-signatory slaughterhouses but did not lose market access altogether. Still, as TAC implementation ramped-up against a background trend of land concentration, participants were concerned that small producers risked being pushed out of the market: "*If we continue at the current pace, in 10 years the medium and small businesses will be extinct*" (BRC10-FAT).

Palm oil in Indonesia

Overall structure: The palm oil value chain is long and complex. Large vertically Integrated Supply chain Companies (LISCs) with growing, milling, refining, trading, and manufacturing operations account for a substantial proportion of trade, although independent producers, mills, refiners, and traders also play prominent roles. Smallholder farmers account for 36% of Indonesia's planted oil palm area.[71]

Polarity of governance and market share: In the late 2000s, NGOs pressured consumer goods manufacturers to tackle palm oil-driven deforestation. Nestlé became the first manufacturer to adopt a zero-deforestation policy in 2010.[15] NGOs and manufacturers also pressured LISCs and traders to adopt policies, which included Wilmar's NDPE policy and Golden Agri Resources' Forest Conservation Policy. In turn, LISCs and traders encouraged NDPE adoption by mills and growers upstream. Thus, while NDPE governance was initially driven by manufacturers downstream, bipolar governance emerged and LISCs at the midstream became "*the leaders in NDPE implementation*" (IPO35-CON). LISCs and large traders applied NDPE policies across their entire value chains to secure access to markets as sustainability demands grew. This resulted in moderate market share, with 70% of firms and 89% of smallholders covered by an NDPE policy on paper by 2020.[17] In practice, however, the rollout of NDPE policies among smallholders has lagged.[15]

Complexity, codification of FSPs, and capabilities in the supply base: Firms' NDPE policies require suppliers to satisfy complex criteria, including proving that forests identified as High Conservation Value (HCV) or High Carbon Stock (HCS) have been conserved. Many firms now implement their policies using highly codified Roundtable on Sustainable Palm Oil (RSPO) certification.[14,15] Yet RSPO certification cannot satisfy the needs of all downstream firms with specific brand requirements: "*Every large consumer goods manufacturer will want things his own way… We have, further downstream, a bit of a mass of different requests as to what is acceptable*" (IPO31-LISC). Some firms' NDPE policies thus go beyond RSPO, although traders claimed they are broadly similar. Codification has been increased by initiatives such as the Implementation Reporting Framework, which provides a consistent basis for NDPE implementation.

Suppliers' capabilities to comply with or implement NDPE policies vary. LISCs "*have full control*" (IPO23-NGO) to implement policies throughout their operations. Larger growers and traders are also often highly capable. However, independent smallholders' lack of capability to achieve RSPO certification is well documented[72] (further details in **SI**). Similar challenges apply to even more stringent NDPE policies. Many smallholders have little knowledge of NDPE requirements [17], as one industrial grower explained: "*Policies are up here*, *producers are down here*" (IPO10-GRO).

Value chain linkages: Variations in producers' capabilities to comply with complex NDPE policies have produced different linkages. LISCs implement their policies through hierarchical linkages. If suppliers are highly capable, RSPO certification often enables firms to implement NDPE through modular linkages. However, firm-specific policies demand relational linkages. This means firms must use a cooperative approach to encourage compliance, engaging with suppliers before suspending or excluding them. Firms also have to invest in building suppliers' capabilities. This may eventually produce modular linkages, as suppliers' expanding capabilities give them access to new buyers: "[We] *were consistently supporting them in that transformation journey, but then, like a kid that grows up, they left us behind. They had better options*" (IPO32-TRA).

Despite the importance of relational linkages or vertical integration for implementing complex and less-codified NDPE policies, growers, traders, and LISCs continue to source palm oil "indirectly" from independent smallholders and mills or intermediaries through market linkages, reportedly to manage investment and logistical costs and to secure supply. Meanwhile, improved infrastructure, high demand, and excess refining capacity have enabled mills (and, via intermediary traders, smallholders) to choose buyers that offer competitive prices and simple transactions, including domestic buyers with no NDPE requirements. Consequently, a bifurcated value chain has emerged with FSP-compliant and conventional streams. While some firms support capability building by smallholders, projects are often site-specific, time-bound, lack scale, and "*not representative of industry*" (IPO15-GRO).

Outcomes: RSPO certification reduced deforestation in Indonesian oil palm concessions by 33% between 2005–2015.[23] However, causal analysis of NDPE policies from 2019–2022 suggests they had no additional impact, as farms in and outside committed firms' supply sheds all reduced deforestation during a period when forest loss in Indonesia fell by 69%.[73,74] Still, growers, LISCs, and manufacturers lauded the progress made in industrial plantations, which they claimed is "*trending down*" while "*deforestation outside concessions is on the rise*" (ID30-LISC). Yet since 2014, the share of industrial oil palm expansion from forests has been higher than that for smallholder expansion.[73] Deforestation outside concessions may continue to be driven by wealthy medium-sized producers (*petani berdasi*) that are nominally considered "smallholders" but may each hold hundreds or thousands of hectares in total.[15] Collectively, this evidence suggests NDPE policies have been at best moderately effective, although negative impacts on equity have been mitigated by continued access to conventional markets for noncompliant producers.

Cocoa in West Africa

Overall structure: Smallholder farmers account for the majority of cocoa production in Côte d'Ivoire and Ghana. In Côte d'Ivoire, farmers sell cocoa beans to cooperatives, or to middlemen

(*pisteurs*) who sell to local buyers (*traitants*) or cooperatives. Cooperatives and *traitants* sell beans to traders. In Ghana, the parastatal cocoa board, Cocobod, licenses "Licensed Buying Companies" (LBCs) to buy beans from farmers. LBCs sell beans to Cocobod's Cocoa Marketing Company, which sells beans to traders. In both countries, cocoa traders and grinders sell cocoa beans and products to chocolate manufacturers.

Polarity of governance and market share: The Cocoa and Forests Initiative (CFI) was adopted in 2017 by manufacturers, traders, and the Ghanaian and Ivorian governments following a campaign by the NGO Mighty Earth. However, traders explained that, within the bounds of the value chain, FSP adoption and design were primarily driven by manufacturers: "*We represent* [them] *on the ground to implement their sustainability ambitions and commitments*" (GHA28-TRA).

The CFI initially only committed firms to traceability in their "direct" value chains.[75] Continued "indirect" sourcing of conventional cocoa has led to low market share. While CFI signatories account for 85% of global cocoa usage, and Côte d'Ivoire and Ghana produce ~60% of global supply, the focus on direct sourcing means just 26% of globally traded cocoa is covered by an FSP.[19]

Complexity and codification of FSPs, and capabilities in the supply base: Cocoa firms' FSPs are complex, with criteria covering forest conservation and restoration, agricultural productivity, and social inclusion. However, FSPs are moderately codified as many firms implement their policies using Fairtrade or Rainforest Alliance certification. Manufacturers usually require additional activities to differentiate their brands, specified by in-house sustainability programmes (e.g., Mondelēz's Cocoa Life, Nestlé's Cocoa Plan). Large, highly capable traders match manufacturers' requirements to their own programmes (e.g., Cargill's Cocoa Promise, Barry Callebaut's Cocoa Horizons), which vary in their emphasis on specific issues. While the compliance capabilities of intermediaries vary widely, for many LBCs and cooperatives they are limited. Farmers' independent compliance capabilities are low (further details in **SI**).

Value chain linkages: When traders' and manufacturers' FSPs align, or certification is used, firms trade FSP-compliant cocoa through modular linkages. When manufacturers' requirements exceed available offerings, traders offer tailored activities and relational linkages emerge. Manufacturers and traders also form relational linkages with highly capable cooperatives and LBCs to implement FSPs with farmers. Less-capable suppliers are controlled more closely. In Côte d'Ivoire, some traders reported installing their own staff in cooperatives, revealing captive linkages. In Ghana,

Barry Callebaut, Cargill, Ecom, and Olam have vertically integrated their value chains by acquiring or establishing LBCs, often explicitly to coordinate FSP implementation.[76]

It is challenging for firms to establish captive or hierarchical linkages with farmers as high demand for cocoa beans means farmers can often choose between several buyers. Implementing FSPs therefore requires firms to develop relational linkages with farmers by building their capabilities and promoting loyalty. To do this, firms offer advance payments and price premiums, alongside training on good agricultural practices, agroforestry, and forest conservation. However, training is undermined by firms only engaging with their direct suppliers, as well as a lack of inter-firm coordination, leading to duplicated efforts: "*When it happens like that, you are not able to achieve impact at the landscape scale. Impact becomes sporadic and scattered and it's a matter of time that you have rollback*" (GHA35-TSO).

Consequently, a bifurcated value chain has emerged with streams for FSP-compliant and conventional beans. As cooperatives and LBCs often source both FSP-compliant and conventional beans for different clients and farmers can mix beans from different plots, beans from deforested areas are easily commingled into FSP-compliant streams. A trader argued this means beans cannot be traced to a single plot: "*Anyone tells you they can attest to that, they're lying. It's impossible. There is always going to be the farmer with a dozen different plots... There's no way you can know exactly, 100%, that your cocoa didn't come from a classified forest*" (CIV21-TRA).

Outcomes: In Ghana, FSPs have produced small reductions in deforestation in forest reserves caused by cocoa and food crops displaced by cocoa.[77,78] Nonetheless, some manufacturers, traders, and cooperatives were positive about FSPs' impacts on forests as they claimed farmers in protected areas were being excluded from FSP value chains. One group of farmers in a "buffer zone" around an Ivorian classified forest described being excluded from their cooperative because of an FSP: "*It hurts, we cried every day… When we were in the cooperative, we managed well... But since that day, we've lost out*" (CIV-FG01). Yet other private, public, and civil society participants were pessimistic about FSPs' effectiveness due to continued sourcing from protected areas. Household surveys in Ghana suggest FSPs have not resulted in market exclusion.[79] Altogether, this suggests cocoa FSPs have achieved low regional effectiveness, albeit without major negative impacts on equity.

Findings for each case are compared in **Table 2** and **Figure 4**.

Table 2. Summary of findings across the four commodity value chains. The values taken by variables were assessed using pre-defined criteria (**Table S2**).

	Brazilian Amazon soy	**Brazilian Amazon cattle**	**Indonesian palm oil**	**West African cocoa**
FSP investigated	Amazon Soy Moratorium (ASM)	TAC agreements signed by slaughterhouses in the Amazon	NDPE commitments by individual firms	CFI and firms' in-house sustainability programmes
Overall value chain structure	Comparatively shorter value chain with fewer tiers; little vertical integration	Comparatively shorter value chain w/ fewer tiers (although multiple calving, raising, and finishing tiers); little vertical integration	Long value chain with multiple tiers; mix of large vertically integrated firms and independent actors	Long value chain with multiple tiers; some vertical integration in Ghana by multinational traders with LBCs
Lead firms	Retailers (McDonald's) and traders (Cargill, followed by ABIOVE)	Slaughterhouses; smaller role for brands and retailers	Consumer goods manufacturers, followed by LISCs and large traders	Chocolate manufacturers and cocoa traders and grinders
Polarity of governance (value chain positions of firms that pre-eminently drive governance in **bold**)	Downstream **Midstream**	**Midstream**	Downstream **Midstream**	**Downstream**, Midstream
Complexity of FSPs	Moderate: ASM requires producers to register properties in CAR, but this is a public requirement, and monitoring is performed by ASM signatories and the GTS using INPE PRODES satellite monitoring system	High. Implementation requires farmers to present numerous documents including a GTA, CAR, LAR, and tax invoice; monitoring of deforestation by slaughterhouses with PRODES; and public audits of slaughterhouses	High: Implementation requires satisfaction of numerous criteria including identification, management, and monitoring of HCS and HCV areas; palm oil traceability to mills; satellite monitoring of deforestation; and observation of FPIC	High: Implementation involves registering and mapping farms; yield estimates; assessing deforestation risks; monitoring deforestation in protected areas; and conducting awareness-raising activities with farmers
Codification of FSPs	High: Amazon Soy Moratorium is a sectoral standard	High: TAC is a sectoral standard enforced by the Federal Public Prosecutor (MPF)	Moderate: upstream firms often implement NDPE using RSPO; midstream use RSPO and own policies; downstream adopt specific but similar policies to differentiate brands. IRF offers some codification	Moderate: some firms' policies are based on Fairtrade or Rainforest Alliance. Downstream firms adopt in-house policies to differentiate brands, but CFI ensures high degree of consistency between firms
Capabilities in the supply base	High; Amazonian soy producers have high capabilities to execute ASM-compliant transactions, but overall capabilities lower than in the Cerrado	Mixed; capabilities are greater among larger than smaller producers, who often have low capabilities for compliance	Mixed; industrial growers, large traders and LISCs are highly capable; smallholders have low capabilities for compliance	Low; smallholder farmers depend on large-scale training and support by firms
Value chain linkages	Modular (Amazon), but high market share of ASM signatories meant linkages took on a captive resemblance at the biome scale; market (Cerrado)	Relational (FSP streams), although some hierarchical linkages emerging as finishers adopt full-cycle management; market (conventional streams)	Hierarchical (LISCs); modular (RSPO-certified streams); relational (NDPE streams); market (conventional streams)	Hierarchical (traders with LBCs); modular/relational (manufacturers with traders); relational (traders with farmers); market (conventional streams)
Collective market share of FSP	High: ASM covers 95% of Amazon soy exports[28]	Moderate: 26% of cattle purchases in Pará, Rondônia and Mato Grosso covered by TAC alone, but 75% covered by TAC and/or G4[18]	Moderate: on paper, 70% of firms and 89% of smallholders are covered by a ZDC, but only 46% of smallholder plots are in the supply bases of mills with ZDCs[17]	Low: while CFI signatories account for 85% of global cocoa use, only 26% of global trade is covered by an FSP due to indirect sourcing,[19] and 55% of Ivoirian exports were untraceable in 2019[80]
FSP outcomes	High effectiveness, moderate equity: ASM reduced soy deforestation by 57%[28] and excluded noncompliant producers, but producer capabilities mitigated livelihood impacts and prevented expansion to the Cerrado	Moderate effectiveness, moderate equity: TAC reduced deforestation by 0.57% year^{-1} on compliant properties;[70] non-compliant small producers risk market exclusion and acquisition into larger landholdings but retain access to conventional markets	Moderate effectiveness, moderate equity: NDPE policies produced no additionality[74] but deforestation for oil palm has fallen nationally;[73] noncompliant industrial, mid-sized, and smallholder producers all retain access to conventional markets	Low effectiveness, moderate equity: deforestation reduced in Ghanaian reserves[78] but cocoa continues to be grown in protected areas; noncompliant farmers excluded from sustainability programmes but retain access to conventional markets

Definitions (Portuguese initialisms defined in English): ABIOVE, Brazilian Association of Vegetable Oil Industries; ASM, Amazon Soy Moratorium; CAR, Rural Environmental Registry; CFI, Cocoa and Forests Initiative; FPIC, Free, Prior, and Informed Consent; G4, Public Livestock Commitment; GTA, Animal Transport Permit; GTS, Soy Moratorium Working Group; HCS, High Carbon Stock; HCV, High Conservation Value; INPE, Brazilian National Institute for Space Research; IRF, Implementation Reporting Framework; LAR, Environmental Production License; LBC, Licensed Buying Company; LISC, Large Integrated Supply chain Company; MPF, Brazilian Federal Public Prosecutor's Office; NDPE, No deforestation, no Peat, no Exploitation; RSPO, Roundtable on Sustainable Palm Oil; ZDC, Zero Deforestation Commitment. *A Cerrado Moratorium was not adopted in practice.

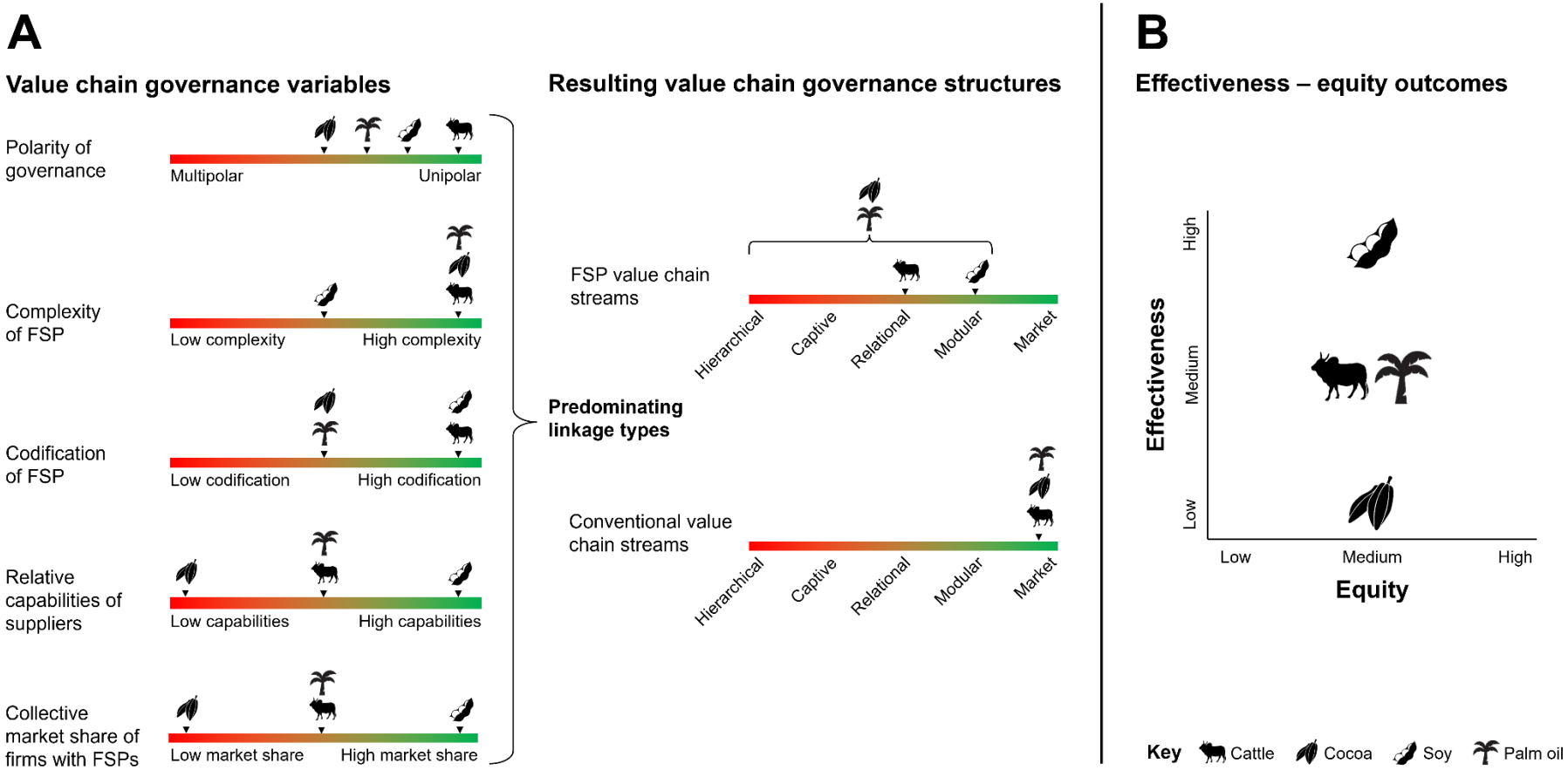


Figure 4. Panel A: Summary of findings for value chain governance variables, including market share, and resulting governance structures across the four commodity value chains. In the resulting value chain governance structures, the predominating linkage types are shown for conventional and FSP streams in each value chain. **Panel B:** Value chain governance outcomes in terms of the propensity of FSPs to be effective and equitable. For both panels, the values taken by variables were assessed using pre-defined criteria (**Table S2**).

Discussion

This study examined how value chain structures influence the adoption, implementation, and outcomes of the four most prominent FSPs across the tropics. With their requirements for proof of deforestation-free production, FSPs increased the complexity of commodity transactions. This required firms to establish close relationships with suppliers through more cooperative relational value chain linkages, or more coercive captive or hierarchical linkages. The degree of policy codification and farmers' compliance capabilities also influenced how linkages formed. In chains where lower codification combined with low farmer capabilities, it was difficult for firms to establish close relationships with farmers. This challenged firms' abilities to coordinate and control deforestation-free production.

By examining vertical linkages between value chain actors, our study revealed how challenges with equity in terms of smallholder inclusion undermine FSPs' effectiveness by limiting their coverage. We also identified exceptions to the linkages hypothesized by the GVC governance framework. For example, Cargill's control over port infrastructure in Santarém led it to implement the Soy Moratorium through captive linkages despite the policy's high codification and producers' high capabilities. This highlights the importance for future research to examine how firms' horizontal linkages with other actors influence deforestation-free governance in specific contexts.[81] Future research could also extend our focus on multinationals in producing countries to examine firms of varying sizes and consumer markets.

Comparing the cases

In Amazonian soy, high codification and high producer capabilities enabled traders to implement the Soy Moratorium through modular linkages with farmers. Together with the Moratorium's high market share, this delivered substantial reductions in deforestation. Yet at the biome scale, modular linkages resembled captive linkages, as farmers faced lower prices or market exclusion if they chose not to comply. Soy farmers are wealthier and more powerful than their counterparts in cattle, cocoa, and palm oil.[65] Market exclusion can therefore be expected to have less extreme livelihood implications and is arguably justified by reduced deforestation. Nonetheless, the tighter requirements placed on Amazonian soy farmers *vis-à-vis* their peers in the Cerrado generated challenges for the Moratorium's legitimacy,[82] producing resistance to its expansion.[83]

In Amazonian cattle, the TAC was also highly codified but achieved lower market share. Despite wide variations in producers' compliance capabilities, high demand for cattle enabled smaller, less-capable producers to find buyers and a bifurcated value chain emerged, enabling leakage.

590 Consequently, effectiveness was more limited, but smaller producers were still threatened by
591 market exclusion or land acquisition.
592
593 In Indonesian palm oil, large firms coordinated deforestation-free production in their own
594 plantations or through relational linkages with highly capable suppliers. But as for cattle, high
595 demand for oil and high investment costs prevented firms establishing captive or hierarchical
596 linkages with less-capable smallholders, resulting in a bifurcated value chain.
597
598 In West African cocoa, some traders attempted to govern deforestation-free production by
599 acquiring LBCs or establishing captive linkages with cooperatives. But as for cattle and palm, high
600 demand for beans enabled smallholders to choose buyers and a bifurcated value chain emerged.
601
602 Across the cases, the complex information required to implement FSPs, low capabilities among
603 small producers, and high demand for commodities impeded firms from establishing the close
604 relationships needed to coordinate deforestation-free production. This produced at best moderate
605 impacts on deforestation, while inequity was mitigated by noncompliant producers' continued
606 access to conventional markets. The sole exception was Amazonian soy, where coordinated action
607 between firms with near-complete market share enabled the Soy Moratorium to substantially
608 reduce deforestation. However, the requirements placed on Amazonian soy farmers compared to
609 their counterparts in other regions hampered the Moratorium's extension to the Cerrado.
610
611 ***A middle-range theory of deforestation-free value chain governance***
612 Drawing on the cross-case comparisons, we present a middle-range theory of deforestation-free
613 value chain governance in **Figure 5**. In line with our aim to describe a well-bounded set of
614 phenomena[43] and our focus on FSPs' regional effectiveness, the theory is focused on regional-scale
615 outcomes. An expanded theory would be needed to incorporate spillovers between regions such as
616 the Amazon and Cerrado.

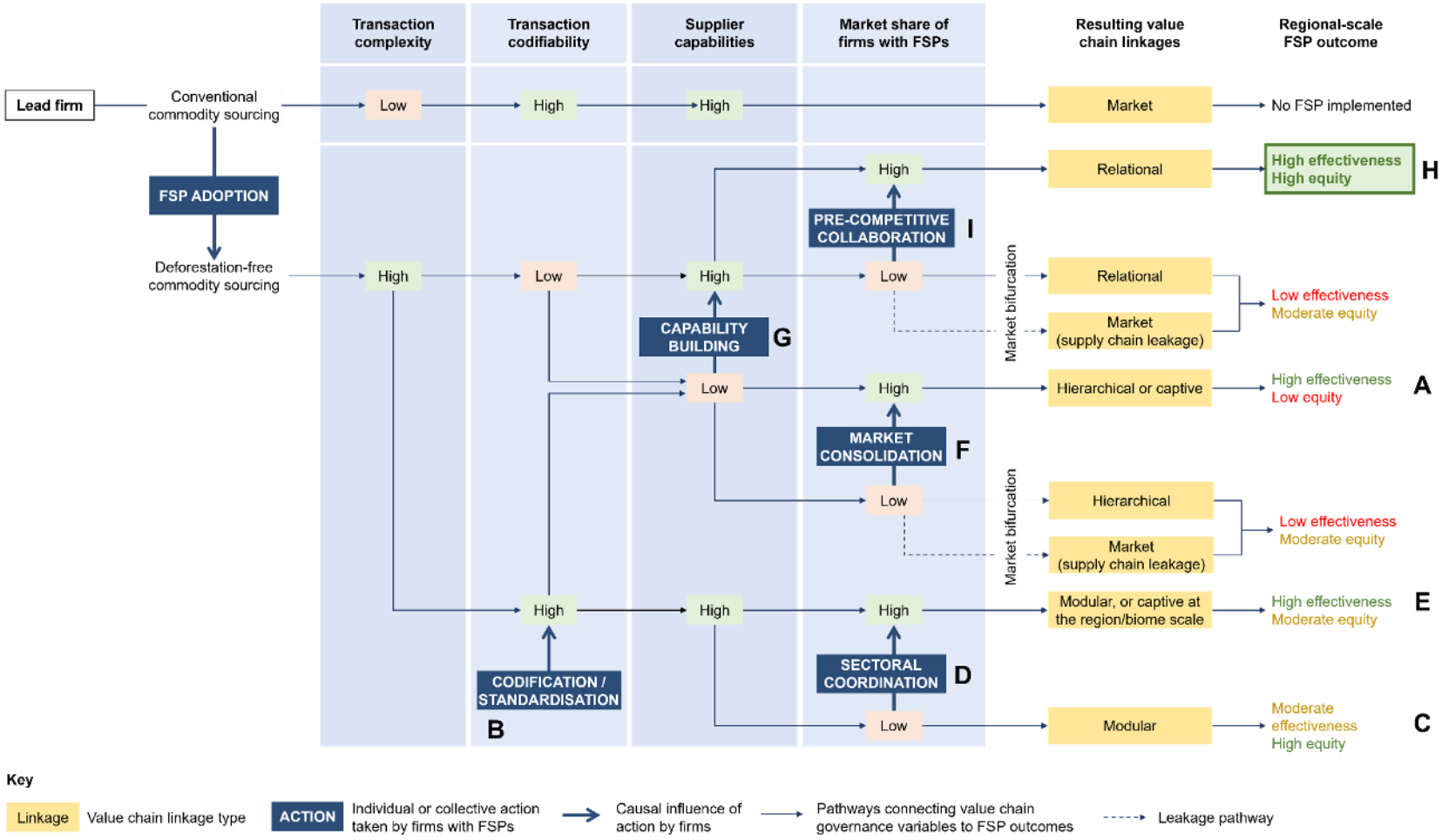


Figure 5. A middle-range theory of deforestation-free value chain governance and its outcomes. Letters denote components that are described in the main text of the Discussion (A–F in "A middle-range theory of deforestation-free value chain governance", G–I in "The importance of capability and relation building"). H denotes the only pathway through which both effective and equitable outcomes can be achieved. This requires both pre-competitive collaboration and capability building by firms with FSPs if suppliers' capabilities are low, as is often the case with smallholder farmers.

623 The theory shows that an optimal value chain configuration to effectively reduce deforestation by
624 less-capable producers could involve firms implementing an FSP through captive or hierarchical
625 linkages (**A**). Alternatively, if suppliers are highly capable and policies are codified (**B**), FSPs can
626 be implemented through modular linkages (**C**). In both cases, high market share is important to
627 avoid supply chain leakage and ensure regional effectiveness. If high market share is achieved,
628 modular linkages may appear captive (**E**), as we observed with the Soy Moratorium.
629
630 The importance of market share for reducing environmental externalities and enhancing FSPs'
631 effectiveness has been widely discussed.[11,18,22,57,58] In practice, however, increasing FSPs' collective
632 market share is challenging due to insufficient demand.[84] A low share of forest-risk commodities is
633 consumed in markets with deforestation-free regulations like the EUDR,[20] while the likelihood of
634 domestic markets and other export markets such as China adopting similar regulations is low.[85]
635
636 An alternative way to grow FSPs' market share would be to target regulations and advocacy at
637 midstream firms, whose positions in hourglass-shaped value chains confer disproportionately high
638 market share.[7,86,87] In common with previous research, we found midstream firms played a more
639 prominent role in FSP implementation than downstream firms,[9,41,42,86] and their potential to achieve
640 greater market share was demonstrated in soy and palm oil. Yet midstream governance does not
641 necessarily translate into increased FSP adoption or implementation. Traders' power to enact
642 change is limited by fine profit margins and they can become squeezed between downstream
643 demands and production realities.[86,88] Many traders also fail to apply FSPs to both "direct" and
644 "indirect" sourcing.[21,80] These issues explain why FSPs' market shares can be higher at midstream
645 than upstream tiers, as in Indonesian palm oil.[17]
646
647 Firms may also attempt to increase their market share and take greater control over production by
648 integrating their value chains, thereby consolidating the market (**F**). However, we found that firms'
649 attempts to integrate their value chains were limited in practice by logistics and investment costs
650 and competition for supply.
651
652 Increasing the market share of firms with FSPs is also likely to undermine equity, particularly if
653 producers' capabilities are low and firms seek to control them through captive or hierarchical
654 linkages (**A**). In Amazonian soy, the Soy Moratorium was implemented through linkages that
655 appeared captive due to firms' high market share, but the comparatively high wealth and power of
656 soy farmers meant they continued to enjoy high incomes, avoiding inequity (**E**). Nonetheless, the
657 coercive manner in which the Moratorium was implemented undermined its legitimacy. In contrast,
658 equity in cocoa and palm oil value chains was preserved only by the limited collective market share
659 of FSP firms, which meant producers retained access to conventional markets. In Brazilian cattle,

smaller producers risked being assimilated into larger operations. These insights reflect previous findings that increasing market concentration can lead to the exclusion and dispossession of smallholders in agri-food value chains.[62,89]

The importance of capability and relation building

Rather than increasing market share through vertical integration (**F**), capability and relation building (**G**) represent the only way to implement FSPs both effectively and equitably in sectors dominated by smaller or poorer farmers with lower capabilities (**H**). Capability building is required to reduce the transaction costs of FSPs without trapping small producers into captive or hierarchical relationships with firms. Relation building is essential to integrate producers' perspectives, needs, and participation into policy design and implementation.[31]

The importance of capability building explains the training programmes we observed by cocoa firms. Yet it is limited in palm and practically non-existent in cattle except for JBS' Green Offices initiative, which provides technical assistance and supports farmers to bring their properties into compliance with environmental regulations.[90] Even in cocoa, training programmes have failed to build producers' capabilities at scale. This may be because there are few apparent incentives for firms to invest in training farmers that are not guaranteed to become suppliers[59] and cannot be accounted for in supply chain-level impact attribution systems.[91] Consequently, firms work in silos, focusing on their own value chains with little collaboration and excluding indirect suppliers.[91] Pre-competitive collaboration has been further stifled by antitrust regulations and competition.[15,92]

Nonetheless, firms do sometimes build suppliers' capabilities outside their direct value chains, occasionally in collaboration with competitors. In Indonesia, Musim Mas has trained >10,000 palm oil farmers through its Smallholders Hub program[93] and hosted workshops with Sinar Mas to introduce both firms' NDPE policies.[94] These activities are pursued because they offer a cost-effective way to implement FSPs in a supply base with high turnover and many intermediaries.[91,95]

Exporting and importing states should encourage more firms to collaborate pre-competitively on capability building (**I**) by reviewing impediments in antitrust regulations and establishing pooled funds for training, with tax or due-diligence concessions for firms that invest. Importing states should also coordinate collaborative capability-building projects, building on examples such as the EU-funded Team Europe Initiative on Deforestation-free Value Chains. Firms should invest in

landscape or supply shed approaches to spread training across their supply bases in partnership with neighboring buyers.[91,95,96]

FSPs' role in ending deforestation

FSPs are now becoming codified through public regulations in importing jurisdictions like the EUDR.[10] Early projections have estimated that the EUDR's impact will be modest and undermined by leakage.[97] The EUDR has also been criticized for failing to ensure equity and favoring corporations, potentially leading to the exclusion of smallholder farmers.[98,99] These flaws mirror the shortcomings of FSPs. The limitations imposed by value chain structures on firms' abilities to govern deforestation-free production are also likely to apply to EUDR compliance.

The EUDR has also undermined FSPs with more stringent criteria like the Soy Moratorium. For example, the EUDR employs a later cut-off date than the Moratorium (2020 versus 2008). While the Soy Moratorium signatories' control over producers led to high effectiveness, it also fomented opposition. The introduction of the less-stringent EUDR created an opportunity for the Soy Moratorium to be challenged. Following a case brought to Brazil's national competition regulator by Aprosoja and state legislation to restrict tax benefits to Moratorium signatories in Mato Grosso, ABIOVE left the agreement in January 2026.[83,100,101] This has left the Moratorium weakened, with its market share substantially reduced, demonstrating how implementing FSPs through coercive linkages can reduce their durability by undermining legitimacy. By comparison, the TAC's alignment with legal requirements generated less hostility, enabling a steady ramping-up of implementation.[18] In cattle, cocoa, and palm oil, our findings that noncompliant producers retain market access may explain the comparatively limited opposition to FSPs. If so, supporting equity by building producers' capabilities and avoiding coercive value chain linkages could be important to build durable political support for conservation.

Opposition to the Soy Moratorium reveals a paradoxical challenge for FSPs: while incomplete market share undermines effectiveness by enabling leakage, increasing market share and tight control over producers undermine equity and legitimacy (**Figure 5A, E**). Similar paradoxes have been reported between the goals of reducing deforestation and including smallholders in palm oil value chains.[15] These paradoxes raise questions about whether FSPs can deliver deforestation-free production both effectively and equitably. Our findings suggest they might, but only with transformative changes to value chain governance by firms, namely by de-commodifying production and developing closer, more supportive relationships with producers. This echoes calls for firms to support different types of smallholders, include them in FSP design and implementation, and engage with their norms and values.[17,24] If firms are going to spend billions

implementing FSPs, it would be better if this was done in a way that improves relationships with producers and promotes equity, which should in turn enhance effectiveness.

Yet, even with enhanced relationality and capability building, FSPs cannot tackle the underlying drivers of deforestation such as growing demand for forest-risk commodities.[77] Producing and importing states must also deliver on their commitments to end deforestation. Essential public interventions include enforcing forest protections, stemming commodity demand, and adopting regulations that improve the codification of FSPs without undermining their stringency.

Conclusions

FSPs increase the complexity of commodity transactions, requiring firms to establish close relationships with suppliers to ensure deforestation-free production. But low compliance capabilities among smaller producers and high demand for commodities often prevent these relationships from forming. Instead, prevailing supply chain structures challenge firms' abilities to control deforestation. If FSPs are to be both more effective and more equitable, the middle-range theory proposed here suggests that firms must de-commodify their value chains by developing relationships with suppliers and collaborating to build compliance capabilities across the supply base. But even with these actions and emerging import regulations, growing demand for forest-risk commodities means private governance is unlikely to end deforestation. Stronger public interventions to protect forests and curb demand for forest-risk commodities will be vital as private governance nears the limits of its potential.

Methods

Study design

We adopted a qualitative comparative case design based on semi-structured interviews. We treated each commodity as a separate case; individual cases have been published previously, but each focused on different aspects of FSP design and/or implementation and none examined value chain structures.[8,15,16,24,39] For each commodity we conducted interviews with actors along the value chain from producers to manufacturers (**Table S1**). We also conducted interviews with farmers and organizations involved with conservation and/or economic development, including government agencies and NGOs. In Indonesia and West Africa, where smallholder farmers account for a substantial proportion of production, we conducted focus groups with farmers on the expectation that they may have been more willing to disclose information in an unfamiliar research setting when among their peers.[102]

Interview guides

We developed adapted interview guides (**SI**) for the main actor groups in each case[103] based on a literature review and existing criteria for effective and equitable FSPs.[12] Interview guides featured some differences for each case, but all explored actors' business operations, procurement and/or sales practices; the content and operationalization of FSPs; engagement with civil society and public policies; and attitudes towards conservation. We developed the interview guide for Brazilian soy separately, as this case explored how the Amazon Soy Moratorium emerged and why a moratorium failed to materialize in the Cerrado.[16] Interview guides were written in English, then forward and back translated into the national language of each country by bilingual members of the study team. We reviewed and refined the interview guides throughout data collection to ensure sensitivity to participant feedback and emerging insights.[103] Focus group guides for cocoa and palm oil farmers were developed using the same procedures.

Sampling design

We adopted a purposive sampling design to include actors identified through systematic stakeholder mapping in each case. We invited actors using email, LinkedIn, and/or personal connections. We invited all cattle slaughterhouses located along the BR-010 highway between Belém and Dom Eliseu in Pará where the TAC was first implemented; all major palm oil firms with NDPE policies in Indonesia; all CFI firms with identifiable representatives in Côte d'Ivoire and Ghana; and firms, producer and industry associations active in the Soy Working Groups in the Brazilian Amazon and Cerrado. We also invited farmers and organizations involved with conservation and/or economic development (**Table S1**). When sampling farmers, we aimed to maximize variation in features that might influence exposure to FSPs, such as proximity to markets via roads and membership of cooperatives. As data collection proceeded, we applied snowball and opportunistic sampling to take advantage of introductions by gatekeepers and chance encounters with relevant actors. We continued sampling in each case until all identified firms had been invited or thematic saturation (monitored using field journals) was attained.[104]

Fieldwork and data collection

We conducted fieldwork in Brazil, Côte d'Ivoire, Ghana, and Indonesia between October 2019–October 2022 (details in **SI**). In total, we conducted 242 interviews and 26 focus groups (**Table S1**) in English (Côte d'Ivoire, Ghana, and Indonesia) or French (Côte d'Ivoire), Portuguese (Brazil), Twi (Ghana), or Bahasa Indonesia (Indonesia), following participants' preferences. We followed the interview guides loosely. This provided structure while allowing the order or phrasing of questions to be altered in response to participants' profiles or earlier responses, and enabling questions about sensitive topics to be skipped if necessary.[103] For Indonesian palm oil, West African cocoa, and Brazilian soy, we audio recorded all interviews, subject to participants' consent, and made detailed fieldnotes. For Brazilian cattle, audio recording was not possible due to the

topic's sensitivity, so fieldnotes were taken instead. All participants freely agreed to a prior informed consent form and interviews were conducted under condition of anonymity. Ethics approval was provided by the ETH Zurich Ethics Commission and the ERC ethics review board.

Analysis

We coded interview transcripts and notes in NVivo.[105] A coding framework was developed deductively using themes identified from Gereffi et al.'s GVC governance framework,[44] namely the polarity of governance; codifiability of FSPs; capabilities in the supply base; evidence of market, modular, relational, captive, or hierarchical linkages; and prevalence of vertical integration. To assess FSPs' complexity, we also included codes based on criteria for analyzing FSPs' design.[11,12] To assess outcomes, we included codes for effectiveness (additionality, permanence, and supply chain bifurcation/leakage) and equity (market access/exclusion). We refined the coding framework throughout the coding process by inductively identifying themes emerging from the data. Once coding was complete, we selected a subset of themes judged most relevant to the research questions for further analysis. These themes included all those relating to the GVC governance framework, plus the three effectiveness and two equity themes. We summarized the selected themes in a framework matrix (**SI**) that organized evidence by commodity, with exemplary quotations linked to interviews using pseudonyms (**Table S1**). We then assessed the values taken by GVC governance and other variables using pre-defined criteria (**Table S2**), which we developed by adapting and extending variable definitions in the original GVC framework[44] using criteria for assessing FSPs' effectiveness and equity.[11,12] The final results were produced by reviewing the framework matrix alongside the scoring criteria, referring to additional themes where further insights were required (e.g., on capability building). Our results also drew on the prior academic literature, from which relevant insights were incorporated into the framework matrix.

REFERENCES

1. IPBES (2019). Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

2. Newton, P., Kinzer, A.T., Miller, D.C., Oldekop, J.A., and Agrawal, A. (2020). The number and spatial distribution of forest-proximate people globally. One Earth *3*, 363–370. https://doi.org/10.1016/j.oneear.2020.08.016.

3. Pendrill, F., Persson, U.M., Godar, J., and Kastner, T. (2019). Deforestation displaced: trade in forest-risk commodities and the prospects for a global forest transition. Environ. Res. Lett. *14*, 055003. https://doi.org/10.1088/1748-9326/ab0d41.

4. Lambin, E.F., and Furumo, P.R. (2023). Deforestation-Free Commodity Supply Chains: Myth or Reality? Annu. Rev. Environ. Resour. *48*, 237–261. https://doi.org/10.1146/annurev-environ-112321-121436.

5. Lambin, E.F., Gibbs, H.K., Heilmayr, R., Carlson, K.M., Fleck, L.C., Garrett, R.D., le Polain de Waroux, Y., McDermott, C.L., McLaughlin, D., Newton, P., et al. (2018). The role of supply-chain initiatives in reducing deforestation. Nat. Clim. Change *8*, 109–116. https://doi.org/10.1038/s41558-017-0061-1.

6. Gibbs, H.K., Rausch, L., Munger, J., Schelly, I., Morton, D.C., Noojipady, P., Soares-Filho, B., Barreto, P., Micol, L., and Walker, N.F. (2015). Brazil's Soy Moratorium. Science *347*, 377–378. https://doi.org/10.1126/science.aaa0181.

7. Lyons-White, J., and Knight, A.T. (2018). Palm oil supply chain complexity impedes implementation of corporate no-deforestation commitments. Glob. Environ. Change *50*, 303–313. https://doi.org/10.1016/j.gloenvcha.2018.04.012.

8. Cammelli, F., Levy, S.A., Grabs, J., Valentim, J.F., and Garrett, R.D. (2022). Effectiveness-equity tradeoffs in enforcing exclusionary supply chain policies: Lessons from the Amazonian cattle sector. J. Clean. Prod. *332*, 130031. https://doi.org/10.1016/j.jclepro.2021.130031.

9. Carodenuto, S., and Buluran, M. (2021). The effect of supply chain position on zero-deforestation commitments: evidence from the cocoa industry. J. Environ. Policy Plan., 1–16. https://doi.org/10.1080/1523908X.2021.1910020.

10. Berning, L., and Sotirov, M. (2023). Hardening corporate accountability in commodity supply chains under the European Union Deforestation Regulation. Regul. Gov. *17*, 870–890. https://doi.org/10.1111/rego.12540.

11. Garrett, R.D., Levy, S., Carlson, K.M., Gardner, T.A., Godar, J., Clapp, J., Dauvergne, P., Heilmayr, R., le Polain de Waroux, Y., Ayre, B., et al. (2019). Criteria for effective zero-deforestation commitments. Glob. Environ. Change *54*, 135–147. https://doi.org/10.1016/j.gloenvcha.2018.11.003.

12. Grabs, J., Cammelli, F., Levy, S.A., and Garrett, R.D. (2021). Designing effective and equitable zero-deforestation supply chain policies. Glob. Environ. Change *70*, 102357. https://doi.org/10.1016/j.gloenvcha.2021.102357.

13. Lyons-White, J., Pollard, E.H.B., Catalano, A.S., and Knight, A.T. (2020). Rethinking zero deforestation beyond 2020 to more equitably and effectively conserve tropical forests. One Earth *3*, 714–726. https://doi.org/10.1016/j.oneear.2020.11.007.

14. Bager, S.L., and Lambin, E.F. (2022). How do companies implement their zero-deforestation commitments. J. Clean. Prod. *375*, 134056. https://doi.org/10.1016/j.jclepro.2022.134056.

15. Grabs, J., and Garrett, R.D. (2023). Goal-Based Private Sustainability Governance and Its Paradoxes in the Indonesian Palm Oil Sector. J. Bus. Ethics. https://doi.org/10.1007/s10551-023-05377-1.

16. Brandão, J., Cardoso, F.C., and Garrett, R. (2025). Why has the Brazilian Cerrado been left behind by voluntary environmental policies? Glob. Environ. Change *92*, 103005. https://doi.org/10.1016/j.gloenvcha.2025.103005.

17. Chandra, A., Garrett, R.D., Carlson, K.M., Heilmayr, R., Stigler, M., Benedict, J.J., and Grabs, J. (2024). How well does the implementation of corporate zero-deforestation commitments in Indonesia align with aims to halt deforestation and include smallholders? Environ. Res. Lett. *19*, 044054. https://doi.org/10.1088/1748-9326/ad33d1.

18. Levy, S.A., Cammelli, F., Munger, J., Gibbs, H.K., and Garrett, R.D. (2023). Deforestation in the Brazilian Amazon could be halved by scaling up the implementation of zero-deforestation cattle commitments. Glob. Environ. Change *80*, 102671. https://doi.org/10.1016/j.gloenvcha.2023.102671.

19. Parra-Paitan, C., zu Ermgassen, E.K.H.J., Meyfroidt, P., and Verburg, P.H. (2023). Large gaps in voluntary sustainability commitments covering the global cocoa trade. Glob. Environ. Change *81*, 102696. https://doi.org/10.1016/j.gloenvcha.2023.102696.

20. zu Ermgassen, E.K.H.J., Godar, J., Lathuillière, M.J., Löfgren, P., Gardner, T., Vasconcelos, A., and Meyfroidt, P. (2020). The origin, supply chain, and deforestation risk of Brazil's beef exports. Proc. Natl. Acad. Sci. USA, 202003270. https://doi.org/10.1073/pnas.2003270117.

21. zu Ermgassen, E.K.H.J., Bastos Lima, M.G., Bellfield, H., Dontenville, A., Gardner, T., Godar, J., Heilmayr, R., Indenbaum, R., dos Reis, T.N.P., Ribeiro, V., et al. (2022). Addressing indirect sourcing in zero deforestation commodity supply chains. Sci. Adv. *8*, eabn3132. https://doi.org/doi:10.1126/sciadv.abn3132.

22. zu Ermgassen, E.K.H.J., Ayre, B., Godar, J., Lima, M.G.B., Bauch, S., Garrett, R., Green, J., Lathuillière, M.J., Löfgren, P., and MacFarquhar, C. (2020). Using supply chain data to monitor zero deforestation commitments: an assessment of progress in the Brazilian soy sector. Environ. Res. Lett. *15*, 035003. https://doi.org/10.1088/1748-9326/ab6497.

23. Carlson, K.M., Heilmayr, R., Gibbs, H.K., Noojipady, P., Burns, D.N., Morton, D.C., Walker, N.F., Paoli, G.D., and Kremen, C. (2017). Effect of oil palm sustainability certification on deforestation and fire in Indonesia. Proc. Natl. Acad. Sci. USA *115*, 121–126. https://doi.org/10.1073/pnas.1704728114.

24. Addoah, T., Lyons-White, J., Cammelli, F., Kouakou, K.M.-P., Carodenuto, S., Thompson, W.J., Renier, C., and Garrett, R.D. (2025). Is the Implementation of Cocoa Companies' Forest Policies on Track to Effectively and Equitably Address Deforestation in West Africa? Sustain. Dev. *n/a*. https://doi.org/10.1002/sd.3380.

25. Gibbs, H.K., Munger, J., L'Roe, J., Barreto, P., Pereira, R., Christie, M., Amaral, T., and Walker, N.F. (2015). Did ranchers and slaughterhouses respond to zero-deforestation agreements in the Brazilian Amazon? Conserv. Lett. *9*, 32–42. https://doi.org/10.1111/conl.12175.

26. Alix-Garcia, J., and Gibbs, H.K. (2017). Forest conservation effects of Brazil's zero deforestation cattle agreements undermined by leakage. Glob. Environ. Change *47*, 201–217. https://doi.org/10.1016/j.gloenvcha.2017.08.009.

27. Garrett, R.D., Levy, S., Gollnow, F., Hodel, L., and Rueda, X. (2021). Have food supply chain policies improved forest conservation and rural livelihoods? A systematic review. Environ. Res. Lett. *16*, 033002.

28. Gollnow, F., Cammelli, F., Carlson, K.M., and Garrett, R.D. (2022). Gaps in adoption and implementation limit the current and potential effectiveness of zero-deforestation supply chain policies for soy. Environ. Res. Lett. *17*, 114003. https://doi.org/10.1088/1748-9326/ac97f6.

29. Heilmayr, R., Rausch, L.L., Munger, J., and Gibbs, H.K. (2020). Brazil's Amazon Soy Moratorium reduced deforestation. Nat. Food *1*, 801–810. https://doi.org/10.1038/s43016-020-00194-5.

30. Villoria, N., Garrett, R., Gollnow, F., and Carlson, K. (2022). Leakage does not fully offset soy supply-chain efforts to reduce deforestation in Brazil. Nat. Commun. *13*, 5476. https://doi.org/10.1038/s41467-022-33213-z.

31. Lyons-White, J., Zodua, P.A., Mikolo Yobo, C., Carlon, S.C., Ewers, R.M., and Knight, A.T. (2025). Challenges for implementing zero deforestation commitments in a highly forested country: Perspectives from Liberia's palm oil sector. World Dev. *185*, 106803. https://doi.org/10.1016/j.worlddev.2024.106803.

32. McDermott, M., Mahanty, S., and Schreckenberg, K. (2013). Examining equity: A multidimensional framework for assessing equity in payments for ecosystem services. Environ. Sci. Policy *33*, 416–427. https://doi.org/10.1016/j.envsci.2012.10.006.

33. Lyons-White, J., Mikolo Yobo, C., Ewers, R.M., and Knight, A.T. (2022). Understanding zero deforestation and the High Carbon Stock Approach in a highly forested tropical country. Land Use Policy *112*, 105770. https://doi.org/10.1016/j.landusepol.2021.105770.

34. Schouten, G., and Glasbergen, P. (2011). Creating legitimacy in global private governance: The case of the Roundtable on Sustainable Palm Oil. Ecol. Econ. *70*, 1891–1899. https://doi.org/10.1016/j.ecolecon.2011.03.012.

35. Bernstein, S. (2004). Legitimacy in global environmental governance. J. Int. Law Int. Relat. *1*, 139–166.

36. Suchman, M.C. (1995). Managing legitimacy: Strategic and institutional approaches. Acad. Manage. Rev. *20*, 571–610.

37. Monterroso, I., and Barry, D. (2012). Legitimacy of forest rights: The underpinnings of the forest tenure reform in the protected areas of Petén, Guatemala. Conserv. Soc. *10*, 136–150.

38. Cheyns, E., Silva-Castañeda, L., and Aubert, P.-M. (2019). Missing the forest for the data? Conflicting valuations of the forest and cultivable lands. Land Use Policy, 103591. https://doi.org/10.1016/j.landusepol.2018.08.042.

39. Kouakou, P., Lyons-White, J., Thompson, W.J., Addoah, T., Cammelli, F., Blaser-Hart, W., Maguire-Rajpaul, V., Dawoe, E., and Garrett, R.D. (2025). Existing sustainability interventions are insufficient to scale up cocoa agroforestry in West Africa. Sustain. Dev. *https://doi.org/10.1002/sd.70266*.

40. Furumo, P.R., and Lambin, E.F. (2021). Policy sequencing to reduce tropical deforestation. Glob. Sustain. *4*, e24. https://doi.org/10.1017/sus.2021.21.

41. Marschner, S., Orsi, L., Olper, A., and Stranieri, S. (2025). Sustainability Strategies in the Cocoa-Chocolate Value Chain: An Analysis Using Stakeholder Theory, Global Value Chain Theory, and Resource Dependence Theory. Agribusiness.

42. Bager, S.L., and Lambin, E.F. (2020). Sustainability strategies by companies in the global coffee sector. Bus. Strategy Environ. *29*, 3555–3570. https://doi.org/10.1002/bse.2596.

43. Meyfroidt, P., Roy Chowdhury, R., de Bremond, A., Ellis, E.C., Erb, K.H., Filatova, T., Garrett, R.D., Grove, J.M., Heinimann, A., Kuemmerle, T., et al. (2018). Middle-range theories of land system change. Glob. Environ. Change *53*, 52–67. https://doi.org/10.1016/j.gloenvcha.2018.08.006.

44. Gereffi, G., Humphrey, J., and Sturgeon, T. (2005). The governance of global value chains. Rev. Int. Polit. Econ. *12*, 78–104. https://doi.org/10.1080/09692290500049805.

45. World Bank (Washington, D. of C. (2019). World development report 2020: Trading for development in the age of global value chains (World Bank Group).

46. Antràs, P. (2020). Conceptual aspects of global value chains. World Bank Econ. Rev. *34*, 551–574.

47. Ponte, S., and Sturgeon, T. (2014). Explaining governance in global value chains: A modular theory-building effort. Rev. Int. Polit. Econ. *21*, 195–223.

48. WRI (2025). Global Forest Review (World Resources Institute).

49. Goldman, E., and Weiss, M. (2024). Global Forest Review: Deforestation linked to agriculture (World Reources Institute).

50. Republic of Ghana (2018). Ghana Cocoa & Forests Initiative National Implementation Plan 2018-2020.

51. République de Côte d'Ivoire (2018). Implementation Plan for the Joint Framework of Action.

52. Brannstrom, C., Rausch, L., Brown, J.C., de Andrade, R.M.T., and Miccolis, A. (2012). Compliance and market exclusion in Brazilian agriculture: Analysis and implications for "soft" governance. Land Use Policy *29*, 357–366. https://doi.org/10.1016/j.landusepol.2011.07.006.

53. Ponte, S., Sturgeon, T.J., and Dallas, M.P. (2019). Governance and power in global value chains. In Handbook on global value chains (Edward Elgar Publishing), pp. 120–137.

54. Coe, N.M., and Yeung, H.W. (2015). Global Production Networks 2.0. In Global Production Networks: Theorizing Economic Development in an Interconnected World, N. M. Coe and H. W. Yeung, eds. (Oxford University Press), p. 0. https://doi.org/10.1093/acprof:oso/9780198703907.003.0001.

55. Autor, D., Dorn, D., Katz, L.F., Patterson, C., and Van Reenen, J. (2020). The Fall of the Labor Share and the Rise of Superstar Firms*. Q. J. Econ. *135*, 645–709. https://doi.org/10.1093/qje/qjaa004.

56. Macchiavello, R., Reardon, T., and Richards, T.J. (2022). Empirical Industrial Organization Economics to Analyze Developing Country Food Value Chains. Annu. Rev. Resour. Econ. *14*, 193–220. https://doi.org/10.1146/annurev-resource-101721-023554.

57. Asker, J., Collard-Wexler, A., De Canniere, C., De Loecker, J., and Knittel, C.R. (2024). Two wrongs can sometimes make a right: The environmental benefits of market power in oil (National Bureau of Economic Research).

58. Buchanan, J.M. (1969). External diseconomies, corrective taxes, and market structure. Am. Econ. Rev. *59*, 174–177.

59. Swinnen, J.F., and Vandeplas, A. (2010). Market power and rents in global supply chains. Agric. Econ. *41*, 109–120.

60. Minten, B., Randrianarison, L., and Swinnen, J.F.M. (2009). Global Retail Chains and Poor Farmers: Evidence from Madagascar. Agrifood Ind. Transform. Small Farmers Dev. Ctries. *37*, 1728–1741. https://doi.org/10.1016/j.worlddev.2008.08.024.

61. Maertens, M., Colen, L., and Swinnen, J.F. (2011). Globalisation and poverty in Senegal: a worst case scenario? Eur. Rev. Agric. Econ. *38*, 31–54.

62. Amanor, K.S. (2012). Global resource grabs, agribusiness concentration and the smallholder: two West African case studies. J. Peasant Stud. *39*, 731–749. https://doi.org/10.1080/03066150.2012.676543.

63. Reis, T.N.P. dos, Bastos Lima, M.G., Russo Lopes, G., and Meyfroidt, P. (2024). Not all supply chains are created equal: The linkages between soy local trade relations and development outcomes in Brazil. World Dev. *175*, 106475. https://doi.org/10.1016/j.worlddev.2023.106475.

64. Heron, T., Prado, P., and West, C. (2018). Global Value Chains and the Governance of 'Embedded' Food Commodities: The Case of Soy. Glob. Policy *9*, 29–37. https://doi.org/10.1111/1758-5899.12611.

65. Garrett, R.D., and Rausch, L.L. (2016). Green for gold: social and ecological tradeoffs influencing the sustainability of the Brazilian soy industry. J. Peasant Stud. *43*, 461–493. https://doi.org/10.1080/03066150.2015.1010077.

66. Levy, S.A., Garik, A.V.N., and Garrett, R.D. (2024). The challenge of commodity-centric governance in sacrifice frontiers: Evidence from the Brazilian Cerrado's soy sector. Geoforum *150*, 103972. https://doi.org/10.1016/j.geoforum.2024.103972.

67. Macedo, M.N., DeFries, R.S., Morton, D.C., Stickler, C.M., Galford, G.L., and Shimabukuro, Y.E. (2012). Decoupling of deforestation and soy production in the southern Amazon during the late 2000s. Proc. Natl. Acad. Sci. *109*, 1341–1346. https://doi.org/10.1073/pnas.1111374109.

68. Garrett, R.D., Lambin, E.F., and Naylor, R.L. (2013). The new economic geography of land use change: Supply chain configurations and land use in the Brazilian Amazon. Land Use Policy *34*, 265–275. https://doi.org/10.1016/j.landusepol.2013.03.011.

69. Cortner, O., Garrett, R.D., Valentim, J.F., Ferreira, J., Niles, M.T., Reis, J., and Gil, J. (2019). Perceptions of integrated crop-livestock systems for sustainable intensification in the Brazilian Amazon. Land Use Policy *82*, 841–853.

70. Brandão, J., Cammelli, F., Sampaio, O., and Garrett, R.D. (in review). Deregulation weakens supply chain efforts to curb Amazon deforestation. Nat. Commun.

71. Gaveau, D.L.A., Locatelli, B., Salim, M.A., Husnayaen, Manurung, T., Descals, A., Angelsen, A., Meijaard, E., and Sheil, D. (2022). Slowing deforestation in Indonesia follows declining oil palm expansion and lower oil prices. PloS One *17*, e0266178. https://doi.org/10.1371/journal.pone.0266178.

72. Ogahara, Z., Jespersen, K., Theilade, I., and Nielsen, M.R. (2022). Review of smallholder palm oil sustainability reveals limited positive impacts and identifies key implementation and knowledge gaps. Land Use Policy *120*, 106258. https://doi.org/10.1016/j.landusepol.2022.106258.

73. Angelsen, A., Dermawan, A., and Ladewig, M. (2025). Explaining the recent reduction in Indonesia's deforestation.

74. Stigler, M., Grabs, J., Heilmayr, R., Carlson, K.M., Chandra, A., and Garrett, R.D. (in review). Zero-deforestation commitments in Indonesia's palm oil sector achieve high compliance but no additionality. Proc. Natl. Acad. Sci. USA.

75. CFI (2019). Summary of company initial action plans for Côte d'Ivoire (World Cocoa Foundation).

76. Barry Callebaut (2015). Barry Callebaut has acquired Nyonkopa to cover growing customer need for sustainable and traceable cocoa from Ghana.

77. Renier, C., Addoah, T., Guye, V., Garrett, R., Van den Broeck, G., Zu Ermgassen, E.K.H.J., and Meyfroidt, P. (2025). Direct and indirect deforestation for cocoa in the tropical moist forests of Ghana. Environ. Res. Food Syst. *2*, 025006. https://doi.org/10.1088/2976-601X/add01b.

78. Addoah, T., Renier, C., Guye, V., Cammelli, F., Meyfroidt, P., Fajardo, J., Blaser-Hart, W.J., and Garrett, R.D. (in review). Cocoa expansion displaces food crops into protected forests, but sustainability programmes reduce loss. Commun. Earth Environ.

79. Addoah, T., Cammelli, F., and Garrett, R.D. (in review). Equity and environmental effectiveness of cocoa sustainability programmes in Ghana. Nat. Sustain.

80. Renier, C., Vandromme, M., Meyfroidt, P., Ribeiro, V., Kalischek, N., and Zu Ermgassen, E.K.H.J. (2023). Transparency, traceability and deforestation in the Ivorian cocoa supply chain. Environ. Res. Lett. *18*, 024030. https://doi.org/10.1088/1748-9326/acad8e.

81. Gereffi, G., and Lee, J. (2016). Economic and Social Upgrading in Global Value Chains and Industrial Clusters: Why Governance Matters. J. Bus. Ethics *133*, 25–38. https://doi.org/10.1007/s10551-014-2373-7.

82. Proforest (2024). Understanding the debate around the Soy Moratorium. https://www.proforest.net/news-and-events/news/understanding-the-debate-around-the-soy-moratorium/.

83. Rittner, D. (2025). Liminar derruba medida do Cade que suspendia moratória da soja. CNN Bras.

84. Zhong, S., and Chen, J. (2019). How Environmental Beliefs Affect Consumer Willingness to Pay for the Greenness Premium of Low-Carbon Agricultural Products in China: Theoretical Model and Survey-based Evidence. Sustainability *11*. https://doi.org/10.3390/su11030592.

85. Vasconcelos, A.A., Bastos Lima, M.G., Gardner, T.A., and McDermott, C.L. (2024). Prospects and challenges for policy convergence between the EU and China to address imported deforestation. For. Policy Econ. *162*, 103183. https://doi.org/10.1016/j.forpol.2024.103183.

86. Grabs, J., Carodenuto, S., Jespersen, K., Adams, M.A., Camacho, M.A., Celi, G., Chandra, A., Dufour, J., zu Ermgassen, E.K.H.J., Garrett, R.D., et al. (2024). The role of midstream actors in advancing the sustainability of agri-food supply chains. Nat. Sustain. *7*, 527–535. https://doi.org/10.1038/s41893-024-01296-9.

87. Folke, C., Österblom, H., Jouffray, J.-B., Lambin, E.F., Adger, W.N., Scheffer, M., Crona, B.I., Nyström, M., Levin, S.A., Carpenter, S.R., et al. (2019). Transnational corporations and the challenge of biosphere stewardship. Nat. Ecol. Evol. *3*, 1396–1403. https://doi.org/10.1038/s41559-019-0978-z.

88. Grabs, J., and Carodenuto, S.L. (2021). Traders as sustainability governance actors in global food supply chains: A research agenda. Bus. Strategy Environ. *30*, 1314–1332. https://doi.org/10.1002/bse.2686.

89. Clapp, J. (2021). The problem with growing corporate concentration and power in the global food system. Nat. Food, 1–5. https://doi.org/10.1038/s43016-021-00297-7.

90. JBS Green Offices. JBS360. https://www.jbs360.com.br/en/green-offices/.

91. Cammelli, F., Addoah, T., Furrer, N.A., Kouakou, P., Lyons-White, J., Renier, C., Thompson, W., and Garrett, R.D. (2025). Scaling out agroforestry and forest conservation in West Africa requires more transformative policy interventions in cocoa supply chains. Environ. Res. Food Syst. *2*, 033001. https://doi.org/10.1088/2976-601X/adf117.

92. Dermawan, A., and Hospes, O. (2018). When the state brings itself back into GVC: the case of the Indonesian Palm Oil Pledge. Glob. Policy *9*, 21–28. https://doi.org/10.1111/1758-5899.12619.

93. Musim Mas (2026). Independent Smallholders: Training for Trainers - Smallholders Hub. musimmas.com. https://www.musimmas.com/sustainability/smallholders/independent-smallholders/training-for-trainers/.

94. Musim Mas (2022). Musim Mas and Sinar Mas Agribusiness and Food Jointly Hosted Second Supplier Workshop in Aceh. musimmas.com. https://www.musimmas.com/resources/news-releases/musim-mas-and-sinar-mas-agribusiness-and-food-jointly-hosted-second-supplier-workshop-in-aceh/.

95. Nakao, K. and K., Ryo (2026). Applicability of Supply Shed Approach in Global Supply Chains: Integrating Supply Shed and Landscape Approaches for Natural capital Assessment. Environ. Res. Commun.

96. von Essen, M., and Lambin, E.F. (2021). Jurisdictional approaches to sustainable resource use. Front. Ecol. Environ. *19*, 159–167. https://doi.org/10.1002/fee.2299.

97. Gilbert, C.L. (2024). The EU Deforestation Regulation. EuroChoices *23*, 64–70. https://doi.org/10.1111/1746-692X.12436.

98. McDermott, C.L., Addoah, T., Agyarko-Kwarteng, T., Asare, R., Assanvo, A., Lima, M.B., Bellfield, H., Berlan, A., Carodenuto, S., Gardner, T., et al. (2025). Equity in unilateral value chain policies: A monitoring framework for the EUDR and beyond. For. Policy Econ. *174*, 103469. https://doi.org/10.1016/j.forpol.2025.103469.

99. Zhunusova, E., Ahimbisibwe, V., Sen, L.T.H., Sadeghi, A., Toledo-Aceves, T., Kabwe, G., and Günter, S. (2022). Potential impacts of the proposed EU regulation on deforestation-free supply chains on smallholders, indigenous peoples, and local communities in producer countries outside the EU. For. Policy Econ. *143*, 102817. https://doi.org/10.1016/j.forpol.2022.102817.

100. Camila, S.R. (2026). Exclusivo: Abiove comunica ONGs sobre saída da Moratória da Soja. Globorural.

101. Mano, A., Andreoni, M., and Romani, A. (2025). Major Brazilian grain traders quit Amazon conservation pact. Reuters.

1122 102. Guest, G., Namey, E., Taylor, J., Eley, N., and McKenna, K. (2017). Comparing focus
1123 groups and individual interviews: findings from a randomized study. Int. J. Soc. Res.
1124 Methodol. *20*, 693–708.

1125 103. Adams, W.C. (2015). Conducting semi-structured interviews. Handb. Pract. Program Eval.
1126 *4*, 365–378.

1127 104. Saunders, B., Sim, J., Kingstone, T., Baker, S., Waterfield, J., Bartlam, B., Burroughs, H.,
1128 and Jinks, C. (2018). Saturation in qualitative research: exploring its conceptualization and
1129 operationalization. Qual. Quant. *52*, 1893–1907. https://doi.org/10.1007/s11135-017-0574-8.

1130 105. QSR International (2022). NVivo Release 1.7 (1533). (QSR International Pty Ltd).

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SUPPLEMENTARY INFORMATION

Supplementary Information for:

Supply chain structures shape governance options and outcomes for deforestation-risk commodities across the tropics

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This file includes:

- Supporting text
- Table S1: Numbers of interviews and focus groups with each actor group in each commodity value chain
- Table S2: Criteria to assess values taken by GVC governance and other variables
- Interview guides
- References for Supporting Information

Other supporting materials for this manuscript include the following:

- **Framework matrix** available at: https://osf.io/6kwz8/?view_only=29b55057daa940cbbd92939dfb722f46

Supporting Text

Additional detail for Results

Linkages in Brazilian soy value chains outside the Amazon:

At the time of the Amazon Soy Moratorium Moratorium's adoption, Brazil was expanding soy production and seeking new markets, so downstream actors could impose the rules of trade. Over time, however, producers became empowered by growing demand from China, supply shortages, inflationary pressures, and the availability of information online. Producers in the Cerrado became increasingly organized and larger, better-capitalized players appeared [1]. These changes produced a technified producer class with greater capabilities and political power, which manifested in the emergence of Aprosoja. Power shifted upstream, leading to an oligopolistic structure where traders were "*not in a position to choose*" suppliers (BRS03-NGO). The greater relative capabilities and power of producers outside the Amazon enabled them to choose whether to sell to traders with FSPs, as one trader noted: "*Producers in the Cerrado are stronger, different from the Amazon"* (BRS09-TRA).

Compliance capabilities of smallholder farmers in Indonesian palm oil, and smallholder farmers and intermediaries in West African cocoa

Indonesia: Independent smallholders' lack of capability to achieve RSPO certification is well documented [2,3]: "[RSPO is] *pretty demanding. It costs a lot, especially in terms of labor*" (IPO-FAR-FG01); "*Actually, RSPO is the most complicated, because we have experienced it. Yes, right. Then directly RSPO, international standards, moreover we live in a village environment, information that is technologically developed we are less familiar with*" (IPO-FGO4-COP). Similar challenges apply for smallholders to comply with even more stringent NDPE policies. Many have little or no knowledge of NDPE requirements, as one industrial grower explained: "*Policies are up here* [points high], *the producers are down here* [points low]" (IPO10-GRO).

West Africa: The capabilities of Licensed Buying Companies (LBCs) in Ghana and cooperatives in both countries vary widely. For example, while the large Ghanaian cooperative Kuapa Kokoo produces its own Fairtrade-certified chocolate, many LBCs in Ghana and smaller cooperatives in both countries have limited capabilities for FSP compliance. One Ivorian cooperative described the costs and challenges of certifying its members: "*In the first year of certification it was difficult for the producers because they had no concept of certification*" (CIV41-COP). The farmers we interviewed understood the importance of forest conservation, but they cited a broader lack of awareness: "*I think there's a problem of awareness. Because when you're not aware, if you don't know what a classified forest means, you're bound to destroy it*" (CIV-FG04). More generally, farmers' capabilities to comply with FSPs independently were low, as one IGO explained: "[Farmers] *don't have the information for all commitments. They know that we have climate change… but they don't know the deforestation aspect, what it means*" (CIV09-IGO).

Additional detail for Methods

Fieldwork: We conducted fieldwork in Pará, Brazil, between October 2019–February 2020; in Jakarta, Indonesia, between February–March 2020; in Ghana between November 2021–February 2022; in Côte d'Ivoire between March–April 2022; in Sumatra, Indonesia between January–May 2022; and in São Paulo, Brasilia, Mato Grosso, and Bahia, Brazil between May–October 2022. We conducted interviews in-person, or online when fieldwork had to be discontinued due to COVID-19 (Indonesia, 2020) or when participants were unavailable (Côte d'Ivoire and Ghana).

Table S1. Summary of the number of interviews (or Focus Group Discussions, FGDs, where indicated) conducted with the actor groups identified in each commodity value chain. N show the numbers of interviews and FGDs but not necessarily the number of organisations we interviewed. For example, in West African cocoa, some representatives of the same firms were interviewed in both Ghana and Côte d'Ivoire. Capitalised abbreviations in brackets define the pseudonyms we used to identify interviews in the results and framework matrix (**SI**), e.g. IPO3-TRA = Indonesian palm oil, interview 3, Trader.

							West African cocoa			
	Brazilian soy (BRS)	**n**	**Brazilian cattle (BRC)**	**n**	**Indo. palm oil (IPO)**	**n**	**Côte d'Ivoire (CIV)**	**n**	**Ghana (GHA)**	**n**
Manufacturers (MAN)					Consumer goods manufacturers (CGM)	5	Chocolate manufacturers (CGM)	5	Chocolate manufacturers (CGM)	7
Traders, exporters, processors	Traders / exporters (TRA)	4	Slaughterhouses and meatpackers (SLA)	8	Traders / processors (TRA)	4	Traders / exporters / grinders* (TRA)	5	Traders / exporters / grinders* (TRA)	6
					Large integrated supply chain companies (LISCs)	8	Local informal trader (*pisteur)*	1	Licensed Buying Companies (local) (LBC)	3
	Industry association (IND)	4							Purchasing clerks (PC)	2
Producers	Corporate growers (GRO)	1	Producers: finishers (FAT)	13	Corporate growers (GRO)	5	Corporate growers (GRO)	1	Smallholders (FAR)	2
	Producers' association (PRO)	1	Producers: calvers (CAL)	15	Cooperatives (COP)	15	Smallholders (FAR): FGDs	5	Smallholders (FAR): FGDs	1
					Cooperatives (COP): FGDs	4	Cooperatives (COP)	5	Cooperatives (COP)	4
					Smallholders (FAR): FGDs	12				
					Smallholder org. (SHO)	2				
Government (GOV)	National dept. / agencies	1	National dept. / agencies	5	National dept. / agencies	1	National dept. / agencies	6	National dept. / agencies	9
					Provincial, District, or Local government	21				
					Extension officers: FGDs	4				
NGOs (NGO)	Environmental and/or social NGOs	9			Environmental and/or social NGOs	9	Environmental and/or social NGOs	9	Environmental and/or social NGOs	9
Supporting orgs, industry experts	Tech support orgs (TSO)	3	Meat industry union (UNI)	2	Tech support orgs (TSO)	8	Tech support orgs (TSO)	1	Tech support orgs (TSO)	1
	Researcher (CON)	2			Consultant or researcher (CON)	5	Researcher (CON)	2	Consultant or researcher (CON)	1
							Cert. scheme (CER)	1	Cert. schemes (CER)	1
					Intergovernmental or foreign dev. agency (IGO)	2	Intergovernmental or foreign dev. agency (IGO)	3	Intergovernmental or foreign dev. agency (IGO)	2
					Multi-stakeholder orgs	1	Multi-stakeholder orgs	1	Multi-stakeholder orgs	1
Total		**25**		**43**		**106**		**45**		**49**

Definitions: Cert. scheme, Certification scheme; Dept., Departments; FGD, Focus Group Discussion; NGOs, Non-Government Organisations. *Some firms fulfilled both trading/exporting and grinding functions. Reported interview numbers differ slightly from those in previously published papers [4–6] due to minor differences in inclusion criteria and the grouping of actor groups between studies.

Table S2. Criteria to assess values taken by GVC governance and other variables. Criteria were developed by adapting and extending variable definitions in the GVC governance framework (Gereffi et al., 2005)[7] using criteria for assessing FSPs' effectiveness and equity (Garrett et al., 2019; Grabs et al., 2021).[8,9]

Complexity of FSP	Codification of FSP	Capabilities in the supply base	Market share	Outcome: Regional effectiveness	Outcome: market access equity
Low complexity: No additional information about deforestation-free production is required for producers or suppliers to sell commodities to buyers.	**Low codification:** Each firm has a unique FSP with specific requirements that are not formalised and cannot be communicated efficiently in transactions without investing in one-to-one relationships with producers or suppliers.	**Low capabilities:** Producers or suppliers lack information and/or technical expertise and/or resources (e.g. time or money) to comply with FSP requirements (i.e., to execute a deforestation-free commodity transaction).	**Low market share:** Firms with FSPs account for a minority (<50%) of the market in the focal region.	**Low effectiveness:** Little or no evidence that an FSP has caused additional reductions in deforestation at the regional level compared to the business-as-usual scenario.	**Low equity:** The least powerful producers in the value chain risk being excluded from the market altogether or incorporated into larger operations through business or land acquisitions.
Moderate complexity: Producers or suppliers are required to provide buyers with relatively simple evidence to demonstrate that the production of a commodity has been deforestation-free. Simple evidence means a small number of separate documents or pieces of information, is aligned with public regulations that producers are already required to follow, and can be monitored by buyers using easily accessible and publicly available information.	**Moderate codification:** FSPs differ in specific features but are broadly similar across the sector and can be easily communicated to producers or suppliers who are used to transacting with other buyers. May be some use of certification standards such as Rainforest Alliance, Roundtable on Sustainable Palm Oil (RSPO) but this is not universal and often accompanied by additional firm-specific requirements. Individual firms' FSPs may differ in focus, e.g. forest conservation or labour exploitation, or criteria, e.g. the content of farmer training.	**Mixed capabilities:** Some producers or suppliers have high capabilities while others have low capabilities.	**Moderate market share:** Firms with FSPs account for the majority (≥50%) of commodity purchasing in the focal region OR Firms with FSPs account for almost all (≥90%) commodity purchasing in the focal region but FSP coverage among producers is lower due to incomplete application to both direct and indirect sourcing, or incomplete uptake of FSPs at value chain tiers upstream (e.g., processors or traders).	**Moderate effectiveness:** EITHER: Evidence available that FSP has caused additional reductions in deforestation at the regional level compared to the business-as-usual scenario, but reductions are modest; OR: Little or no evidence that the FSP has caused additional reductions in deforestation at the regional level compared to the business-as-usual scenario, but substantial evidence that overall levels of deforestation driven by the focal commodity has fallen substantially in regions where the FSP was implemented over the time period since it was implemented.	**Moderate equity:** The least powerful producers in the value chain risk being excluded from the FSP-compliant commodity market but retain access to the conventional market and are not at risk of being incorporated into larger operations.
High complexity: Producers or suppliers are required to provide detailed evidence to demonstrate that production of a commodity has been deforestation-free. Detailed evidence means numerous documents or pieces of information, and/or information that is additional to requirements in public regulations, and/or information that requires specific management processes (e.g. completion and filing of audits) to be put in place by the producer and/or buyer. Examples include High Conservation Value (HCV) assessment reports or the delineation and provision of farm boundary data.	**High codification:** FSPs are explicitly standardised across an entire sector or region or take a consistent form between firms. This generally involves a set of widely accepted specifications set out in a sectoral standard. Buyers can purchase compliant commodities that conform with the standard without investing in a relationship with each producer or supplier.	**High capabilities:** Producers or suppliers have sufficient information, technical expertise, and resources to comply with FSP requirements.	**High market share:** Firms with FSPs account for almost all (≥90%) commodity purchasing in the focal region, to the extent that it is feasible that commodities purchased by firms without FSPs are still likely to conform with FSP requirements.	**High effectiveness:** Evidence available that an FSP has caused additional reductions in deforestation at the regional level compared to the business-as-usual scenario, and these reductions are substantial.	**High equity:** The least powerful producers in the value chain do not risk being excluded in the FSP-compliant market, or steps have been taken to ensure their inclusion in the FSP-compliant market.

SUPPLEMENTARY INFORMATION

Interview guides: This document contains the project interview guides in English. We developed adapted interview guides for the main actor groups in each case. Interview guides featured some differences between cases but generally explored the nature of actors' business operations, procurement and/or sales practices; the content and operationalisation of their FSPs and/or partners' FSP requirements; engagement with civil society and public policies; and attitudes towards conservation. We developed interview guides for Brazilian soy separately, as this case explored both how the Amazon Soy Moratorium emerged and why a moratorium failed to materialise in the Cerrado.

Interview guides: Contents

1. Brazilian Amazon cattle interview guides

1.1 Brazilian Amazon cattle: Producer

1. Background

1.1. What is your name?

1.2. How old are you?

1.3. Where did you grow up?

1.4. Did you ever participate in a research project before?

1.5. If not local area: Why did you move here?

1.6. How long have you been working in farming?

1.7. How long have you had this farm?

1.8. Male or female (just note down)

1.9. What is your religion?

1.10. How many properties do you have?

1.11. For each property: (make sure to note if some properties cattle is raised to be sent to another farm owned by same person)

Name	Municipality & State	Area	Produce	Who do you sell to?

2. Ease of finding sellers

2.1. Is it easy to find a buyer for your production?

(listen/probe for: market share of various buyers; levels of competition among buyers; distance willing to travel to find buyers)

2.2. Has it always been so easy/difficult (depending on answer above)?

2.2.1. If no, what has changed? -> if they mention ZDCs here, jump right to Q 5 to avoid duplications

2.2.2. When did it change?

2.2.3. And why?

2.2.4. How did you react to these changes?

(listen/probe for: adjustment to market requirements re: compliance, quality, legality; expand distance willing to travel; expand into other types of production)

2.3. Do you anticipate that it will become easier or harder to find a buyer for your production in the future? Why?

3. Choice of buyer

3.1. When you are choosing a buyer, what do you care about? How did you choose your current buyer? [Alt: Why did you choose to sell to the buyers that you are currently selling to?]

(listen/probe for: prices/money; other incentives (in-kind support, fair treatment, contract terms, access to credit); relationship with buyer (personal ties); distance to/ease of access to market; what neighbors do; norms, habits, values, what heuristics do they use)

3.2. [depending on explanation above, probe:] Do you have a close personal relationship with any of the buyers?

3.3. Do the buyers in your region…

3.3.1. Offer different prices for the same quality of product?

- If yes: does your buyer offer better prices than competitors?

3.3.2. Ask for different types of quality?

- If yes: does your buyer ask for higher or lower quality than competitors?

3.3.3. Provide credit to their suppliers?

- If yes: does your buyer offer better rates than competitors?

3.3.4. Offer other types of support to their suppliers (e.g. subsidized inputs, pick-up of cattle)?

- If yes: does your buyer offer higher support than competitors?

3.3.5. Provide different types of contracts/purchasing guarantees/are some buyers more reliable than others?

- If yes: is your buyer more reliable than competitors?

If no to any of the above: why don't you sell to others?

4. Incentive programs

4.1. Do any of the buyers locally have incentive programs? Please explain

4.2. Do you sell to this buyer? If not, why not?

5. Commitment – requirement awareness/ satisfaction

5.1. Do buyers in your region have any requirements for you to sell to them? What kinds of documents? (listen for/probe: documents, certifications)

5.2. Do buyers in your region have any restrictions regarding the types of farms/producers they accept products from? What kinds of restrictions? (listen for/probe: behavior such as land clearance or fire…)

5.3. Are there any differences between buyers?

5.4. Has this changed over time? If so, when?

5.5. Do you sell to such buyers?

- If yes: Why do you accept such restrictions to keep selling to them?
- If yes: Has it been difficult to adapt to such restrictions? Why?
- If yes: What would need to change to make it easier to adapt to such restrictions?
- If yes: Would you say that such restrictions (i.e. ZDCs) are an economic opportunity for you?
- If yes: Do you make more money with your current buyer than with others?

- If Yes: Do you agree with such criteria?
- If no: Why don't you sell to such buyers?
- If no: What would need to change for you to sell to such buyers?
- If no: Has the introduction of these restrictions affected your ability to sell your product under advantageous conditions? [may have already been covered under Q2]
- If no: Do you feel excluded or marginalized by such restrictions?
- If no: Do you disagree with such criteria? Do you think they are fair?

5.6. Do many people in your social circle sell to such buyers?

5.6.1. Why do you think this is so? How did that happen?

5.6.2. Did that change how they produce?

5.6.3. Would you say anything else changed after they started selling to them?

5.7. In your opinion, have such restrictions changed farmers' production and sales behaviors? How so? (Listen/probe for: decrease of burning or deforestation; switch to other buyers, maybe in larger distance; switch to other production; move away; lower profits; capital shortage; …)

5.8. Have such restrictions changed farmers' in other ways? How so? (Listen/probe for: worse livelihoods; less enjoyment of production; worse relations in the value chain…)

5.9. In your opinion have such restrictions caused farmers to leave the region?

6. Commitment – monitoring and enforcement

6.1. Has your property ever been inspected by a buyer? Have you heard of others who have been inspected?

- If yes to either: When, by whom and how often?
- If yes to either: Did this have an effect on your behavior/farming practices or (if inspected directly) your ability to sell your product?
- If no: Do you think it is likely that you will be inspected in the future? Does this affect your behavior/farming practices?

6.2. Have you ever been prevented from selling your production due to a lack of documentation or due to other restrictions (as discussed above)?

- If yes: What did you do?
- If yes: Where there options the company offered to help you achieve documentation (or fulfill other requirements)?
- If no: Do you think it is likely that you will be prevented from selling in the future? Does this affect your behavior/farming practices?

7. Do you have any other agreement with your buyers that you did not mention yet? For how long has it been so? If it changed, why did it change?

8. Public policy support

8.1. Have you received support by the government [municipio?] to fulfill the requirements of your buyer?

- If yes: How important was such support to your participation?

- If no: Do you think such support would have made it easier/convinced you to participate?

8.2. Are the government forest policies stricter, the same as, or less stringent the company policies?

- Which one has a greater effect on your decisions? Why?

(listen/probe for: fear of conviction; fear of fine; norms e.g. "it's bad to break the law"; collective norm change - "everybody else is doing it too")

9. Intrinsic values and extrinsic norms

9.1. Are there any production behaviors that you would never engage in, even if it was legal and profitable? Which ones? Why?

(listen/probe for: because it's wrong; need to protect environment for children; tradition; collective norms 'that's not what we do here')

9.2. Have you changed your opinion in this regard in the past? Why?

(listen/probe for: Municipio Verde blacklisting; collective norm changes; social influence by peers or family members; education by buyers, …)

10. Closing:

10.1. Looking forward, what would be your vision for your farm in the next ten years?

10.2. Is there anything else you would like to mention that is relevant to the conversation we just had?

1.2. Brazilian Amazon cattle: Buyer (Slaughterhouse)

1. Background

1.1. What is your name?
1.2. What is your position at your company?
1.3. Have you ever been interviewed as part in a research project?
1.4. Where did you grow up?
1.5. How long have you been working in this industry?
1.6. How long have you been working at this company?
1.7. If not local area: Why did you move here?
1.8. Male or female (just note down)

2. Company information

2.1. When did this facility open?
2.2. How much production can you process?
2.3. Who are your main buyers? (probe/follow-up: what sector are these companies in?)
2.4. Do you sell internationally?
2.5. If so, which countries?

3. Ease of finding suppliers

3.1. Is your mill/slaughterhouse at capacity?
3.2. Is it easy to obtain the production you need/want? (listen/probe for: market share of various buyers; levels of competition; distance suppliers are willing to travel to find buyers)
3.3. Has it always been so easy?
3.4. If no, what has changed?
3.5. If no, when did it change?
3.6. Did the change in ease in obtaining production volumes occur for other as well? Why?
3.7. Do you anticipate that it will become easier or harder to obtain sufficient production for your mill/slaughterhouse in the future? Why?

4. Ease of selling production onward

4.1. Is it easy to sell your output onwards? (listen/probe for: market share of various buyers; existence of various export markets; levels of competition; requirements by multinational buyers)
4.2. Has it always been so easy/difficult?
4.3. If no, what has changed?
4.4. If no, when did it change?
4.5. Do you anticipate that it will become easier or harder to sell the output of your mill/slaughterhouse in the future? Why?

5. Assurance of supply base

5.1. Does your company normally seek out producers to buy from or do they seek you out?

5.2. If you seek: How do you choose the farmers you are buying from?

5.3. If you seek: How do you enter in contact with them?

5.4. If they seek: How does your company get farmers to sell to you and not your competitors? (listen/probe for: prices/money; other incentives (in-kind support, fair treatment, contract terms, access to credit); personal relationship with buyer (personal ties); distance to/ease of access to market; what neighbors do; values?)

5.5. [depending on explanation above, probe:] Do buyers in your region…

5.5.1. Have strong personal relationships with their suppliers?

- If yes: Does your company invest more in building these relationships with suppliers than other buyers in the region?
  - If no: why don't you use it as a way to attract suppliers?

5.5.2. Offer different prices for the same quality of product?

- If yes: does your company offer better prices than your competitors? Does this help you get farmers to sell to you?
  - If no: why don't you use it as a way to attract suppliers?

5.5.3. Ask for different types of quality? (fat cover/genetics/organic/humidity)

- If yes: does your company ask for higher or lower quality than your competitors? Does this help you get farmers to sell to you?

5.5.4. Provide credit to their suppliers?

- If yes: does your company you offer better rates than your competitors? Does this help you get farmers to sell to you?
  - If no: why don't you use it as a way to attract suppliers?

5.5.5. Offer other types of support to their suppliers (e.g. subsidized inputs, pick-up of cattle)? Does this help you get farmers to sell to you?

- If yes: do you offer higher support than your competitors?
  - If no: why don't you use it as a way to attract suppliers?

5.5.6. Provide different types of contracts/purchasing guarantees/are some buyers more reliable than others? (probe: payment terms/delays in payment)

- If yes: do you offer more favorable terms than your competitors?
  - If no: why don't you use it as a way to attract suppliers?

6. Commitment – how implement part 1: requirements

6.1. What do you require of farmers that sell commodities to you? What kinds of documents do you require?

6.2. What kinds of restrictions do you place on farmers that sell commodities to you? (listen for/probe: documents, certifications, behavior such as land clearance or fire…)

6.3. Why? Do you agree with them?

6.4. Do you accept production from farmers who have deforested parts of their property **legally**?

6.5. Is there a cut-off year that you use?

6.6. In your opinion, have such restrictions changed farmers' production and sales behaviors? (Listen/probe for: decrease of burning or deforestation; switch to other buyers, maybe in larger distance; switch to other production; move away; lower profits; capital shortage; less enjoyment of production…)

6.7. How do you feel these restrictions have affected the farmers who sell to you in other ways? How so? (Listen/probe for: worse livelihoods; less enjoyment of production; worse relations in the value chain…)

6.8. In your opinion, have such restrictions changed the make-up of your supply base and your customer base?

6.9. In your opinion have such restrictions caused farmers to leave the region?

7. Commitment – how implement part 2: monitoring (do if ZDC or not, still interesting for legality)

7.1. How do you monitor/identify deforestation on your suppliers' properties? (Listen/probe for: use of geospatial data (coming from HQ?); government-provided data; third-party verifiers [certification], consultants; NGOs…)

7.2. How easy or challenging is it to monitor deforestation at the property level?

7.3. Since your commitment began, how many instances of (illegal) deforestation have you identified on your suppliers' properties?

8. Commitment – how implement part 3: enforcement

8.1. If you find your supplier is breaking the rules (deforestation, documentation or otherwise), what do you do?

8.2. If you exclude the producer, do you exclude them by property (CAR) or by producer (CPF)?

9. Commitment – how implement part. 4: engagement with excluded farmers

9.1. Do you work with farmers who you have taken action against to help them become compliant?

9.2. If so how? Do you have a specific program to do so?

9.3. Does your company have any CSR activities locally? If so, are excluded farmers able to access these?

10. Public policy and civil society support

10.1. Do you engage in any collaborations with governmental actors (municipios?) or non-governmental entities to make the implementation of your supply chain policy easier? (Listen/probe for multi-stakeholder/jurisdictional processes)

10.1.1. If yes: How important is such support to the implementation of this policy? What elements are most helpful? Would you like to see even more cooperation in the future? In what areas?

10.1.2. If no: Do you think such support would make it easier to implement such a policy? How so?

10.2. How do legal restrictions limit your sourcing practices?

10.2.1. If yes: Do they influence your behavior or those of your suppliers? Why?

(listen/probe for: fear of conviction; fear of fine; norms e.g. "it's bad to break the law"; collective norm change - "everybody else is doing it too")

10.2.2. If yes: What do you perceive as more important in shaping your suppliers' behavior, the legal or the buyers' restrictions?

10.3. Are your company policies stricter, the same as, or less stringent than government policy?

10.4. (If less stringent) Does the fact that the government already has more stringent policies reduce the costs to you?

11. Intrinsic values and extrinsic norms

11.1. How would you characterize the attitudes of local farmers toward the environment and environmental conservation?

(listen/probe for: they don't care and just want to expand production; they feel protective of the forest; conservation is for lazy people; etc.)

11.2. Have farmer attitudes changed since you started applying purchasing restrictions?

11.3. Had attitudes already changed? Why? When?

(listen/probe for: Municipio Verde blacklisting; collective norm changes; social influence by peers or family members; education by buyers, …)

12. Opinion

12.1. How do you think your company's forest policy is affecting business?

(Listen/probe for: decrease of available supply; decrease (or increase?) of available quality; need to pay higher prices; need to offer higher incentives; need to go source from farmers…)

12.2. How do you think your company's forest policy is affecting your personal relationships with your suppliers?

12.3. [If they mentioned CSR/outreach activities]: How has the introduction of outreach activities influenced your operating costs?

12.4. Do you think that forest policies as a whole are benefitting or harming the soy/cattle sector of this region?

13. Closing

13.1. Looking forward, what would be your vision for agricultural production in this region be in the future?

13.2. Is there anything else you would like to mention that is relevant to the conversation we just had?

1.3. Brazilian Amazon cattle: Government official / NGO / producer association

1. Background

1.1. What is your name?
1.2. What organization do you work at?
1.3. What is your position at your office?
1.4. Where did you grow up?
1.5. How long have you been working at this office?
1.6. If not local area: Why did you move here?
1.7. Male or female (just note down)

2. Assessment of ZDC existence and incentivization

2.1. Are you aware of sourcing companies in this region that have requirements of farmers that sell commodities to them? What kinds of documents do they usually ask for? (listen for/probe: documents, certifications
2.2. Are you aware of sourcing companies in this region that have restrictions on farmers that sell commodities to them? What kinds of restrictions (listen for/probe: land clearance, fire…)
2.3. In your opinion, have such restrictions changed farmers' production and sales behaviors? (Listen/probe for: decrease of burning or deforestation; switch to other buyers, maybe in larger distance; switch to other production; move away; lower profits; capital shortage; less enjoyment of production…)
2.4. Do you think that these restrictions have affected the farmers in other ways? How so? (Listen/probe for: worse livelihoods; less enjoyment of production; worse relations in the value chain…)
2.5. If compliance is mentioned: In your opinion, why do farmers sell to committed companies rather than non-committed ones?

(listen/probe for: prices/money; other incentives (in-kind support, fair treatment, contract terms, access to credit); relationship with buyer (personal ties); distance to/ease of access to market; what neighbors do; values?)

2.6. What do you think farmers most care about when choosing a soy/cattle buyer? Can you think of incentives that would make farmers more likely to sell to committed companies?
2.7. In your opinion, have such restrictions changed the make-up of companies' supply base or their economic situation? How so?

(Listen/probe for: decrease of available supply; decrease (or increase?) of available quality; need to pay higher prices; need to offer higher incentives; need to go source from farmers…)

3. Assessment of ZDC monitoring and enforcement

3.1. To the best of your knowledge, do sourcing companies monitor deforestation on their suppliers' properties? How? Do you think they monitor too little or too much?

(Listen/probe for: use of geospatial data (coming from HQ?); government-provided data; third-party verifiers [certification], consultants; NGOs…)

3.2. To the best of your knowledge, how do sourcing companies react when they find deforestation on their suppliers' properties?

(Listen/probe for: exclude; engage; exclude then engage; no reaction; …)

3.3. In your opinion, are these measures adequate? Are there better ways in which companies could react?

4. Public policy/civil society support

4.1. Does your organization engage in any collaborations with supply chain actors to make the implementation of your supply chain policy easier?

4.1.1. If yes: How important is such support to the implementation of this policy? What elements are most helpful? Would you like to see even more cooperation in the future? In what areas?

4.1.2. If no: Why not? Do you think such support would make it easier to implement such a policy? How so?

4.2. Are you aware of any legal restrictions that limit the behavior of companies or that of their suppliers? Which ones? [adapt this question depending on the person asked/assumed level of knowledge]

4.2.1. If yes: In your opinion, do they influence the behavior or companies or their suppliers? Why?

(listen/probe for: fear of conviction; fear of fine; norms e.g. "it's bad to break the law"; collective norm change - "everybody else is doing it too")

4.2.2. If yes: What do you perceive as more important in shaping producers' behavior, the legal or the buyers' restrictions?

5. Intrinsic values and extrinsic norms

5.1. How would you characterize the attitudes of local farmers toward the environment and environmental conservation?

(listen/probe for: they don't care and just want to expand production; they feel protective of the forest; conservation is for lazy people; etc.)

5.2. Have farmer attitudes changed since companies started applying purchasing restrictions?

5.3. Had attitudes already changed? Why? When?

(listen/probe for: Municipio Verde blacklisting; collective norm changes; social influence by peers or family members; education by buyers, …)

6. Opinion

6.1. How do you think companies' forest policies are affecting the soy/cattle sector of this region? How are they affecting the regional economy as a whole?

6.2. How do you think companies' forest policies are affecting the environment in the region?

6.3. If you could change something about companies' forest policies, what would it be?

7. Closing:

7.1. Looking forward, what would be your vision for agricultural production in this region be in the future?

7.2. Is there anything else you would like to mention that is relevant to the conversation we just had?

2. Brazilian Amazon soy interview guide

Block 01: Historical process referring to the Soy Moratorium in the Amazon

1. Did your organization/did you follow the process of negotiating the Soy Moratorium in the Amazon commitment?
    1.1. If so: Can you tell me about the Soy Moratorium negotiation process?
    1.2. If not: How did you participate in the Soy Moratorium?
2. What were the pivotal moments in the decision-making process?
3. What were the main conditions that led to the agreement and the implementation of the Soy Moratorium in the Amazon being consolidated?
4. What role did your organization play in the negotiations and why?
5. Were there internal disagreements among participants and/or support for the Moratorium? What were the topics and why? Are there still disagreements?
6. What was the national political context like at that negotiation? To what extent did this context influence the decision?
7. How did the international context of the soybean market influence the decision? Why?
8. How has the governance of the moratorium evolved? Why?
9. Why was there no Moratorium for the Cerrado at that time and up to now?

Block 02: Historical process negotiations of sustainability policies in the Cerrado

1. Is there any sectoral sustainability policy for the Cerrado? If yes: Which one?
2. Did your organization/did you participate in creating the Cerrado Working Group?
    2.1. If yes: Can you tell me why it was created?
    2.2. If No: Have you participated in the GTC at any point since its inception? Which? Why did you participate?
3. What were/are the priorities established in the GTC? And what were/are your organization's priorities for the GTC?
4. Were there internal disagreements, in your organization, in participating and/or supporting the GTC? What were they and why? Are there still disagreements?
5. Do you still participate in the GTC?
6. What was the political context like at that moment of negotiation for the formation of the GTC? And how have the most recent political developments influenced the positioning of actors/organizations?
7. How did the international context of the soybean market influence the decision? Why?

Block 03: Actors participating in the Soy Moratorium in the Amazon

1. Who and which organizations were present during the Soy Moratorium negotiations in the Amazon?
2. Who dropped out of the process and why?
3. Who were the leaders of this process?
4. Who got in the middle of the process and why?

Block 04: Actors participating in the Cerrado Agreement negotiations

1. Who and which organizations were present during the process of creating the GTC?
2. Who were the leaders of this process?
3. Who is still present at the GTC? And who got in the middle of the process?
4. Who left the GTC, and why?

3. Indonesian palm oil interview guides

3.1 Indonesian palm oil: Buyer (retailer / manufacturer)

1. Background

1.1. What is your name? [or fill in previously]
1.2. What is your position at your company? [or fill in previously]
1.3. Have you ever been interviewed as part in a research project?
1.4. How long have you been working in this industry?
1.5. How long have you been working at this company?
1.6. Male or female (just note down)

2. Company information (try to fill out beforehand based on collected information)

2.1. How much palm oil do you source on a yearly basis?
2.2. Who are your main suppliers?
2.3. Do you buy from different countries?
2.4. If so, which countries?

3. Ease of finding suppliers

3.1. Is it easy to obtain the production you need/want? (listen/probe for: market share of various buyers; levels of competition; distance suppliers are willing to travel to find buyers)
3.2. Has it always been so easy?
3.3. If no, what has changed?
3.4. If no, when did it change?
3.5. Did the change in ease in obtaining production volumes occur for other as well? Why?
3.6. Do you anticipate that it will become easier or harder to obtain sufficient production for your purposes in the future? Why?

4. Ease of selling production onward

4.1. [For manufacturers] Is it easy to sell your output onwards? (listen/probe for: market share of various buyers; existence of various export markets; levels of competition; requirements by multinational buyers)
4.2. Has it always been so easy/difficult?
- If no, what has changed?
- If no, when did it change?

4.3. Do you anticipate that it will become easier or harder to sell the output of your company in the future? Why?

5. Assurance of supply base

5.1. Does your company normally seek out suppliers to buy from or do they seek you out?

5.2. If you seek: How do you choose the suppliers you are buying from?

5.3. If you seek: How do you enter in contact with them?

5.4. If they seek: How does your company get suppliers to sell to you and not your competitors? (listen/probe for: prices/money; other incentives (in-kind support, fair treatment, contract terms, access to credit); personal relationship with buyer (personal ties); distance to/ease of access to market; what neighbors do; values?)

5.5. [depending on explanation above, probe:] Do buyers in your position of the value chain…

5.5.1. Have strong personal relationships with their suppliers?

- If yes: Does your company invest more in building these relationships with suppliers than other buyers in the region?
  - If no: why don't you use it as a way to attract suppliers?

5.5.2. Offer different prices for the same quality of product?

- If yes: does your company offer better prices than your competitors? Does this help you get farmers to sell to you?
  - If no: why don't you use it as a way to attract suppliers?

5.5.3. Ask for different types of quality? (fat cover/genetics/organic/humidity)

- If yes: does your company ask for higher or lower quality than your competitors? Does this help you get farmers to sell to you?

5.5.4. Provide credit to their suppliers?

- If yes: does your company offer better rates than your competitors? Does this help you get farmers to sell to you?
  - If no: why don't you use it as a way to attract suppliers?

5.5.5. Offer other types of support to their suppliers (e.g. subsidized inputs, pick-up of cattle)? Does this help you get farmers to sell to you?

- If yes: do you offer higher support than your competitors?
  - If no: why don't you use it as a way to attract suppliers?

5.5.6. Provide different types of contracts/purchasing guarantees/are some buyers more reliable than others? (probe: payment terms/delays in payment)

- If yes: do you offer more favorable terms than your competitors?
  - If no: why don't you use it as a way to attract suppliers?

6. Commitment – how implement part 1: requirements

6.1. What do you require of suppliers that sell commodities to you? What kinds of documents do you require?

6.2. What kinds of restrictions do you place on suppliers that sell commodities to you? (listen for/probe: documents, certifications, behavior such as land clearance or fire…)

6.3. Do you accept production from farmers who have deforested parts of their property **legally**?

6.4. Is there a cut-off year that you use?

6.5. In your opinion, have such restrictions changed farmers' production and sales behaviors? (Listen/probe for: decrease of burning or deforestation; switch to other buyers, maybe in larger

distance; switch to other production; move away; lower profits; capital shortage; less enjoyment of production…)

6.6. How do you feel these restrictions have affected the suppliers who sell to you in other ways? How so? (Listen/probe for: worse livelihoods; less enjoyment of production; worse relations in the value chain…)

6.7. In your opinion, have such restrictions changed the make-up of your supply base and your customer base?

6.8. In your opinion have such restrictions caused farmers to leave the regions you source from?

7. Commitment – how implement part 2: monitoring (do if ZDC or not, still interesting for legality)

7.1. How do you monitor/identify deforestation on your suppliers' properties?

(Listen/probe for: use of geospatial data (coming from HQ?); government-provided data; third-party verifiers [certification], consultants; NGOs…)

7.2. How easy or challenging is it to monitor deforestation at the property level?

7.3. Since your commitment began, how many instances of (illegal) deforestation have you identified on your suppliers' properties?

8. Commitment – how implement part 3: enforcement

8.1. If you find your supplier is breaking the rules (deforestation, documentation or otherwise), what do you do?

9. Commitment – how implement part 4: engagement with excluded farmers

9.1. Do you work with farmers who you have taken action against to help them become compliant?

9.2. If so how? Do you have a specific program to do so?

9.3. Does your company have any CSR activities locally? If so, are excluded farmers able to access these?

10. Public policy and civil society support

10.1. Do you engage in any collaborations with governmental actors (municipios?) or non-governmental entities to make the implementation of your supply chain policy easier? (Listen/probe for multi-stakeholder/jurisdictional processes)

10.1.1. If yes: How important is such support to the implementation of this policy? What elements are most helpful? Would you like to see even more cooperation in the future? In what areas?

10.1.2. If no: Do you think such support would make it easier to implement such a policy? How so?

10.2. How do legal restrictions limit your sourcing practices?

10.2.1. If yes: Do they influence your behavior or those of your suppliers? Why?

(listen/probe for: fear of conviction; fear of fine; norms e.g. "it's bad to break the law"; collective norm change - "everybody else is doing it too")

10.2.2. If yes: What do you perceive as more important in shaping your suppliers' behavior, the legal or the buyers' restrictions?

10.3. Are your company policies stricter, the same as, or less stringent than government policy?

10.4. (If less stringent) Does the fact that the government already has more stringent policies reduce the costs to you?

11. Intrinsic values and extrinsic norms

11.1. How would you characterize the attitudes of local farmers toward the environment and environmental conservation?

(listen/probe for: they don't care and just want to expand production; they feel protective of the forest; conservation is for lazy people; etc.)

11.2. Have farmer attitudes changed since you started applying purchasing restrictions?

11.3. Had attitudes already changed? Why? When?

(listen/probe for: collective norm changes; social influence by peers or family members; education by buyers, …)

12. Opinion

12.1. How do you think your company's forest policy is affecting business?

(Listen/probe for: decrease of available supply; decrease (or increase?) of available quality; need to pay higher prices; need to offer higher incentives; need to go source from farmers…)

12.2. How do you think your company's forest policy is affecting your personal relationships with your suppliers?

12.3. [If they mentioned CSR/outreach activities]: How has the introduction of outreach activities influenced your operating costs?

12.4. Do you think that forest policies as a whole are benefitting or harming the soy/cattle sector of this region?

13. Closing

13.1. Looking forward, what would be your vision for agricultural production in this supply chain be in the future?

13.2. Is there anything else you would like to mention that is relevant to the conversation we just had?

3.2 Indonesian palm oil: Buyer (trader / Large Integrated Supply chain Company [LISC])

1. Background

1.1. What is your name? [or fill in previously]
1.2. What is your position at your company? [or fill in previously]
1.3. Have you ever been interviewed as part in a research project?
1.4. How long have you been working in this industry?
1.5. How long have you been working at this company?
1.6. Male or female (just note down)

2. Company information

2.1. When did this facility open?
2.2. How much production can you process?
2.3. Who are your main buyers? (probe/follow-up: what sector are these companies in?)
2.4. Do you sell internationally?
2.5. If so, which countries?

3. Ease of finding suppliers

3.1. Is your mill/slaughterhouse at capacity?
3.2. Is it easy to obtain the production you need/want? (listen/probe for: market share of various buyers; levels of competition; distance suppliers are willing to travel to find buyers)
3.3. Has it always been so easy?
3.4. If no, what has changed?
3.5. If no, when did it change?
3.6. Did the change in ease in obtaining production volumes occur for other as well? Why?
3.7. Do you anticipate that it will become easier or harder to obtain sufficient production for your mill/slaughterhouse in the future? Why?

4. Ease of selling production onward

4.1. Is it easy to sell your output onwards? (listen/probe for: market share of various buyers; existence of various export markets; levels of competition; requirements by multinational buyers)
4.2. Has it always been so easy/difficult?
4.3. If no, what has changed?
4.4. If no, when did it change?
4.5. Do you anticipate that it will become easier or harder to sell the output of your mill/slaughterhouse in the future? Why?

5. Assurance of supply base

5.1. Does your company normally seek out producers to buy from or do they seek you out?
5.2. If you seek: How do you choose the farmers you are buying from?

5.3. If you seek: How do you enter in contact with them?

5.4. If they seek: How does your company get farmers to sell to you and not your competitors? (listen/probe for: prices/money; other incentives (in-kind support, fair treatment, contract terms, access to credit); personal relationship with buyer (personal ties); distance to/ease of access to market; what neighbors do; values?)

5.5. [depending on explanation above, probe:] Do buyers in your region…

5.5.1. Have strong personal relationships with their suppliers?

- If yes: Does your company invest more in building these relationships with suppliers than other buyers in the region?
  - If no: why don't you use it as a way to attract suppliers?

5.5.2. Offer different prices for the same quality of product?

- If yes: does your company offer better prices than your competitors? Does this help you get farmers to sell to you?
  - If no: why don't you use it as a way to attract suppliers?

5.5.3. Ask for different types of quality? (fat cover/genetics/organic/humidity)

- If yes: does your company ask for higher or lower quality than your competitors? Does this help you get farmers to sell to you?

5.5.4. Provide credit to their suppliers?

- If yes: does your company you offer better rates than your competitors? Does this help you get farmers to sell to you?
  - If no: why don't you use it as a way to attract suppliers?

5.5.5. Offer other types of support to their suppliers (e.g. subsidized inputs, pick-up of cattle)? Does this help you get farmers to sell to you?

- If yes: do you offer higher support than your competitors?
  - If no: why don't you use it as a way to attract suppliers?

5.5.6. Provide different types of contracts/purchasing guarantees/are some buyers more reliable than others? (probe: payment terms/delays in payment)

- If yes: do you offer more favorable terms than your competitors?
  - If no: why don't you use it as a way to attract suppliers?

6. Commitment – how implement part 1: requirements

6.1. What do you require of farmers that sell commodities to you? What kinds of documents do you require?

6.2. What kinds of restrictions do you place on farmers that sell commodities to you? (listen for/probe: documents, certifications, behavior such as land clearance or fire…)

6.3. Why? Do you agree with them?

6.4. Do you accept production from farmers who have deforested parts of their property **legally**?

6.5. Is there a cut-off year that you use?

6.6. In your opinion, have such restrictions changed farmers' production and sales behaviors? (Listen/probe for: decrease of burning or deforestation; switch to other buyers, maybe in larger

distance; switch to other production; move away; lower profits; capital shortage; less enjoyment of production…)

6.7. How do you feel these restrictions have affected the farmers who sell to you in other ways? How so? (Listen/probe for: worse livelihoods; less enjoyment of production; worse relations in the value chain…)

6.8. In your opinion, have such restrictions changed the make-up of your supply base and your customer base?

6.9. In your opinion have such restrictions caused farmers to leave the region?

7. Commitment – how implement part 2: monitoring (do if ZDC or not, still interesting for legality)

7.1. How do you monitor/identify deforestation on your suppliers' properties? (Listen/probe for: use of geospatial data (coming from HQ?); government-provided data; third-party verifiers [certification], consultants; NGOs…)

7.2. How easy or challenging is it to monitor deforestation at the property level?

7.3. Since your commitment began, how many instances of (illegal) deforestation have you identified on your suppliers' properties?

8. Commitment – how implement part 3: enforcement

8.1. If you find your supplier is breaking the rules (deforestation, documentation or otherwise), what do you do?

8.2. If you exclude the producer, do you exclude them by property (CAR) or by producer (CPF)?

9. Commitment – how implement part 4: engagement with excluded farmers

9.1. Do you work with farmers who you have taken action against to help them become compliant?

9.2. If so how? Do you have a specific program to do so?

9.3. Does your company have any CSR activities locally? If so, are excluded farmers able to access these?

10. Public policy and civil society support

10.1. Do you engage in any collaborations with governmental actors (municipios?) or non-governmental entities to make the implementation of your supply chain policy easier? (Listen/probe for multi-stakeholder/jurisdictional processes)

10.1.1. If yes: How important is such support to the implementation of this policy? What elements are most helpful? Would you like to see even more cooperation in the future? In what areas?

10.1.2. If no: Do you think such support would make it easier to implement such a policy? How so?

10.2. How do legal restrictions limit your sourcing practices?

10.2.1. If yes: Do they influence your behavior or those of your suppliers? Why?

(listen/probe for: fear of conviction; fear of fine; norms e.g. "it's bad to break the law"; collective norm change - "everybody else is doing it too")

10.2.2. If yes: What do you perceive as more important in shaping your suppliers' behavior, the legal or the buyers' restrictions?

10.3. Are your company policies stricter, the same as, or less stringent than government policy?

10.4. (If less stringent) Does the fact that the government already has more stringent policies reduce the costs to you?

11. Intrinsic values and extrinsic norms

11.1. How would you characterize the attitudes of local farmers toward the environment and environmental conservation?

(listen/probe for: they don't care and just want to expand production; they feel protective of the forest; conservation is for lazy people; etc.)

11.2. Have farmer attitudes changed since you started applying purchasing restrictions?

11.3. Had attitudes already changed? Why? When?

(listen/probe for collective norm changes; social influence by peers or family members; education by buyers, …)

12. Opinion

12.1. How do you think your company's forest policy is affecting business?

(Listen/probe for: decrease of available supply; decrease (or increase?) of available quality; need to pay higher prices; need to offer higher incentives; need to go source from farmers…)

12.2. How do you think your company's forest policy is affecting your personal relationships with your suppliers?

12.3. [If they mentioned CSR/outreach activities]: How has the introduction of outreach activities influenced your operating costs?

12.4. Do you think that forest policies as a whole are benefitting or harming the soy/cattle sector of this region?

13. Closing

13.1. Looking forward, what would be your vision for agricultural production in this region be in the future?

13.2. Is there anything else you would like to mention that is relevant to the conversation we just had?

3.3 Indonesian palm oil: Intermediary (palm oil mill / trader)

1. Background

1.1. What is your name? [or fill in previously]
1.2. What is your position at your company? [or fill in previously]
1.3. Have you ever been interviewed as part in a research project?
1.4. How long have you been working in this industry?
1.5. How long have you been working at this company?
1.6. Male or female (just note down)

2. Company information

2.1. When did this facility open?
2.2. How much production can you process?
2.3. Who are your main buyers? (probe/follow-up: what sector are these companies in?)
2.4. Do you sell internationally?
2.5. If so, which countries?

3. Ease of finding suppliers

3.1. Is your mill at capacity?
3.2. Is it easy to obtain the production you need/want? (listen/probe for: market share of various buyers; levels of competition; distance suppliers are willing to travel to find buyers)
3.3. Has it always been so easy?
3.4. If no, what has changed?
3.5. If no, when did it change?
3.6. Did the change in ease in obtaining production volumes occur for other as well? Why?
3.7. Do you anticipate that it will become easier or harder to obtain sufficient production for your mill in the future? Why?

4. Ease of selling production onward

4.1. Is it easy to sell your output onwards? (listen/probe for: market share of various buyers; existence of various export markets; levels of competition; requirements by multinational buyers)
4.2. Has it always been so easy/difficult?
4.3. If no, what has changed?
4.4. If no, when did it change?
4.5. Do you anticipate that it will become easier or harder to sell the output of your mill/slaughterhouse in the future? Why?

5. Assurance of supply base

5.1. Does your company normally seek out producers to buy from or do they seek you out?

5.2. If you seek: How do you choose the farmers you are buying from?

5.3. If you seek: How do you enter in contact with them?

5.4. If they seek: How does your company get farmers to sell to you and not your competitors? (listen/probe for: prices/money; other incentives (in-kind support, fair treatment, contract terms, access to credit); personal relationship with buyer (personal ties); distance to/ease of access to market; what neighbors do; values?)

5.5. [depending on explanation above, probe:] Do buyers in your region…

5.5.1. Have strong personal relationships with their suppliers?

- If yes: Does your company invest more in building these relationships with suppliers than other buyers in the region?
  - If no: why don't you use it as a way to attract suppliers?

5.5.2. Offer different prices for the same quality of product?

- If yes: does your company offer better prices than your competitors? Does this help you get farmers to sell to you?
  - If no: why don't you use it as a way to attract suppliers?

5.5.3. Ask for different types of quality? (fat cover/genetics/organic/humidity)

- If yes: does your company ask for higher or lower quality than your competitors? Does this help you get farmers to sell to you?

5.5.4. Provide credit to their suppliers?

- If yes: does your company you offer better rates than your competitors? Does this help you get farmers to sell to you?
  - If no: why don't you use it as a way to attract suppliers?

5.5.5. Offer other types of support to their suppliers (e.g. subsidized inputs, pick-up of cattle)? Does this help you get farmers to sell to you?

- If yes: do you offer higher support than your competitors?
  - If no: why don't you use it as a way to attract suppliers?

5.5.6. Provide different types of contracts/purchasing guarantees/are some buyers more reliable than others? (probe: payment terms/delays in payment)

- If yes: do you offer more favorable terms than your competitors?
  - If no: why don't you use it as a way to attract suppliers?

6. Commitment – how implement part 1: requirements

6.1. What do you require of farmers that sell commodities to you? What kinds of documents do you require?

6.2. What kinds of restrictions do you place on farmers that sell commodities to you? (listen for/probe: documents, certifications, behavior such as land clearance or fire…)

6.3. Do you accept production from farmers who have deforested parts of their property **legally**?

6.4. Is there a cut-off year that you use?

6.5. In your opinion, have such restrictions changed farmers' production and sales behaviors? (Listen/probe for: decrease of burning or deforestation; switch to other buyers, maybe in larger

distance; switch to other production; move away; lower profits; capital shortage; less enjoyment of production…)

6.6. How do you feel these restrictions have affected the farmers who sell to you in other ways? How so? (Listen/probe for: worse livelihoods; less enjoyment of production; worse relations in the value chain…)

6.7. In your opinion, have such restrictions changed the make-up of your supply base and your customer base?

6.8. In your opinion have such restrictions caused farmers to leave the region?

7. Commitment – how implement part 2: monitoring (do if ZDC or not, still interesting for legality)

7.1. How do you monitor/identify deforestation on your suppliers' properties? (Listen/probe for: use of geospatial data (coming from HQ?); government-provided data; third-party verifiers [certification], consultants; NGOs…)

7.2. How easy or challenging is it to monitor deforestation at the property level?

7.3. Since your commitment began, how many instances of (illegal) deforestation have you identified on your suppliers' properties?

8. Commitment – how implement part 3: enforcement

8.1. If you find your supplier is breaking the rules (deforestation, documentation or otherwise), what do you do?

9. Commitment – how implement part 4: engagement with excluded farmers

9.1. Do you work with farmers who you have taken action against to help them become compliant?

9.2. If so how? Do you have a specific program to do so?

9.3. Does your company have any CSR activities locally? If so, are excluded farmers able to access these?

10. Public policy and civil society support

10.1. Do you engage in any collaborations with governmental actors or non-governmental entities to make the implementation of your supply chain policy easier? (Listen/probe for multi-stakeholder/jurisdictional processes)

10.1.1. If yes: How important is such support to the implementation of this policy? What elements are most helpful? Would you like to see even more cooperation in the future? In what areas?

10.1.2. If no: Do you think such support would make it easier to implement such a policy? How so?

10.2. How do legal restrictions limit your sourcing practices?

10.2.1. If yes: Do they influence your behavior or those of your suppliers? Why? (listen/probe for: fear of conviction; fear of fine; norms e.g. "it's bad to break the law"; collective norm change - "everybody else is doing it too")

10.2.2. If yes: What do you perceive as more important in shaping your suppliers' behavior, the legal or the buyers' restrictions?

10.3. Are your company policies stricter, the same as, or less stringent than government policy?

10.4. (If less stringent) Does the fact that the government already has more stringent policies reduce the costs to you?

11. Intrinsic values and extrinsic norms

11.1. How would you characterize the attitudes of local farmers toward the environment and environmental conservation?

(listen/probe for: they don't care and just want to expand production; they feel protective of the forest; conservation is for lazy people; etc.)

11.2. Have farmer attitudes changed since you started applying purchasing restrictions?

11.3. Had attitudes already changed? Why? When?

(listen/probe for: collective norm changes; social influence by peers or family members; education by buyers, …)

12. Opinion

12.1. How do you think your company's forest policy is affecting business?

(Listen/probe for: decrease of available supply; decrease (or increase?) of available quality; need to pay higher prices; need to offer higher incentives; need to go source from farmers…)

12.2. How do you think your company's forest policy is affecting your personal relationships with your suppliers?

12.3. [If they mentioned CSR/outreach activities]: How has the introduction of outreach activities influenced your operating costs?

12.4. Do you think that forest policies as a whole are benefitting or harming the soy/cattle sector of this region?

13. Closing

13.1. Looking forward, what would be your vision for agricultural production in this region be in the future?

13.2. Is there anything else you would like to mention that is relevant to the conversation we just had?

3.4 Indonesian palm oil: Producer (grower / farmer)

1. Background

1.1. What is your name?

1.2. How old are you?

1.3. Where did you grow up?

1.3.1. If not local area: Why did you move here?

1.4. Have you ever participated in a research project before?

1.5. How long have you been working in farming?

1.6. How long have you had this farm?

1.7. Male or female (just note down)

1.8. What is your religion?

1.9. How many properties do you have?

1.10. For each property: (make sure to note if some properties cattle is raised to be sent to another farm owned by same person)

Name	Muni/UF	Area	Produce	Who do you sell to?

2. Ease of finding sellers

2.1. Is it easy to find a buyer for your production?

(listen/probe for: market share of various buyers; levels of competition among buyers; distance willing to travel to find buyers)

2.2. Has it always been so easy/difficult (depending on answer above)?

2.2.1. If no, what has changed? -> if they mention ZDCs here, jump right to Q 5 to avoid duplications

2.2.2. When did it change?

2.2.3. And why?

2.2.4. How did you react to these changes?

(listen/probe for: adjustment to market requirements re: compliance, quality, legality; expand distance willing to travel; expand into other types of production)

2.3. Do you anticipate that it will become easier or harder to find a buyer for your production in the future? Why?

3. **Choice of buyer**

3.1. Why did you choose to sell to the buyers that you are currently selling to?

(listen/probe for: prices/money; other incentives (in-kind support, fair treatment, contract terms, access to credit); relationship with buyer (personal ties); distance to/ease of access to market; what neighbors do; norms, habits, values, what heuristics do they use)

3.2. [depending on explanation above, probe:] Do you have a close personal relationship with any of the buyers?

3.3. Do the buyers in your region…

3.3.1. Offer different prices for the same quality of product?

- If yes: does your buyer offer better prices than competitors?

3.3.2. Ask for different types of quality?

- If yes: does your buyer ask for higher or lower quality than competitors?

3.3.3. Provide credit to their suppliers?

- If yes: does your buyer offer better rates than competitors?

3.3.4. Offer other types of support to their suppliers (e.g. subsidized inputs, pick-up of cattle)?

- If yes: does your buyer offer higher support than competitors?

3.3.5. Provide different types of contracts/purchasing guarantees/are some buyers more reliable than others?

- If yes: is your buyer more reliable than competitors?

If no to any of the above: why don't you sell to others?

4. Commitment – requirement awareness/ satisfaction

4.1. Do buyers in your region have any requirements or place any kinds of restrictions on the types of products you can sell to them? What are they?

4.2. Are there any differences between buyers?

4.3. Has this changed over time? If so, when?

4.4. Do you sell to such buyers?

- If yes: Why do you accept such restrictions to keep selling to them?
- If yes: Has it been difficult to adapt to such restrictions? Why?
- If yes: What would need to change to make it easier to adapt to such restrictions?
- If yes: Would you say that such restrictions are an economic opportunity for you?
- If yes: Do you make more money with your current buyer than with others?
- If yes: Do you agree with such criteria?

- If no: Why don't you sell to such buyers?
- If no: What would need to change for you to sell to such buyers?
- If no: Has the introduction of these restrictions affected your ability to sell your product under advantageous conditions?
- If no: Do you feel excluded or marginalized by such restrictions?
- If no: Do you disagree with such criteria? Do you think they are fair?

4.5. Do many people in your social circle sell to such buyers?

4.5.1. Why do you think this is so? How did that happen?

4.5.2. Did that change how they produce?

4.5.3. Would you say anything else changed after they started selling to them?

4.6. In your opinion, have such restrictions changed farmers' production and sales behaviors? How so? (Listen/probe for: decrease of burning or deforestation; switch to other buyers, maybe in larger distance; switch to other production; move away; lower profits; capital shortage; …)

4.7. Have such restrictions changed farmers' in other ways? How so? (Listen/probe for: worse livelihoods; less enjoyment of production; worse relations in the value chain…)

4.8. In your opinion have such restrictions caused farmers to leave the region?

5. [if they sell to buyers with restrictions:] Commitment – monitoring and enforcement

5.1. Has your property ever been inspected by a buyer? Have you heard of others who have been inspected?

- If yes to either: When, by whom and how often?
- If yes to either: Did this have an effect on your behavior/farming practices or (if inspected directly) your ability to sell your product?
- If no: Do you think it is likely that you will be inspected in the future? Does this affect your behavior/farming practices?

5.2. Have you ever been prevented from selling your production due to a lack of documentation or due to other restrictions (as discussed above)?

- If yes: What did you do?
- If yes: Where there options the company offered to help you achieve documentation (or fulfill other requirements)?
- If no: Do you think it is likely that you will be prevented from selling in the future? Does this affect your behavior/farming practices?

5.3. Do you have any other agreement with your buyers that you did not mention yet? For how long has it been so? If it changed, why did it change?

6. Public policy support

6.1. Have you received support by the government to fulfill the requirements of your buyer?

- If yes: How important was such support to your participation?
- If no: Do you think such support would have made it easier/convinced you to participate?

6.2. Are the government forest policies stricter, the same as, or less stringent the company policies?

- Which one has a greater effect on your decisions? Why?

(listen/probe for: fear of conviction; fear of fine; norms e.g. "it's bad to break the law"; collective norm change - "everybody else is doing it too")

7. Closing:

7.1. Looking forward, what would be your vision for your farm in the next ten years?

7.2. Is there anything else you would like to mention that is relevant to the conversation we just had?

3.5 Indonesian palm oil: Government official / NGO / producer association

1. Background

1.1. What is your name? [or fill in previously]

1.2. What organization do you work at? [or fill in previously]

1.3. What is your position at your office? [or fill in previously]

1.4. How long have you been working at this office?

1.5. Male or female (just note down)

2. Assessment of ZDC existence and incentivization

2.1. On the basis of your organization's research and perspective, please describe your impression of the current state of ZDC implementation. I am particularly interested in the types of strategies that companies use to fulfill their commitments, as well as challenges and best practices to overcome such challenges on the ground, and future trends in this area. (listen for/probe: RSPO (identity preserved, segregated, P&C 2018), sourcing codes, jurisdictional approaches, within-supply chain versus sectoral initiatives)

2.2. [Are you aware of sourcing companies in this region that have requirements of farmers that sell palm oil FFBs to them? What kinds of documents do they usually ask for? (listen for/probe: documents, certifications

2.3. Are you aware of sourcing companies in this region that have restrictions on farmers that sell palm oil FFBs to them? What kinds of restrictions (listen for/probe: land clearance, fire…)]

2.4. In your opinion, have such restrictions changed farmers' production and sales behaviors? (Listen/probe for: decrease of burning or deforestation; switch to other buyers, maybe in larger distance; switch to other production; move away; lower profits; capital shortage; less enjoyment of production…)

2.5. Do you think that these restrictions have affected the farmers in other ways? How so? (Listen/probe for: worse livelihoods; less enjoyment of production; worse relations in the value chain…)

2.6. If compliance is mentioned: In your opinion, why do farmers sell to committed companies rather than non-committed ones?

(listen/probe for: prices/money; other incentives (in-kind support, fair treatment, contract terms, access to credit); relationship with buyer (personal ties); distance to/ease of access to market; what neighbors do; values?)

2.7. What do you think farmers most care about when choosing a palm oil buyer? Can you think of incentives that would make farmers more likely to sell to committed companies?

2.8. In your opinion, have such restrictions changed the make-up of companies' supply base or their economic situation? How so? In your opinion, have such restrictions caused farmers to leave the region?

(Listen/probe for: decrease of available supply; decrease (or increase?) of available quality; need to pay higher prices; need to offer higher incentives; need to go source from farmers…)

3. Assessment of ZDC monitoring and enforcement

3.1. To the best of your knowledge, do sourcing companies monitor deforestation on their suppliers' properties? How? Do you think they monitor too little or too much?

(Listen/probe for: use of geospatial data (coming from HQ?); government-provided data; third-party verifiers [certification], consultants; NGOs…)

3.2. To the best of your knowledge, how do sourcing companies react when they find deforestation on their suppliers' properties?

(Listen/probe for: exclude; engage; exclude then engage; no reaction; …)

3.3. In your opinion, are these measures adequate? Are there better ways in which companies could react?

4. Assessment of credibility of ZDCs

4.1. In your opinion, are corporate commitments useful tools to make the sector more sustainable? How does your organization react to the non-achievement of commitments?

5. Public policy/civil society support

5.1. Does your organization engage in any collaborations with supply chain actors to make the implementation of their supply chain policy easier?

5.1.1. If yes: How important is such support to the implementation of this policy? What elements are most helpful? Would you like to see even more cooperation in the future? In what areas?

5.1.2. If no: Why not? Do you think such support would make it easier to implement such a policy? How so?

5.2. Are you aware of any legal restrictions that limit the behavior of companies or that of their suppliers? Which ones? [adapt this question depending on the person asked/assumed level of knowledge]

5.2.1. If yes: In your opinion, do they influence the behavior or companies or their suppliers? Why?

(listen/probe for: fear of conviction; fear of fine; norms e.g. "it's bad to break the law"; collective norm change - "everybody else is doing it too")

5.2.2. If yes: What do you perceive as more important in shaping producers' behavior, the legal or the buyers' restrictions?

6. Intrinsic values and extrinsic norms

6.1. How would you characterize the attitudes of local farmers toward the environment and environmental conservation?

(listen/probe for: they don't care and just want to expand production; they feel protective of the forest; conservation is for lazy people; etc.)

6.2. Have farmer attitudes changed since companies started applying purchasing restrictions?

6.3. Had attitudes already changed? Why? When?

(listen/probe for: collective norm changes; social influence by peers or family members; education by buyers, …)

7. Opinion

7.1. How do you think companies' forest policies are affecting the palm oil sector of this region? How are they affecting the regional economy as a whole?

7.2. How do you think companies' forest policies are affecting the environment in the region?

7.3. If you could change something about companies' forest policies, what would it be?

8. Closing:

8.1. Looking forward, what would be your vision for agricultural production in this region be in the future?

8.2. Is there anything else you would like to mention that is relevant to the conversation we just had?

8.3. Is there anybody else you would recommend that I talk to about these questions?

8.4. Possibility to access data/information that we talked about?

3.6 Indonesian palm oil: Focus Group Discussion (FGD) guide

Introductory questions – forest, community values, norms, and cultures

On forests and land use motivations and behaviors:

1. What is on your mind when you think about forests?
2. How does the forest impact your community's well-being? [spiritual or religious belief, cultural [adat or customary land], basic needs [fresh air, water, food, alternative livelihood], disaster prevention, etc.)
3. Are there any community rules or beliefs related to forests and how forests are used?

Transitioning to ZDCs:

4. A word or image that comes into your mind when you think about private (or company)-led sustainable initiatives in the palm oil sector?

On sustainability initiatives:

5. Can you tell us briefly about your or your group's experiences with any sustainable initiatives introduced or initiated by companies in the palm oil sector in the past 5 years?
    a. Can you identify the companies or mill companies that are linked to the initiative you or your group have participated in the past 5 years?

On restrictions and rules:

6. Can you tell us briefly about your or your group's experiences with any restrictions or rules introduced by private companies (or mills or your buyers) in the past 5 years?
    a. What are the restrictions or rules that affect you or your group?
    b. Can you identify the companies or mill companies that are linked to restrictions or rules you or your group have been affected by in the past 5 years?
7. What motivates you or your community to involve in any sustainable initiatives or compliance? [can be financial, environmental (water, disaster, climate change), etc.]
8. Do you have any community rules/expectations about the sustainability of community members' practices?

Key questions 1 – IF the participants have experience or are knowledgeable in ZDCs, otherwise move to 'key questions 2'

On policy preparation and adoption:

1. What were the most important issues that you encountered in regards to the private-led sustainability initiatives?
2. What were the most important issues that your group encountered in regards to the private-led sustainability initiatives? [1]
3. What were the main challenges that you or your group encountered when being affected by the restrictions or rules introduced by the companies?

[1] Pay attention to exclusion issues, if there was any group members who could not participate in the initiatives.

4. What are the supports or options or alternatives (if any) available for you or your group in order to solve the issues ? please explain.
    a. What were the constraints you face when trying to obtain such supports or alternatives?

Key questions 2 – IF the participants have NO experience or are NOT knowledgeable in ZDCs, otherwise skip.

[moderator will then provide a hypothetical case]

5. Imagine that there is a sustainability initiative introduced by a company in your district. This initiative may provide benefits for you. However, whether or not you will be part of the initiative is unclear. In this situation, what would be the most important things the company should consider to make sure that the initiative is inclusive to you and your community?
6. Imagine that there are some rules and restrictions introduced by a company in your district. This rules and restrictions may provide benefits for you, however, may also become a challenge for you. The challenge, for example, if your plot does not have clear land title, or located in the forest, then you will be imposed with some restrictions. In this situation, what would be the most important things the company should consider when applying this restrictions or rules to you and your community?

Key questions – all participants

On policy improvements (operationalization, monitoring, and enforcement):

7. How do you think those issues and barriers you or your community (may) face can be solved?
8. What do you think can be done to improve the existing initiatives, restrictions, or rules? (possible answers: facilitation, trainings, subsidies, so on)
9. What are the supports or alternatives that can improve your or your group's access to involve in sustainability initiatives or compliance?
10. Are there any mechanisms or procedures from the companies that could help you voice your opinions, issues, or suggestions? Please explain.
11. What do you think can be done by the companies to better integrate you and your community in sustainable initiatives and compliance? [expectations]
12. What do you think can be done by the companies to improve the reporting mechanisms?

Closing questions

13. Is there anything else that anyone feels that we should have talked about but didn't?

4. West African cocoa: Côte d'Ivoire interview guides

4.1 West African cocoa: Côte d'Ivoire: Manufacturer

1. Cocoa trade and the cocoa value chain

1.1. Please could you describe how your company sources its cocoa?

1.2. Who are your company's main suppliers (companies) and how are they selected?

1.3. How does your company select what cooperatives / communities it sources from?

1.4. What specific requirements does your company place on suppliers that sell it cocoa?

1.5. Thinking specifically about your company's sustainability programme:

1.5.1. What mechanism (e.g., certification, own programme, or combination) does your company use to implement the programme?

1.5.2. What proportion of your company's total sourcing in Côte d'Ivoire is accounted for by each mechanism?

1.5.3. How is sourcing through these mechanisms verified or audited?

1.5.4. What role do your suppliers play in implementing your sustainability programme?

1.5.5. How are premiums delivered to cooperatives and farmers?

2. Implementation of your company's FSP initiatives

2.1. Please could you name the specific sustainability projects your company is implementing?

Zero deforestation

2.2. We now want to ask you about activities to ensure ZD in your company's supply chain:

2.2.1. How are farms mapped in practice (who does the mapping)? How is cooperative membership turnover managed, and how are farmers retained in the programme?

2.2.2. What do the deforestation risk assessments involve and how are they done in practice?

2.2.3. How is traceability achieved?

2.2.4. How are activities for forest protection and restoration by communities / community-based natural resource management (CBNRM) managed?

2.2.5. How are community sensitization activities rolled out, and by whom?

2.3. What happens to farmers who are found to have farms in protected areas? Does this vary across different categorisations of forêts classées?

2.3.1. Are farmers ever excluded from your supply chain? How often does this happen?

2.3.2. What remedial action do you take with these farmers, if any?

2.4. In your opinion, how likely are all these activities to achieve ZD in your supply chain?

2.5. Do you perceive any tensions between the effectiveness of these activities to achieve ZD and farmers' livelihoods? If so, what are these tensions and how can they be resolved?

Agroforestry

2.6. What challenges prevent your agroforestry activities (e.g., nursery management, seedling distribution, GAP training) leading to shade tree adoption by farmers?

2.7. How do tree and land ownership in Côte d'Ivoire affect the implementation of your agroforestry activities? What is your company doing to address these problems?

2.8. Please could you explain how your payments for ecosystem services (PES) scheme works? Probe on criteria; payment sizes; how financed; duration; frequency; permanence; leakage

3. Engagement with other public, private and civil society stakeholders, and communities

3.1. Please can you describe how your company is involved with landscape approaches?

3.1.1. Which organizations are leading these landscape approaches?

3.1.2. What role is the government playing in these initiatives?

3.2. How does existing legislation and law enforcement in Cote d'Ivoire support or hinder the implementation of ZD activities?

3.2.1. How will ZD activities be affected by incoming EU due diligence legislation?

3.2.2. How are sustainable supply chain initiatives linked to the national REDD+ strategy?

3.2.3. How does land tenure in Côte d'Ivoire influence companies' ability to achieve ZD?

3.3. How have communities been involved with designing and implementing your company's programme?

4. Systemic challenges

4.1. Thinking broadly about the cocoa sector in Cote d'Ivoire as a whole, what problems are preventing it from transforming to a more sustainable model?

If not mentioned:

4.1.1. Where, or with whom, does the power to address these challenges reside?

Probe on locus of power in the cocoa value chain

4.2. How has the CFI changed efforts to achieve sustainability in the cocoa sector?

4.2 West African cocoa: Côte d'Ivoire: Trader

1. Cocoa trade and the cocoa value chain

1.1. Please could you describe how your company sources its cocoa?

1.2. Which organizations or individuals are your company's main suppliers?

1.3. How does your company select which cooperatives, traitants, and communities it sources from?

1.4. What specific requirements does your company place on suppliers that sell it cocoa?

1.5. Thinking specifically about your company's sustainability programme or initiatives:

1.5.1. What mechanism (e.g., certification, own programme, or combination) does your company use to implement its programme in Côte d'Ivoire?

1.5.2. What proportion of your company's sourcing in Côte d'Ivoire is accounted for by each mechanism?

1.5.3. How is sourcing through these mechanisms verified or audited?

1.5.4. What role do your suppliers play in implementing your sustainability programme? Probe on cooperatives and traitants

1.5.5. How are premiums delivered to cooperatives and farmers?

2. Implementation of your company's FSP initiatives

2.1. Please could you name any specific sustainability projects your company is implementing?

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2.2. We now want to ask you about activities to ensure ZD in your company's supply chain:

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2.2.4. How are activities for forest protection and restoration by communities / community-based natural resource management (CBNRM) managed?

2.2.5. How are community sensitization activities rolled out, and by whom?

2.3. What happens to farmers who are found to have farms in protected areas? Does this vary across different categorisations of forêts classées?

2.3.1. Are farmers ever excluded from your supply chain? How often does this happen?

2.3.2. What remedial action do you take with these farmers, if any?

2.4. In your opinion, how likely are all these activities to achieve ZD in your supply chain?

2.5. Do you perceive any tensions between the effectiveness of these activities to achieve ZD and farmers' livelihoods? If so, what are these tensions and how can they be resolved?

Agroforestry

2.6. What challenges prevent your agroforestry activities (e.g., nursery management, seedling distribution, GAP training) leading to shade tree adoption by farmers?

2.7. How do tree and land ownership in Côte d'Ivoire affect the implementation of your agroforestry activities? What is your company doing to address these problems?

2.8. Please could you explain how your payments for ecosystem services (PES) scheme works?
Probe on criteria; payment sizes; how financed; duration; frequency; permanence; leakage

3. Engagement with other public, private and civil society stakeholders, and communities

3.1. Please can you describe how your company is involved with landscape approaches?

3.1.1. Which organizations are leading these landscape approaches?

3.1.2. What role is the government playing in these initiatives?

3.2. How does existing legislation and law enforcement in Cote d'Ivoire support or hinder the implementation of ZD activities?

3.2.1. How will ZD activities be affected by incoming EU due diligence legislation?

3.2.2. How are sustainable supply chain initiatives linked to the national REDD+ strategy?

3.2.3. How does land tenure in Côte d'Ivoire influence companies' ability to achieve ZD?

3.3. How have communities been involved with designing and implementing your company's programme?

4. Systemic challenges

4.1. Thinking broadly about the cocoa sector in Cote d'Ivoire as a whole, what problems are preventing it from transforming to a more sustainable model?

If not mentioned:

4.1.1. Where, or with whom, does the power to address these challenges reside?

Probe on locus of power in the cocoa value chain

4.2. How has the CFI changed efforts to achieve sustainability in the cocoa sector?

4.3 West African cocoa: Côte d'Ivoire: Cooperative

1. Local organizational role (if member of local org.: coop, etc.)

1.1. Please could you describe how the cooperative set up and how it is governed?

1.2. How many members are there in your cooperative? Does it change from year to year? If so, by how many members does it change, on average?

2. Cocoa trade and engagement with the cocoa value chain

2.1. Please could you explain how you purchase cocoa beans?

2.1.1. Do you purchase from your members only, or also from pisteurs? In what proportions?

2.1.2. How do farmers get paid?

Probe on "Déchargé / Payé" or "Dépôt / Vente"

2.1.3. What other incentives (e.g. premiums) are farmers offered and how are these distributed?

Probe on: differential prices; cash premiums (LID, certification premium, others); in-kind benefits; off-season credit; agricultural inputs; extension services; training; contracts.

2.1.4. What requirements do you make for beans, and farmers that sell beans to you, and why?

2.2. Please could you explain how you sell cocoa beans to your customers?

2.2.1. Which companies are your main customers? Do you segregate beans by customer?

2.2.2. Why do you sell to these companies rather than any others?

2.2.3. Does your cooperative encounter any challenges with selling cocoa to its customers?

Probe on challenges with offloading cocoa beans at ports

3. Knowledge about FSP initiatives by companies

3.1. What specific requirements or restrictions, if any, do cocoa buyers in this region place on farmers they buy beans from? That is, **what do cocoa buyers check for** before they buy beans?

Probe for requirements other than bean quality or dryness, such as mapping / certification / audits

3.1.1. Are you aware that any buyers check to make sure cocoa has **not come from farms in the forêts classées**? If so, what do these checks involve?

3.1.2. How do these checks positively or negatively affect farmers?

3.1.3. Are there any differences in requirements between certification (e.g. Rainforest Alliance) and companies' own standards?

3.2. What are the legal regulations that farmers must follow in relation to cocoa production and sustainable forest management? How are they applied? Is it effective? Is it fair?

3.3. What happens to farmers with cocoa **farms in the forêts classées**? What do you think about what happens to these farmers?

3.4. What support have companies provided for cocoa farmers in this area?

Probe on training / alternative livelihoods / seedling distribution / extension services

3.4.1. How has your cooperative been involved with developing and delivering these activities?

3.4.2. Which farmers are eligible and why do they choose to participate in these projects?

3.4.3. What support or activities have other organizations (ANADER, NGOs) provided to cocoa farmers in this region?

3.5. Please can you describe any activities by companies that encourage farmers to do agroforestry / plant shade trees on their farms?

3.5.1. How has your cooperatives been involved with developing and delivering these activities?

3.5.2. What challenges are there with implementing these activities?

Probe on **ownership of trees**; types of trees; availability of seedlings; products from trees

3.6. How have all these activities changed the way cocoa farming is done?

4. Systemic challenges

4.1. Thinking broadly about the cocoa sector in Cote d'Ivoire as a whole, what three challenges are preventing it from transforming to a more sustainable model?

4.2. What challenges does land ownership pose for farmers here?

4.3. How can these challenges be addressed?

4.4. Thinking more broadly, what issues are preventing the farmers from achieving a secure livelihood from cocoa farming?

4.4.1. Who has the power to address these challenges?

4.4 West African cocoa: Côte d'Ivoire: Local stakeholder (farmer/pisteur/coop delegate)

1. Background

1.1. What is your name? (If not yet recorded)

1.2. How old are you?

1.3. Where did you grow up? (If not from the local area) Why did you move here?

1.4. What is your ethnicity?

1.5. Are you a cocoa farmer?

1.5.1. (If yes) How long have you been working in cocoa farming?
1.5.2. (If yes) Do you own your farm? (If yes) How long have you owned it?
1.5.3. (If yes) How big is your farm / the farm where you work? How many plots does it have?
1.5.4. (If yes) Where is your farm? Where is each plot?

1.6. Please could you describe any role(s) you have in the community besides cocoa farming (e.g., local official, pisteur, member of other community organization)?

1.6.1. (If yes) What activities does this role involve you doing?

2. Local organizational role (if member of local org.: coop, local government, etc.)

2.1. (If a member of an organization) What functions does [name institution] perform in the community? If unclear: What specific activities does [name organization] perform?

2.2. Please could you describe the governance structure of [name organization]?

2.3. When was this organization set up?

2.4. What other local institutions are involved with cocoa farming here (e.g., cooperatives)?

3. Cocoa trade and engagement with the cocoa value chain

Cocoa selling

3.1. For cooperative delegates / pisteurs / traitants: Please could you explain how farmers sell cocoa beans to you?

3.2. For farmers: Who do you sell your beans to?

3.2.1. Do you sell your beans to one buyer or multiple buyers in a season? Why?
3.2.2. Are there any other companies, cooperatives or pisteurs that buy cocoa here? Who are they?

3.3. Why do you / farmers here sell cocoa beans to one buyer rather than another?

Probe on: differential prices; cash premiums (LID, certification premium, others); in-kind benefits; off-season credit; agricultural inputs; extension services; training; contracts.

3.4. How are premiums given to farmers (i.e., at community level / to individual farmers)?

3.5. How easy or difficult is it for you / cocoa farmers here to sell their cocoa beans?

Cocoa purchasing (For pisteurs, traitants, or other cocoa-purchasing entities only)

3.6. For pisteurs / traitants: Which farmers do you buy cocoa from and why?

3.7. For cooperative delegates:

3.7.1. How many members are there in your cooperative? Does this number change from year to year? If so, by how many members does it change, on average?
3.7.2. Why are some farmers members of your cooperative but not others?
3.7.3. Why does your cooperative sell to some companies rather than others?

3.8. What requirements do you make for beans, and farmers that sell beans to you, and why?

3.9. How easy or difficult is it to buy cocoa? How easy is it to meet your purchasing targets? Has this changed?]

4. Knowledge about FSP initiatives by companies

4.1. What specific requirements or restrictions, if any, do cocoa buyers in this region place on farmers they buy beans from? That is, **what do cocoa buyers check for** before they buy beans? Probe for requirements other than bean quality or dryness, such as certification / audits

4.1.1. Are you aware that any buyers check to make sure cocoa has **not come from farms in the forêts classées**? If so, what do these checks involve?
4.1.2. How do these checks **positively or negatively affect farmers**?
4.1.3. What do you perceive as being **more important** in shaping how farmers here manage their cocoa farms: **legal regulations or buyers' checks/requirements**?

4.2. What happens to farmers with cocoa **farms in the forêts classées**?

4.2.1. **How** are their farms **discovered** by cocoa buyers?
4.2.2. **How** do farmers in the forêts classées **sell their beans** and **to whom**?
4.2.3. What do you think about what happens to these farmers?

4.3. If cocoa farmers were to plant cocoa in the forêts classées, how would they do it?

4.3.1. Where would they go?
4.3.2. On average, how far would people travel from the village to establish a cocoa farm?
4.3.3. How would they make the farm? That is, how would they remove the forest trees?

4.4. How do people here view cocoa farming in the forêts classées? How acceptable or unacceptable is it?

4.5. What support have companies provided for cocoa farmers in this area?

Probe on training / alternative livelihoods / seedling distribution / extension services

4.5.1. How have communities / cooperatives been involved in each step of these activities, from inception to implementation?
4.5.2. Why do cocoa farmers in this area choose to participate in these projects?

4.6. Please can you describe any activities by companies that encourage farmers to do agroforestry / plant shade trees on their farms?

4.6.1. What makes you / farmers here decide to plant shade trees on their farms, or not?
Probe on **ownership of trees**; types of trees; availability of seedlings; products from trees
4.6.2. Why would you keep shade trees on your farm or not?

4.7. How have all these activities changed the way cocoa farming is done?

5. Systemic challenges

5.1. What are (three) major challenges cocoa farmers face in this area?

5.2. What challenges does land ownership pose for farmers here?

5.3. How can these challenges be addressed?

5.4. Thinking more broadly, what issues are preventing the farmers from achieving a secure livelihood from cocoa farming?

5.4.1. Who has the power to address these challenges?

4.5 West African cocoa: Côte d'Ivoire: NGO

1. Background

1.1. Please could you briefly describe your role at this organization, and what it involves?

2. Your civil society organization's activities to promote a more sustainable cocoa sector

2.1. Please can you describe the sustainability initiatives your civil society organisation is involved with implementing or supporting (advising or advocating) in the cocoa sector?

Probe on partners, locations, sizes, and forest conservation / agroforestry

2.2. Please could you describe, in your own words, your organization's goals for these initiatives?

If not mentioned:

2.3. Do you work with companies on forest sustainability issues and, if so, how?

3. Views on deforestation and implementation of FSP initiatives by companies

3.1. What is your perception of **the effectiveness of zero deforestation** commitments adopted by companies in the cocoa sector more generally? In your opinion, how likely are these activities to reduce deforestation?

3.1.1. What is the effectiveness of, and challenges with, farm mapping and traceability?

3.1.2. What is the effectiveness of, and challenges with, monitoring deforestation (remote sensing and community monitoring)?

3.1.3. What is the effectiveness of, and challenges with, sensitization and capacity building?

3.2. Do you perceive any (potential) **tensions** between the effectiveness of companies' ZDCs and their impacts on farmers' livelihoods? If so, what are they? (How have companies' zero deforestation commitments positively or negatively affected farmers' livelihoods?)

3.2.1. Are you aware of farmers being **excluded** from supply chains due to non-compliance?

3.2.2. How do you anticipate this will **change in the future**?

3.2.3. How can these tensions be **reconciled?**

3.3. How can, or should, ZD policy be differentiated across different forest zones and the rural domain (e.g., classified forests vs reserves; how is "deforestation" defined)?

Agroforestry:

3.4. What challenges are preventing the effective adoption of agroforestry by farmers?

3.5. How does the ownership of trees in Côte d'Ivoire affect the implementation of these agroforestry activities? What is your organization doing to solve these problems?

3.6. Are you aware of any payments for ecosystem services (PES) being made to farmers as part of any agroforestry schemes? Probe on criteria; payment sizes; financing; duration; frequency; permanence; leakage

4. Engagement between public, private and civil society stakeholders, and communities

4.1. How is the Ivorian government supporting companies to implement ZDCs effectively?

4.1.1. How is the national REDD+ strategy supporting the implementation of ZDCs?

4.1.2. How does land tenure in Côte d'Ivoire influence companies' ability to achieve ZD?

4.1.3. How does existing legislation and law enforcement support or hinder ZDC implementation?

4.1.4. How is this related to incoming EU due diligence legislation?

4.1.5. How are landscape approaches supporting the implementation of ZDCs?

Participation by local stakeholders

4.2. To the best of your knowledge, how have communities been involved with developing and implementing zero deforestation or agroforestry activities?

4.3. Are you aware of how local government, civil society or other organizations are involved with implementing these various activities? Probe on cooperatives, other institutions

4. Deforestation drivers and systemic challenges

4.1. Thinking broadly about the cocoa sector in Cote d'Ivoire as a whole, and worldwide, what challenges are preventing it from transforming to a more sustainable model?

If not mentioned:

4.1.1. Where, or with whom, does the power to address these challenges reside?

Probe on locus of power in the cocoa value chain

4.1.2. Are there any other ways these challenges can be addressed?

4.2. Now thinking just about your organization, what are (three) day-to-day challenges that make the implementation of your sustainability initiative difficult?

If not mentioned:

4.2.1. How can these challenges be addressed?

4.2.2. What is your organization doing specifically to address these challenges?

4.3. How has the CFI changed efforts to achieve sustainability in the cocoa sector?

4.6 West African cocoa: Côte d'Ivoire: Government

1. Background

1.1. Please could you briefly describe your role at this organization, and what it involves?

2. Your government organization's activities to promote a more sustainable cocoa sector

2.1. Please can you describe what function your agency / department plays in the Ivorian cocoa sector?

2.2. What activities is your agency / department pursuing to promote a more sustainable cocoa sector?

Probe on names, partners, locations, sizes, and activities on forest conservation / agroforestry (census of producers, geolocation).

2.3. Please could you describe, in your own words, your department/agency's goals for these initiatives?

2.4. If not mentioned, do you work with companies on forest sustainability issues and, if so, how?

3. Views on deforestation and implementation of FSP initiatives by companies

Zero deforestation

3.1. What is your perception of **the effectiveness of zero deforestation** commitments adopted by companies in the cocoa sector more generally? In your opinion, how likely are these activities to reduce deforestation?

3.1.1. What is the effectiveness of, and challenges with, farm mapping and traceability?

3.1.2. What is the effectiveness of, and challenges with, monitoring deforestation (remote sensing and community monitoring)?

3.1.3. What is the effectiveness of, and challenges with, sensitization and capacity building?

3.2. Do you perceive any (potential) **tensions** between the effectiveness of companies' ZDCs and their impacts on farmers' livelihoods? If so, what are they? (How have companies' zero deforestation commitments positively or negatively affected farmers' livelihoods?)

3.2.1. What happens to **farmers who are found in forests** or have cleared forests for cocoa?

3.2.2. **How often** are farmers found in forests? Is this increasing or decreasing?

3.2.3. What remedial action does the government take with these farmers, if any?

3.2.4. How do you anticipate this will **change in the future**? (E.g., after EU legislation?)

3.3. How can, or should, ZD policy be differentiated across different forest zones and the rural domain (e.g., classified forests vs reserves; how is "deforestation" defined)?

Agroforestry:

3.4. What challenges are preventing the effective adoption of agroforestry by farmers?

3.5. How does the ownership of trees in Côte d'Ivoire affect the implementation of these agroforestry activities? What is your agency/department doing to solve these problems?

3.6. Are you aware of any payments for ecosystem services (PES) being made to farmers as part of any agroforestry schemes? Probe on criteria; payment sizes; financing; duration; frequency; permanence; leakage

4. Engagement between public, private and civil society stakeholders, and communities

4.1. How is the Ivorian government supporting companies to implement ZDCs effectively?

4.1.1. How is the national REDD+ strategy supporting the implementation of ZDCs?

4.1.2. How does land tenure in Côte d'Ivoire influence companies' ability to achieve ZD?

4.1.3. How does existing legislation and law enforcement support or hinder ZDC implementation?

4.1.4. How is this related to incoming EU due diligence legislation?

4.1.5. How are landscape approaches supporting the implementation of ZDCs?

Participation by local stakeholders

4.2. To the best of your knowledge, how have communities been involved with developing and implementing zero deforestation or agroforestry activities?

4.3. Are you aware of how local government, civil society or other organizations are involved with implementing these various activities? Probe on cooperatives, other institutions

5. Deforestation drivers and systemic challenges

5.1. Thinking broadly about the cocoa sector in Cote d'Ivoire as a whole, and worldwide, what challenges are preventing it from transforming to a more sustainable model?

If not mentioned:

5.1.1. Where, or with whom, does the power to address these challenges reside?

Probe on locus of power in the cocoa value chain

5.2. How has the CFI changed efforts to achieve sustainability in the cocoa sector?

4.7 West African cocoa: Côte d'Ivoire: FGD guide

1. Introductory questions

1.1. To begin with, please could you tell us about the history of this town/village?

Prompts:

1.1.1. When was the town/village established (what year)?

1.1.2. Where do the people here come from? (If migrants) why did you settle here?

1.1.3. When did you start cultivating cocoa? Why did you start cultivating cocoa?

1.1.4. How has the community changed over the years?

1.1.5. When was the local protected area established? Do you know why it was established?

2. Cocoa trade

2.1. Please could you explain how farmers here sell their cocoa beans?

Prompts:

2.1.1. How many cooperatives / companies buy cocoa here? What are their names?

2.1.2. Do you sell your beans to one buyer or multiple buyers in a season? Why so?

2.1.3. Why do you decide to sell your cocoa beans to one buyer rather than another (e.g., pisteurs / traitants / cooperatives)?

Probe on premiums; loans / prefinance; agricultural tools / inputs; seedlings; training

2.1.4. How easy or difficult is it to sell your cocoa beans?

3. Views on forest conservation and FSP initiatives by companies

3.1. What do buyers check for before buying cocoa beans?

Probe on certification / audits, farm mapping, no deforestation, shade trees

Prompts:

3.1.1. Are you able to satisfy these checks? How easy or difficult is it to satisfy them?

3.1.2. How do buyers make sure you have satisfied these checks? What do they look for?

3.1.3. What do you think about the impacts of these requirements on you? Are they positive or negative? How?

3.2. What support or projects have companies provided for cocoa farmers in this area?

Probe on training / alternative livelihoods / seedling distribution / extension services

Prompts:

3.2.1. Have any of you participated in these projects? If yes, why?

3.2.2. Have these projects changed how you farm? If so, how?

3.2.3. Have these projects improved the productivity of your cocoa farms?

3.2.4. What effects have these projects had on the environment here?

3.3. If cocoa farmers were to plant cocoa in the forêts classées (near) here, how would they do it?

Prompts:

3.3.1. Where would they go?

3.3.2. On average, how far would people travel from the village to establish a cocoa farm?

3.3.3. How would they make the farm? That is, how would they remove the forest trees?

3.4. What happens to cocoa farmers who have farms in the forêts classées?

Prompts:

3.4.1. Have cocoa buyers (companies) ever discovered cocoa farms in the forêts classées?

3.4.2. How did the cocoa buyers (companies) discover these farms?

3.4.3. Are there any pisteurs/cooperatives/companies that don't buy beans from farmers in the forêts classées? Who are they?

3.4.4. How do farmers with cocoa farms in the forêts classées sell their beans, and to whom?

3.4.5. What do you think about the way these farmers are treated by cocoa buyers?

3.5. How do you view cocoa farming in the forêts classées? Is it acceptable or unacceptable? Why?

3.6. What do you think about having shade trees on your farms?

Prompts:

3.6.1. What makes you decide to plant shade trees on your farms, or not?

3.6.2. What kind of trees do you prefer to keep on your farms?

3.6.3. Have you received seedlings or other support to plant shade trees by companies?

3.6.4. Why would you keep shade trees on your farm or not? Probe on tree ownership

4. Systemic challenges

4.1. What issues prevent you from achieving a secure livelihood from cocoa farming?

4.1.1. How does owning, or not owning, your farm(land) make life easier or more difficult?

4.1.2. Who has the power to address these challenges? How should they be addressed?

5. West African cocoa: Ghana interview guides

5.1. West African cocoa: Ghana: Buyer (manufacturer / trader)

1. Background

1.1. Please could you briefly describe your role at the company, and what it involves?

2. Cocoa sourcing

2.1. What are your most important sourcing regions within Ghana?

2.2. Do you manage to source all the cocoa you need and if so, how? If not, why not?

2.3. Which, or what kind of, organisations are your main customers? And suppliers?

2.4. How do you maintain farmer participation in your supply base?

3. Your company's FSP initiatives and theory of change

3.1. Please can you describe your company's forest-related sustainability policy?

3.2. **Initiatives:** Please can you list the initiatives your organisation is involved with implementing in the cocoa sector, including:

- 1) Names; 2) Partners; 3) Locations; 4) Size (farmers); 5) Start, cut-off, end dates?

3.3. How do you translate your customers' requirements into these initiatives?

3.4. **Implementation:** Please describe how these initiatives are being implemented:

3.4.1. What specific activities are being implemented?

3.4.2. What organizations are rolling-out these activities with cocoa farmers?

3.4.3. What (local) institutions are being used to roll-out these activities?

3.5. **Specific activities:** Please can you describe in detail any activities to promote:

1) Zero deforestation; 2) Agroforestry? How do these activities work?

3.5.1. **Selection:** How are 1) communities and 2) farmers selected?

3.5.2. **Incentives:** What incentives are provided to farmers to participate?

3.5.3. **Monitoring:** How are the outcomes of your initiative monitored?

3.5.4. **Verification:** How do you ensure farmers comply before purchasing beans?

3.5.4.1. How do you ensure PCs only buy from participating farms?

3.5.5. **Enforcement:** What requirements does your initiative place on cocoa farmers?

What happens to farmers who fail to comply with your initiative?

3.6. Community involvement:

3.6.1. How are communities involved with developing these activities?

3.6.2. How are communities involved with implementing these activities?

3.7. **Timeline:** Please talk us through your first initiatives in the cocoa sector? When were they implemented, and how have they have changed to become what they are now?

3.7.1. How do you anticipate your initiatives might change over the next 5 years?

3.8. How do these requirements differ from your partners or competitors?

4. Systemic challenges

4.1. What is your perception of the relationship between cocoa and deforestation?

4.2. How do other initiatives influence implementation of your initiative(s), and vice versa?

4.3. How does the public policy context influence the implementation of your initiative?

4.4. What are (three) major challenges you are facing with implementing your initiative?

4.4.1. How can these challenges be addressed?

4.4.2. What is your organization doing to address these challenges?

4.5. CFI

4.5.1. How has the CFI changed efforts to achieve sustainability in the cocoa sector?

4.5.2. How have your initiatives changed since the CFI was adopted?

4.5.3. How do you anticipate companies' initiatives will change over the next 5 years?

4.6. More broadly, what challenges are preventing the cocoa sector from transforming to a more sustainable model?

5. Any other issues

5.1. Is there anything else you would like to mention before we finish the interview?

5.2. West African cocoa: Ghana: Licensed Buying Company (LBC)

1. Background

1.1. What is your name? [Or fill in previously]

1.2. What is your gender? [Or fill in previously]

1.3. What is the name of the LBC you work for? [Or fill in previously]

1.4. Where is your LBC's head office located?

1.5. What is your formal title / position at this LBC? [Or fill in previously]

1.6. How long have you been working at this LBC? And in this role?

1.7. Please could you briefly describe your role at the LBC?

2. Cocoa sourcing

2.1. Please could you describe how your LBC sources cocoa beans?

Probe on direct vs indirect sourcing from farmers

2.2. Which, or what kind of, organisations are your main customers?

2.3. Can you describe your relationships with cocoa traders and manufacturers?

2.4. Can you describe your relationships with 1) purchasing clerks; 2) cooperatives; and 3) cocoa farmers?

2.5. What challenges does your LBC face with sourcing cocoa beans?

2.6. Which regions do you source from?

2.7. What is the current state of forests and agroforestry in these regions?

2.8. Do you think the security of your cocoa bean supply might change? If so, how?

3. LBCs' involvement with implementing FSPs

3.1. Does your LBC have a sustainability policy? What does it involve?

3.2. Is your LBC involved with implementing any of your customer's commitments, policies, or programs on deforestation, forest degradation, forest conservation, and/or agroforestry (hereafter "company forest policies")? If so, what are these policies?

3.3. Where is the policy being implemented?

3.4. What do company forest policies require from you, and from your suppliers?

3.5. Please can you explain how company forest policies are being implemented?

3.5.1. What mechanisms or activities are being used to implement these policies?

3.5.2. If your LBC is responsible for any of these activities, what do they involve?

3.5.3. Are any third parties helping to implement these policies? If so, who and how?

3.6. How have these policies affected your operations, including cocoa sourcing?

3.7. How have company forest policies affected your suppliers, including farmers?

3.8. How have they affected your LBC's relationships with its customers and suppliers?

4. FSP implementation activities

Monitoring

4.1. Can you describe how deforestation by farmers is being monitored?

4.2. Can you describe how agroforestry activities by farmers are being monitored?

5. Enforcement

5.1. If you have been involved with implementing company forest policies:

5.1.1. How have you managed any farmers found to engage in deforestation?

5.1.2. How are legal versus illegal deforestation addressed?

5.1.3. Have you excluded non-compliant farmers? If so, by plot or farmer?

5.1.4. How have you worked with non-compliant farmers to achieve compliance?

5.1.5. If farmers are excluded, do you ever buy from them again?

5.1.6. How have you dealt with beans from noncompliant farmers being laundered?

5.2. How could these enforcement measures be improved?

6. Training, capacity building, benefit sharing, and other activities

6.1. Does your LBC undertake any training with farmers under company forest policies?

6.1.1. If so, what does this training entail?

6.1.2. How is this training delivered, and by whom?

6.2. Does your LBC distribute any materials, such as seedlings, under these policies?

6.2.1. If so, what is distributed?

6.2.2. How are these materials distributed, and by whom?

6.3. Do your suppliers receive any other incentives or benefits from complying with company forest policies (e.g., price premiums)? If so, what are they?

6.4. Are any other activities carried out to implement these policies? If so, what are they?

7. FSP implementation challenges

7.1. What challenges has your LBC faced in implementing company forest policies?

7.1.1. How do you think these should be addressed?

7.2. What challenges have your suppliers or farmers encountered in meeting these policies' requirements?

7.2.1. How do you think these should be addressed?

7.3. What other challenges do you see with the implementation of these policies?

7.3.1. How do you think they should be addressed?

8. Interactions with other public sector and civil society initiatives

8.1. Are any other initiatives (e.g., certification, HIAs) being implemented in the same areas that your LBC sources from, or in the same areas as the company forest policies your LBC is involved with implementing?

8.2. How do government initiatives influence your LBC's ability to source cocoa beans?

8.3. How do legal requirements influence your LBC's ability to source cocoa beans?

8.4. How do initiatives by civil society, or other non-government stakeholders, influence your LBC's efforts to source cocoa beans?

8.5. How do government initiatives influence your company forest policies?

8.6. Beyond the implementation partners you have mentioned, who are the most important stakeholders for successfully implementing company forest policies?

9. Future trends and anticipated changes

9.1. How do you think company forest policies are affecting your LBC's business?

9.2. How do you think these policies are affecting your relationships with farmers?

9.3. In general, how are company forest policies affecting Ghana's cocoa sector?

9.4. What would guarantee the successful implementation of companies' policies on deforestation, forest conservation, degradation, or agroforestry?

9.5. What is your vision for sustainable cocoa production? How can this be achieved?

10. Any other issues

Is there anything else you would like to mention before we finish the interview?

5.3. West African cocoa: Ghana: Local stakeholder / farmer (interview and FGD guide)

NOTE: This guide was also used for Focus Group Discussions in Ghana

1. Background

1.1. What is your name?

1.2. What is your age?

1.3. Are you a cocoa farmer? If so, do you own your farm?

1.4. Please could you describe your role in the community (e.g., purchasing clerk)

1.5. How long have you been doing this role, and how did you come to do it?

1.6. What activities does this role involve you doing?

1.7. What other organizational roles do you have in the community, if any?

2. Institutional role (for members of local institutions)

2.1. [If a member of an institution] Please could you describe the governance structure?

2.2. What functions does your institution perform in the community?

2.3. How often does your institution meet?

2.4. What specific activities does the institution perform?

2.5. Which people execute these activities?

2.6. Are any other institutions active in this community (e.g., CREMAs, CRMCs)?

2.7. How does the role of your institution in the community differ from these other ones?

3. Cocoa production and sales

3.1. Please could you explain how farmers here sell their cocoa beans?

3.2. Who do the farmers here mainly sell their cocoa beans to?

3.3. What happens to farmers' beans after they are sold to their buyers?

3.4. What are the main challenges farmers here face in producing cocoa?

3.5. What are the main challenges cocoa farmers here face in selling their beans?

4. Knowledge about FSPs

4.1. **Initiatives:** Please can you describe any projects on forest protection or agroforestry being implemented by cocoa companies in this area?

4.2. **Implementation:** How are these projects are being implemented?

4.2.1. What activities are being implemented?

4.2.2. What organizations are involved with implementing these activities?

4.3. Specific activities:

4.3.1. Please can you describe in detail any activities to promote:

4.3.1.1. 1) Forest protection; 2) Agroforestry?

How do these activities work?

4.4. Community involvement:

4.4.1. How are communities involved with developing these activities?

4.4.2. How are communities involved with implementing these activities?

4.5. Selection:

4.5.1. How are farmers are selected for these activities?

4.5.2. How do farmers participate/enrol in these activities?

4.6. **Incentives:** Why do farmers to participate in these activities?

4.7. **Monitoring:** Are farmers' participation in these activities monitored? If so, how?

4.8. **Verification:** What does this project require farmers to do to sell their beans?

4.9. **Enforcement:** What happens to farmers that do not comply with these activities?

4.10. **Timeline:** How have the projects in this area changed over the years to become what they are now?

4.10.1. By when will these projects be completed?

4.11. How do these projects differ between companies?

5. Interactions with other public sector and civil society projects

5.1. What other projects (e.g., certification, CREMAs) are there in this area?

5.2. How do these projects affect farmers in comparison with cocoa companies' projects?

5.3. How do legal requirements affect farmers' ability to sell their cocoa beans?

6. Future trends and anticipated changes

6.1. How have these projects affected cocoa farmers in this area?

6.2. What are the three key challenges farmers are facing with these projects?

7. Any other issues

7.1. Is there anything else you would like to mention before we finish the interview?

5.4. West African cocoa: Ghana: Government / NGO

1. Introduction

1.1. Please could you describe your role at this organization?

2. Your organization's involvement with sustainable cocoa initiatives

2.1. **Initiatives:** Please can you list the initiatives your organisation is involved with implementing in the cocoa sector, including:

- 1) Names; 2) Partners; 3) Locations; 4) Size (farmers); 5) Start, cut-off, end dates?

2.2. **Implementation:** Please describe how these initiatives are being implemented:

2.2.1. What specific activities are being implemented?

2.2.2. What organizations are rolling-out these activities with cocoa farmers?

2.2.3. What (local) institutions are being used to roll-out these activities?

2.3. **Specific activities:** Please describe in detail any activities to promote:

1) Agroforestry? 2) Deforestation? How do these activities work?

2.3.1. **Selection:** How are 1) communities and 2) farmers selected?

2.3.2. **Incentives:** What incentives are provided to farmers to participate?

2.3.3. **Monitoring:** How are the outcomes of your initiative monitored?

2.3.4. **Verification:** What does this project require farmers to do to sell their beans?

2.3.5. **Enforcement:** What requirements does your initiative place on cocoa farmers?

What happens to cocoa farmers who fail to comply with your initiative?

2.4. Community involvement:

2.4.1. How are communities involved with developing these activities?

2.4.2. How are communities involved with implementing these activities?

3. Involvement with, and perceptions of, companies' FSPs

3.1. Have you been working with any companies to implement forest-focused supply chain policies (company initiatives related to forest conservation / agroforestry)?

3.2. Which companies' policies have you been involved with implementing?

4. Systemic challenges

4.1. What is your perception of the relationship between cocoa and deforestation?

4.2. How do other initiatives influence implementation of your initiative(s), and vice versa?

4.3. How does the public policy context influence the implementation of your initiative?

4.4. What are (three) major challenges you are facing with implementing your initiative?

4.4.1. How can these challenges be addressed?

4.4.2. What is your organization doing to address these challenges?

4.5. CFI

4.5.1. How has the CFI changed efforts to achieve sustainability in the cocoa sector?

4.5.2. How have your initiatives changed since the CFI was adopted?

4.5.3. How do you anticipate companies' initiatives will change over the next 5 years?

4.6. More broadly, what challenges are preventing the cocoa sector from transforming to a more sustainable model?

5. Any other issues

5.1. Is there anything else you would like to mention before we finish the interview?

References for Supporting Information

1. Reis, T.N.P. dos, Bastos Lima, M.G., Russo Lopes, G., and Meyfroidt, P. (2024). Not all supply chains are created equal: The linkages between soy local trade relations and development outcomes in Brazil. World Dev. *175*, 106475. https://doi.org/10.1016/j.worlddev.2023.106475.

2. Brandi, C., Cabani, T., Hosang, C., Schirmbeck, S., Westermann, L., and Wiese, H. (2015). Sustainability Standards for Palm Oil: Challenges for Smallholder Certification Under the RSPO. J. Environ. Dev. *24*, 292–314. https://doi.org/10.1177/1070496515593775.

3. Ogahara, Z., Jespersen, K., Theilade, I., and Nielsen, M.R. (2022). Review of smallholder palm oil sustainability reveals limited positive impacts and identifies key implementation and knowledge gaps. Land Use Policy *120*, 106258. https://doi.org/10.1016/j.landusepol.2022.106258.

4. Grabs, J., and Garrett, R.D. (2023). Goal-Based Private Sustainability Governance and Its Paradoxes in the Indonesian Palm Oil Sector. J. Bus. Ethics. https://doi.org/10.1007/s10551-023-05377-1.

5. Addoah, T., Lyons-White, J., Cammelli, F., Kouakou, K.M.-P., Carodenuto, S., Thompson, W.J., Renier, C., and Garrett, R.D. (2025). Is the Implementation of Cocoa Companies' Forest Policies on Track to Effectively and Equitably Address Deforestation in West Africa? Sustain. Dev. *n/a*. https://doi.org/10.1002/sd.3380.

6. Kouakou, P., Lyons-White, J., Thompson, W.J., Addoah, T., Cammelli, F., Blaser-Hart, W., Maguire-Rajpaul, V., Dawoe, E., and Garrett, R.D. (2025). Existing sustainability interventions are insufficient to scale up cocoa agroforestry in West Africa. Sustain. Dev. *https://doi.org/10.1002/sd.70266*.

7. Gereffi, G., Humphrey, J., and Sturgeon, T. (2005). The governance of global value chains. Rev. Int. Polit. Econ. *12*, 78–104. https://doi.org/10.1080/09692290500049805.

8. Grabs, J., Cammelli, F., Levy, S.A., and Garrett, R.D. (2021). Designing effective and equitable zero-deforestation supply chain policies. Glob. Environ. Change *70*, 102357. https://doi.org/10.1016/j.gloenvcha.2021.102357.

9. Garrett, R.D., Levy, S., Carlson, K.M., Gardner, T.A., Godar, J., Clapp, J., Dauvergne, P., Heilmayr, R., le Polain de Waroux, Y., Ayre, B., et al. (2019). Criteria for effective zero-deforestation commitments. Glob. Environ. Change *54*, 135–147. https://doi.org/10.1016/j.gloenvcha.2018.11.003.

– END OF SUPPLEMENTARY INFORMATION –