Designing effective and equitable zero-deforestation supply chain policies

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Abstract: In response to the clearing of tropical forests for agricultural expansion, agri-food companies have adopted promises to eliminate deforestation from their supply chains in the form of 'zero-deforestation commitments' (ZDCs). While there is growing evidence about the environmental effectiveness of these commitments (i.e., whether they meet their conservation goals), there is little information on how they influence producers' opportunity to access sustainable markets and related livelihood outcomes, or how design and implementation choices influence tradeoffs or potential synergies between effectiveness and equity in access. This paper explores these research gaps and makes three main contributions by: i) defining and justifying the importance of analyzing access equity and its relation to effectiveness when implementing forest-focused supply chain policies such as ZDCs, ii) identifying seven policy design principles that are likely to maximize synergies between effectiveness and access equity, and iii) assessing effectiveness-access equity tensions and synergies across common ZDC implementation mechanisms amongst the five largest firms in each of the leading agricultural forest-risk commodity sectors: palm oil, soybeans, beef cattle, and cocoa. To enhance forest conservation while avoiding harm to the most vulnerable farmers in the tropics, it is necessary to combine stringent rules with widespread capacity building, greater involvement of affected actors in the co-production of implementation mechanisms, and support for alternative rural development paths.

Keywords: Agriculture; Conservation; Supply chain; Voluntary environmental policies; Effectiveness; Equity

1. Introduction

With the rise of globalized trade patterns and the concentration of resource flows into the hands of a small number of multinational companies (Folke et al., 2020), private environmental governance has become an important leverage point to achieve global conservation goals in international supply chains (Lambin et al., 2018; Thorlakson et al., 2018). In recent years, conservationists' attention has focused on a handful of 'forest-risk commodities' (e.g. palm oil, soybeans, cattle, or cocoa), due to their disproportionate impact on the loss of primary forests, particularly in biodiversity hotspots (Curtis et al., 2018). The production of such goods is estimated to be the direct driver of two-thirds of all deforestation in the tropics and subtropics (Pendrill et al., 2019).

In response to public campaigns targeting the world's largest firms in the food and timber sectors for their role in encouraging deforestation, a growing number of these companies have adopted 'zero-deforestation commitments' (ZDCs) (Lister and Dauvergne, 2014). ZDCs are "voluntary sustainability initiatives that signal a company's intention to eliminate deforestation from its supply chain" (Garrett et al., 2019, p. 136). Actors at all levels of forest-risk supply chains from production to retail have now adopted these commitments. For instance, current forest commitments cover an estimated 83% of Southeast Asia's palm oil refining capacity (ten Kate et al., 2020). In Brazil, the world's other principal deforestation hotspot, around 60% of soy and 85% of beef exports are covered by individual company commitments and sectoral agreements (Haupt et al., 2018a). As these commitments mature and reach their target dates, their effectiveness in eliminating deforestation among all direct and indirect suppliers of single supply chains ('individual effectiveness'), among all commodity producers in a region ('regional effectiveness'), or across global commodity sectors ('net global effectiveness') has become a focus of academic inquiry (Alix-Garcia and Gibbs, 2017; Garrett et al., 2019; Gibbs et al., 2016; Gollnow et al., 2018; Heilmayr et al., 2020; Lambin et al., 2018; Lyons-White et al., 2020; Pereira et al., 2020).

Simultaneously, concerns have been raised that commodity-centric private governance initiatives may exacerbate inequities in rural land use, livelihoods, and poverty rates by excluding producers with limited financial and educational capacity to meet industry requirements from sustainable market access (INOBU, 2016; Klooster, 2005; Pereira et al., 2016). Deforestation frontiers contain actors and countries with a variety of baseline land use conditions and risks, and different tenure, access, and capital constraints (Cammelli et al., 2020; Galudra et al., 2010; Garrett et al., 2017). Smallholder farmers (i.e., farmers with

incomes generated primarily from natural resources whose property size is below the national average (Dou et al., 2020; Zimmerer et al., 2018)); manage an estimated 50% of global oil palm land (Byerlee et al., 2016; Qaim et al., 2020); 70% of global cocoa supply comes from West African smallholders (Wessel and Quist-Wessel, 2015); and small-scale farmers form an integral part of the South American livestock systems (78% of the livestock farms in Brazil are classified as "family farmers" (IBGE, 2017; Pacheco and Poccard-Chapuis, 2012; Pereira et al., 2016). Soy in South America is typically not undertaken by smallholder farmers, but they play a large role in production in India (Romijn, 2014). Most commonly, smallholder land size thresholds are ≤ 2 ha (e.g. for cocoa, coffee, tea, bananas), but thresholds may reach ≤ 50 ha, for instance in palm oil (ISEAL Alliance, 2019). In many cases, the livelihoods of such smallholders are highly vulnerable and depend on their integration into global commodity supply chains (Dou et al., 2020; Lee et al., 2012). In certain contexts, and as a result of wider political economic conditions, agricultural practices used by smallholders have also been identified as potential drivers of deforestation and land degradation (Cammelli et al., 2020; Kalamandeen et al., 2018; Kroeger et al., 2017; Schoneveld et al., 2019a). Yet, in the past, agri-food smallholders have shown limited capacity to comply with sustainable supply chain initiatives such as certification schemes. This is explained inter alia by low education levels and financial means, unclear land tenure, and risk adversity in switching to more sustainable land use practices (Ansah et al., 2020; Brandi et al., 2015; Brandi, 2017; DeFries et al., 2017; Grabs, 2020). The goal of eliminating deforestation in such commodity chains via supply chain initiatives thus risks limiting vulnerable producers' opportunity to access the supply chain and associated resources, and constraining their options for exiting poverty (Schoneveld et al., 2019b).

The potential for these perverse outcomes warrants closer evaluation of the potential impacts of zero-deforestation commitments and in particular, tensions between likely conservation outcomes and producers' equity in access to markets (henceforth 'access equity'). This paper contributes to this research question in three ways by: i) defining and justifying the importance of analyzing access equity and its relation to effectiveness when implementing forest-focused supply chain policies such as ZDCs, ii) identifying seven policy design principles that are likely to maximize synergies between effectiveness and access equity, and iii) assessing effectiveness-access equity tensions and synergies across common ZDC implementation mechanisms amongst the five largest firms in each of the leading agricultural forest-risk commodity sectors: palm oil, soybeans, beef cattle, and cocoa.

2. Balancing access equity and effectiveness in zero-deforestation supply chain policies

2.1. The importance of equity in access

Preventing unfair market exclusion as a result of private environmental governance initiatives is important for both normative and instrumental reasons. Normatively, having equal opportunities to participate is an important dimension of the equity of a given conservation intervention (McDermott et al., 2013). This dimension is alternately described as 'equity in access', which "relates to the ways in which different actors in society are able to engage with and participate in" specific interventions (Brown and Corbera, 2003, p. S45), or 'contextual equity', which "acknowledges the initial distributions of access, capabilities and power from which people and nations engage in – or are swept up by –" particular initiatives (McDermott et al., 2013, p. 420). Two other equity dimensions frequently mentioned are procedural equity, focused on "recognition, inclusion, representation and participation in decision-making", and distributive equity, which hones in on the "allocation among stakeholders of costs and benefits resulting from, for example, environmental policy or resource management decisions" (McDermott et al., 2013, pp. 418–419). Other authors differentiate between input and output equity; a range of equity metrics that include participation, access, spatial, and financial equity; or types of equity that concern social class, gender, ethnicity, generational, educational, or occupational groups (Klein et al., 2015).

We place our analytical focus on producers' *equity in access to ZDC markets*, representing the equal opportunity of different groups of producers, particularly those with high and low adaptive capacities, to participate in a ZDC supply chain (Pignataro, 2012). Adaptive capacity here refers to any capability or asset that allows producers to rapidly adapt to changing market conditions and expectations (such capabilities may include, for instance, education, knowledge, technological capacity, legal standing, financial assets or social capital; see Section 4.1). We use the distinction between producers with low and high adaptive capacities to indicate which producers are more or less likely to be excluded from ZDC markets, preferring it to distinctions made on the basis of producer size or farm system alone. While poor and smallholder farmers tend to have low adaptive capacities, not all face the same barriers to access. Medium-scale producers and those with larger family farms, in turn, might be frontrunners or laggards regarding their adaptive capacities. In contrast, our analysis does not consider equity implications for non-commodity-producing forest landscape dwellers. We leave such considerations, alongside how those issues are addressed via social

requirements of corporate supply chain policies, for future analysis (see also Cheyns et al., 2020; Newton and Benzeev, 2018).

We focus on equity in access rather than distributional equity, given that ZDC supply chain participation may provide producers with a variety of distributional gains or benefits depending on their local context. Producer-level benefits from inclusion in ZDC supply chains might include higher prices, advantageous contract terms (e.g. in volume or length), the provision of technical and financial support, or – in the case of complete ZDC implementation among all market actors – the ability to sell their product at all (Haupt et al., 2018b). In many cases, producers cannot expect any financial or economic benefits from participating in ZDC supply chains (Larsen et al., 2018). This variability in the likely costs or benefits of ZDC participation makes assessing the distributional equity of ZDC policies complex and highly context-dependent, justifying our analytical focus on protecting producers' ability to choose whether to access such markets or not.

Finally, it should be noted that the various dimensions of equity are inextricably linked (Brown and Corbera, 2003). Indicative evidence exists, for instance, that procedural equity in designing particular interventions improves access to those same interventions by marginalized groups; procedural exclusion in turn often precedes project exclusion (Gill et al., 2019). Equity in access to particular interventions (as well as to relevant decision-making) is further a necessary antecedent for distributional equity (Corbera et al., 2007; Gebara, 2013; Haas et al., 2019). We will thus refer to other equity dimensions as applicable.

2.2. Synergies and tradeoffs between equity in access and effectiveness

From an instrumental perspective, the more inclusive a voluntary environmental initiative is, the more likely it is that it will achieve its goals of preventing environmental harm, as it will influence more actors in the production landscape (Garrett et al., 2019; Lambin et al., 2018). Conversely, policies that focus on quick wins by targeting only the largest, most influential actors may exclude a large number of small-scale producers with cumulative high impact, lack local buy-in and legitimacy, or cause political pushback (Bush et al., 2015; Klein et al., 2015; Klooster, 2005; Pascual et al., 2014). Producers excluded from ZDC markets are likely to still establish or expand farms on forest land, even if they need to sell their product into lower-value markets or travel further to find a buyer (Atmadja and Verchot, 2012), lowering regional and global ZDC effectiveness. Hence, ZDC equity in access may engender higher policy effectiveness.

On the other hand, certain private governance design choices that favor inclusion may represent conservation effectiveness tradeoffs, for instance if rules are set too leniently, or their implementation not assured (Chan et al., 2017; Dietz and Grabs, 2021; Giuliani et al., 2017). We may also encounter tradeoffs when assessing policy coverage. At present, non-ZDC markets continue to exist in all sectors we analyze, particularly for domestic consumption or exports into the Global South (Alix-Garcia and Gibbs, 2017; Christopoulou et al., 2018; Schleifer and Sun, 2018). Yet, on a more local level, supply chains may be highly integrated and commodity buyers can have monopsony power over their supply shed, especially in frontier areas (Agergaard et al., 2009; Brandi, 2017; German et al., 2011; le Polain de Waroux et al., 2018). Strong buyer power might increase the effectiveness of sustainable supply chain initiatives in changing producer behavior by pushing more producers toward engagement, but may also exacerbate the consequences of ZDC market exclusion on local livelihoods and poverty. This underlines the importance of closely analyzing conflicting and potentially synergistic policy design for both access equity and effectiveness.

3. Materials and methods

We first conducted a scoping literature review (Grant and Booth, 2009) to develop a theoretical understanding of likely interactions between ZDC effectiveness and access equity. Given that access equity has not yet been the subject of in-depth academic study in the context of ZDCs – notwithstanding first contributions on ZDCs and rural livelihoods (Newton and Benzeev, 2018) and ZDCs and broader equity implications (Lyons-White et al., 2020) –, we drew mainly on insights from alternative private environmental governance interventions such as certification schemes and payments for ecosystem services, but reference ZDC-specific literature where possible. On the basis of these insights, in Section 4.3 we propose seven design principles (P1-P7) on how ZDC implementation at various stages (during ZDC adoption, operationalization, and monitoring and enforcement) may lead to synergies between the desired effectiveness and access equity outcomes.

In a next step, we operationalized our design principles by identifying 13 criteria that measure the extent to which various current ZDC implementation mechanisms align with our design principles. We followed Auld et al. (2008) in classifying mechanisms, which range from individual firm endeavors to public-private partnerships (see Section 5.1).

To evaluate the likely impacts of current ZDC policy design on effectiveness and access equity, we drew on empirical evidence in the four largest agricultural forest-risk commodities: palm oil, soybeans, beef cattle, and cocoa (Goldman et al., 2020). For each commodity, we identified the top five companies in terms of their global market dominance (by volume and/or value) – all of which have zero-deforestation commitments. Given that these commodity supply chains tend to be hourglass-shaped, with the highest concentration of actors in the mid-stream (taking on the steps of processing, trading, and occasionally manufacturing), we focused on companies at that stage of the supply chain. These actors are furthermore essential in implementing downstream actors' commitments, making their implementation choices particularly relevant (Grabs and Carodenuto, 2021). Table 1 shows the list of companies for each commodity and their estimated market share at their point of the supply chain.

[Table 1 about here]

We then analyzed what mechanisms the top five firms used to implement their commitments, and coded both individual and collective implementation mechanisms using our design principles and associated evaluation criteria. Each criterion was coded as either showcasing synergies between effectiveness and access equity (S); favoring effectiveness over equity (E); favoring access equity over effectiveness (Q); or unlikely to support effectiveness and unlikely to affect access equity (N). The codebook in Appendix 1 presents the coding options, examples, as well as aggregation codes for cases where design principles are represented by more than one evaluation criterion. The results are presented by design principle.

We drew on secondary literature to characterize the ZDC context for each commodity, while using both primary document analysis of ZDC policies, progress reports, and other corporate sustainability communications as the basis for our coding of commitments and their implementation choices for the 20 analyzed companies. It should be noted that such an analysis of self-reported data and aspirational goals is likely to represent a best-case scenario for actual policy implementation and should in the future be further tested through interviews and fieldwork. Nonetheless, it provides a first approximation of the extent to which corporate actors have – at least on paper – taken access equity into account, and already allows us to identify clear performance gaps.

In Section 5, we first report aggregated results of the complete coding matrix alongside comparative insights, and then summarize sector-by-sector analyses in our case study section, structuring insights by implementation mechanism. The extended coded table can be found in Appendix 1.

4. ZDC implementation to maximize both effectiveness *and* access equity

4.1. Policy design for equity in access

A review of the literature shows that contextual barriers to participation in sustainable supply chain and conservation initiatives can be classified into six main groups (see Table 3). Farmers may be constrained by a lack of education and access to information; a lack of technological capacity (regarding knowledge and ability to implement sustainable practices); or a lack of assets and financial resources to implement sustainability demands. Further barriers may be related to the legal standing of farmers and their land; the size of individual farms or inability to access farmer groups; and to farmers' values and cultural norms, which may not align with a program's conservation objectives. Table 3 also shows that the various barriers can be removed or counteracted through context-sensitive policy design of the sustainability interventions. Key policy design priorities include: 1) increase awareness about sustainable supply chain initiatives via broad outreach and engagement; 2) simplify criteria and provide capacity building opportunities for participating farmers; 3) provide financial support that covers producers' opportunity costs of compliance; 4) design criteria to avoid legal exclusion by marginalized farmers or assist them in attaining the necessary documentation; 5) design criteria to avoid size-based discrimination or support the establishment of farmer groups; and 6) respect and acknowledge local values and norms, for instance through participatory policy design.

[Table 2 about here]

4.2. The implementation of ZDCs

We now turn to how such design criteria may be respected when implementing zero-deforestation commitments. Figure 1 shows the stages of ZDC implementation across a stylized supply chain, highlighting four steps: ZDC adoption, operationalization, monitoring, and enforcement. Supply chain policy *adoption* sets the stage for defining what behavioral changes are required of actors along the supply chain (e.g. regarding the deforestation reduction target, forest definition, commitment scope, and target date) (Garrett et al., 2019).

During the *operationalization* phase, companies determine how they plan to reach their targets. Decisions include the corporate involvement in collective or public-private approaches; the clarity of policies and consequences; the choice of incentives for supplier compliance (positive, e.g. certification schemes or negative, e.g. market exclusion mechanisms); the attribution of responsibility; the definition of a cut-off date; and plans on how to disseminate the policy (Garrett et al., 2019; Lambin et al., 2018). When surveying approaches to *monitoring and identification of non-compliance*, we can broadly distinguish between police-patrol monitoring (with active and direct oversight by the company adopting the commitment) and fire-alarm monitoring approaches (where oversight activity is delegated to civil society) (cf. McCubbins and Schwartz, 1984). An example of police-patrol monitoring is the sophisticated satellite-based monitoring of suppliers, such as the use of PRODES deforestation maps by the participants in the G4 Cattle Agreement, a market-exclusion mechanism in Brazil (Gibbs et al., 2016). In contrast, grievance management systems of palm oil companies, which allow individuals, governmental and non-governmental organizations to raise concerns over non-compliance with ZDC policies, are examples of fire-alarm monitoring systems (see for example Wilmar International, 2015). Then, the policy needs to be *enforced*, and companies need to decide what action to take with non-compliant suppliers (Merino, 2019). Finally, producers are expected to change their behaviors in response to the private policy implementation or incentives, in which case the ZDC is successful.

[Figure 1 about here]

Policy failure occurs when producers decide to leave the ZDC market and change to less stringent buyers (the 'leakage market'), or when they are able to sell (or 'launder') non-compliant goods into ZDC markets (Alix-Garcia and Gibbs, 2017; Gibbs et al., 2016; Meyfroidt et al., 2020). This process becomes more complex when the committed company does not buy directly from the producer whose behavior the policy seeks to change, a very common situation in globalized tropical commodity supply chains (e.g., the case of calf producers in beef supply chains, or refiners purchasing palm oil from mills who source from independent plantations). In these instances, the committed company must delegate on-the-ground enforcement to upstream actors ('intermediaries' in Figure 1), and/or rely on third-party tools such as audits and certification to achieve compliance.

4.3. Seven design principles for synergies between ZDC effectiveness and access equity

At each stage of this process, ZDC policy design can improve or exacerbate equity in access vis-a-vis the potential barriers to participation outlined in Section 4.1. Connecting the identified general key policy design priorities to the more specific case of ZDC implementation outlined above, we here propose a set of key design principles (P) likely to affect equity in access and synergies with ZDC effectiveness.

4.3.1. Policy adoption stage

To prevent unfair market exclusion, ZDC companies should set forest protection goals in a way that takes into account the differential capacities of actors to comply with them. Of particular concern are farmers with limited awareness of market demands, as well as high forest, low-income countries that have historically conserved their forest, but have high potential for agricultural production (Lyons-White et al., 2020). Such actors may require a longer policy phase-in to give producers time to adapt, or they might be exempted from rules that are difficult to achieve in their context. It has further been proposed that ZDC goal definitions be adapted to allow for development-focused, community-led clearing in high forest cover regions (Senior, 2018). However, making exceptions to the policy target dates or scope creates serious tensions with ZDC effectiveness, which is highest when commitments are stringent, comprehensive, cover both target products and their substitutes (e.g., oil palm and soybeans, which may both be used for biofuel production), and are ambitious in cut-off dates to prevent anticipatory clearing (Garrett et al., 2019). High-forest cover countries, for instance, constitute some of the last vestiges of intact forest landscapes, which makes equity-driven exceptions in these regions a serious loophole to the goal of preventing habitat loss from commodity-driven deforestation (Potapov et al., 2017). To overcome tensions, we propose that:

P1: ZDCs should be stringent and cover all producers, regions, and substitutable products to undercut leakage opportunities, but be accompanied by commitments to support alternative developments paths (i.e., with development aid or value-added industry) to offset negative economic impacts resulting from exclusion choices, from the individual to national scale.

4.3.2. Policy operationalization stage

When implementing the supply chain policy, ensuring equity of access requires that barriers related to awareness about the supply chain rules, the technical ability to implement them (e.g., by identifying forest that should not be converted), and legal limitations to participation (e.g. requiring full land tenure) are either removed or counteracted by the provision of support to meet such rules. Financial constraints are a further barrier to

participation in ZDC markets, especially if vulnerable farmers have a low economic capacity to bear the opportunity costs of such rules. To date, most implementation costs of ZDC measures have been borne by farmers upstream, while such policies originated in downstream demands (Garrett et al., 2021; Lyons-White et al., 2020). To decrease financial barriers to access ZDC markets, downstream companies should share both the costs as well as potential benefits arising from consumers' willingness to pay for deforestation-free commodities (which may in turn enhance distributional equity). Assistance in overcoming such barriers to compliance is likely to represent synergies with effectiveness, as it will enhance the breadth and quality of compliance (Bardach and Kagan, 1982; Kiser and Ostrom, 2000). We thus posit that:

P2: ZDCs should pursue active dissemination of rules via trainings that are adapted to the specific capacity gaps and concerns of various suppliers.

P3: ZDCs should further include active removal of barriers to compliance via differentiated and locally targeted capacity-building measures, and both financial and in-kind support.

P4: ZDCs should provide benefit-sharing schemes for compliance through price or non-price mechanisms and consider payments to offset lost income, especially for farmers living in poverty.

There are further two broader procedural design characteristics that are likely to boost both effectiveness and access equity of ZDC measures. The co-production of rules and implementation procedures with users is likely to enhance corporate knowledge on local barriers and support needs for adoption, as well as enhance the legitimacy and cultural appropriateness of such measures (Mena and Palazzo, 2012). Such co-production could lead to the development of incentive systems that are more in line with local norms, attitudes and values. In addition, coordination of ZDC actors with other (public and private) policymakers can standardize requirements and co-finance support measures, making it easier for farmers to comply, while shrinking the leakage market and improving monitoring capacities.

P5: ZDCs should involve the co-production of rules and implementation procedures with affected supply chain members and surrounding communities.

P6: ZDC actors should further coordinate with other policy-making actors (private and public) to enhance the inclusivity and complementarity of policies.

4.3.3. Policy monitoring and enforcement stages

It is also important to avoid unfair exclusion when monitoring the performance of ZDC producers, and when deciding how to react to non-compliances. Unfair exclusion related to size may occur when monitoring systems (e.g. satellite imagery) are only accurate in their attribution as of a minimum area size, or when the lack of knowledge about ownership patterns on the ground precludes an accurate assessment of a company's supply risk, and an area is removed from the supply chain for that reason. Alternative monitoring technologies and ground-truthing all relevant information can prevent such situations. When reacting to non-compliance, it is important to assess whether non-compliance was due to delinquency, or rather due to a lack of knowledge of rules or ways in which to comply with them. In the former case, strict supply chain exclusion may be desirable. In the latter, however, a collaborative compliance management approach (Bardach and Kagan, 1982), whereby ZDC companies work with suppliers to bring them into compliance without excluding them at first, may lead to greater equity in access as well as improved sustainability outcomes (Koberg and Longoni, 2019).

P7: ZDCs should use inclusive oversight, equal monitoring, but differentiated enforcement.

Table 3 provides an overview of the seven principles, alongside the criteria we used to operationalize the principles and apply them to various ZDC implementation options in the palm oil, soybean, cattle, and cocoa sectors. Section 5 summarizes our findings on how well different implementation mechanisms are able to balance effectiveness and equity in access.

[Table 3 about here]

5. Assessing likely tensions and synergies between access equity and effectiveness in implemented ZDCs in the palm oil, soybean, cattle, and cocoa sectors

5.1. Comparative overview of ZDC implementation mechanisms and policy design

Adapting the terminology of Auld et al. (2008), ZDCs can be implemented using a variety of so-called "new Corporate Social Responsibility" tools (Carodenuto, 2019; Furumo and Lambin, 2020; Garrett et al., 2019, 2018; Gibbs et al., 2016; Lambin et al., 2018). Table 4 shows an overview of existing examples of new CSR tools that have been used to implement ZDCs in the palm oil, soybean, cattle and cocoa sectors, alongside their differences with regard to the operationalization, monitoring, and enforcement of the commitment as well as their incentive mechanisms. These differences are of high relevance when evaluating the likely effectiveness and access equity of the tools in comparison.

384 [Table 4 about here]

385 Companies often pursue multiple interventions in parallel, making it more difficult to
386 tease apart their contributions. In order to be able to compare both different sectors as well as
387 different implementation approaches, we used the five largest companies in each sector as a
388 guide for collecting information on initiatives that have been adopted – ranging from their
389 own policy to collaborations they pursue – and then categorized these according to Auld et al.
390 (2008)'s terminology. This approach allows us to capture a comprehensive section of each
391 market. Figure 2 shows the results of the coding exercise, where we coded to what extent
392 different mechanisms followed the seven principles laid out in section 4.3. We include the
393 individual company policies of the five largest corporate actors, alongside the most
394 prominent example of industry agreements, public-private partnerships, and certification
395 schemes for each sector (if present).

396 [Figure 2 about here]

397 Select mechanisms, such as palm-focused single company policies or the cocoa-focused
398 public-private partnership CFI, show a number of synergistic design choices, while others
399 such as the Soy Moratorium or the cattle-focused public-private partnership TAC have very
400 few synergies. Where one outcome is favored, it is more often effectiveness than access
401 equity. However, and strikingly, many mechanisms include implementation choices that
402 contribute to neither effectiveness nor access equity, which leaves great room for
403 improvement.

404 Sections 5.2-5.6 present more in-depth evidence of the patterns shown in Figure 2 by
405 drawing on the most prominent sectoral example of each implementation mechanism and its
406 fit with the design principles P1-P7.

407 *5.2. Individual firm endeavors: the example of palm oil*

408 Individual firm-level sourcing policies can be found in all sectors under analysis, but
409 many of these policies are not or only poorly implemented (Garrett et al., 2019). We thus
410 focus on insights from No Deforestation, No Peat, No Exploitation (NDPE) policies in the oil
411 palm sector, which have existed since 2011 and have at least been partially implemented
412 (Lyons-White and Knight, 2018). In palm oil, actors typically differentiate between 'tied' or
413 'plasma' smallholders, which are smallholders that belong to concessions either as
414 outgrowers or shareholders of a part of the larger concession, and independent smallholders,

who started their farm on their own and have no assistance from larger grower companies (Schoneveld et al., 2019b).

Equity in access to sustainable markets for smallholder farmers has been recognized as core goal alongside environmental aims in corporate policies. All five companies analyzed – and indeed, 41 out of 57 mid- and upstream palm oil companies with sustainable supply chain policies (SPOTT, 2021) – have made a commitment to support and include smallholders. Nonetheless, they all commit to gross-zero deforestation (i.e., no deforestation beyond a cut-off date including no clearing of areas defined by High Carbon Stock approach) in their entire supply chain, including all third-party suppliers and independent smallholder farmers (P1). They balance these criteria mainly by using *differentiated enforcement* (P7) in which smallholders are rarely excluded, but instead targeted with capacity building programs. In addition, to date, most individual firm programs *pursue differentiated monitoring* (P7), as they tend to monitor only large-scale concessions in their supply base (using satellite imagery), which makes it unlikely that non-compliance by smaller producers will be detected or punished.

Individual NDPE policies tend to include wide-reaching policy dissemination (P2) and (more targeted) capacity building (P3), though such efforts are still mainly focused at supplying plantations and palm oil mills, the first aggregation point of palm fruit. While much producer-level capacity building is limited to pilot projects, some companies go beyond that. Wilmar's training program on compliance with the public Indonesian Palm Oil Standard reached 8,670 independent smallholders out of 18,100 farmers that directly supply their mills (Wilmar, 2020), while Musim Mas cooperated with the International Finance Corporation to roll out training on best agricultural management practices to 43,000 independent palm smallholders (Musim Mas, 2021). Further, select farmers are aided in getting land titles and other types of legal alignment (P3), albeit still on a pilot project level. While smallholder support is becoming more common, it is however not always linked to zero-deforestation compliance per se. Programs to support alternative livelihoods are few and far between and mainly aimed at supporting farmers during the replanting period, rather than offering them an alternative to palm production in the long term (P1).

Where most individual policies still fall short is on the provision of benefit sharing (P4), as most do not offer improved market conditions for ZDC participation, unless it is coupled with RSPO certification (see 5.5), and policy co-production (P5), as supply chain policies are defined internally or in consultation with leading NGOs, but not with suppliers. Finally,

while NDPE policies are similar across the sector (thanks to a combination of stakeholder interaction and institutional isomorphism (Roszkowska-Menkes and Aluchna, 2017)), companies are still not centrally coordinated – among each other or with state actors – in how they engage with suppliers and react to non-compliances (P6). This lack of alignment opens the possibility that efforts are duplicated or undermine one another. However, efforts are currently underway to address this issue, for instance through the Palm Oil Collaboration Group and through landscape programs such as the Siak-Pelalawan Landscape program. Overall, palm NDPE policies thus show considerable efforts at synergies, but still tend to prioritize producer inclusion over effectiveness in a way that may allow for continued deforestation in smaller and more informal land holdings.

5.3. Industry agreements and moratoria: The example of soy

The Soy Moratorium is a collective agreement signed in 2006 by all of the members of the Brazilian Vegetable Processing (Portuguese acronym ABIOVE) and the National Association of Cereal Exporters (Portuguese acronym ANEC), which accounted for 90% of the companies in the Brazilian soy sector, to not source soy from areas in the Brazilian Amazon deforested after July 24, 2006 (this was later amended to July 22, 2008). The signatories to the agreement include all of the top five soy trading companies. This agreement prioritizes effectiveness over equity in design, operationalization, and monitoring. The policy design is stringent in terms of a zero-gross deforestation target covering all actors, but only targets actors in the Brazilian Amazon, allowing farmers in the neighboring Amazonian countries or Brazilian Cerrado to continue clearing (P1). This may be mitigated to a certain extent by individual company global zero-deforestation commitments that on paper extend to other production regions, but most often these are not implemented, given that there is no monitoring or enforcement system (Garrett et al., 2019; Gollnow et al., 2018; zu Ermgassen et al., 2020). In operationalizing the policy there were no efforts made to build capacity with the farmers except in isolated areas, e.g., the Responsible Soy Project of Cargill in Santarem (Jung and Polasky, 2018). The policy was developed in a top-down manner by industry (P5). The only identifiable equity-mitigating impact is that the monitoring and enforcement systems were aligned with existing legal processes already underway in Brazil, including property boundary registration in Brazil's Environmental Property Cadaster (Cadastro Ambiental Rural – CAR) (P3) and near-real time deforestation monitoring (INPE, 2020) (P6).

480 Despite these features, the policy is unlikely to further marginalize or exclude many
481 farmers for several regions. First, soy production is a capital-intensive activity that already is
482 inaccessible to most poorer farmers (Garrett and Rausch, 2016; Russo Lopes et al., 2021).
483 Second, soy is undertaken on a range of farm sizes, but two-thirds of soy farmers in the
484 Amazon (North) region are commercial, rather than "family" farms, and even including
485 family farmers, the average farm size is >2,000 hectares (IBGE, 2017). Finally, producers
486 sell directly to traders rather than through intermediaries, which enables monitoring and
487 enforcement across the entire supply chain (Garrett et al., 2013). However, the penalty of
488 market exclusion is without exception so there is little room for capacity building, which
489 theoretically could lead to some producers who are excluded either selling into local leakage
490 markets (i.e., confined pork and poultry systems), which could be harmful to their livelihoods
491 if the marketing conditions decline (P7). Additionally, the narrow Amazonian scope coupled
492 with the negative disincentive could favor leakage to other areas, exacerbating effectiveness
493 (P1).

494 *5.4. Public-private partnerships: The example of cocoa*

495 The Cocoa and Forests Initiative was launched in 2017 as a highly ambitious, sector-
496 wide, public-private partnership that aimed to tackle the problem of commodity-driven
497 deforestation in a holistic fashion. It unites the governments of Ghana and Cote d'Ivoire –
498 countries which together account for 63% of global cocoa production and have been
499 identified as deforestation hotspots – with 35 cocoa and chocolate companies in the aim to
500 stop forest conversion for cocoa, eliminate cocoa production from national parks and legal
501 forest reserves, and restore forests in both countries (Carodenuto, 2019). In a step-wise,
502 multi-stakeholder approach, actors moved from statements of intent to joint action
503 frameworks and implementation plans, which ensured a strong coordination between public
504 and private actors (P6). Although cocoa farmers were not strongly involved in policy
505 development, some companies organized consultations in cocoa communities on the
506 implementation of the framework (P5). Participating cocoa processing and trading companies
507 have largely aligned their own policies with the initiative's goals and focused their immediate
508 efforts on action in and around legal forest reserves and national parks (allowing for legal
509 alignment), while also investing in large-scale capacity-building measures promoting
510 agroforestry and climate-smart cocoa production (P3), and sensitization around deforestation
511 issues (P2). Positive incentive-setting for conservation (P4) was also integrated, as companies
512 promoted payments for ecosystem services to protect and restore forested areas. However,

513 such schemes are still at a small scale and not supported by any of the major actors we
514 assessed. As of 2019, only 1,340 farmers were participating in PES contracts (out of a target
515 of 215,900 by 2022). Most companies have focused more immediate action on their direct
516 supply chains (where they buy directly from cocoa cooperatives), rather than their indirect
517 suppliers, although estimates suggest that indirect supply chains account for around 50% of
518 cocoa sourced, and are likely where deforestation for cocoa farming is concentrated
519 (Carodenuto and Buluran, 2021) (P1).

520 On the other hand, the close alignment in public-private partnerships also increases the
521 interdependency of actors for policy implementation and enforcement to occur as planned. In
522 the case of CFI, governments were responsible for providing transparent satellite-based
523 monitoring systems with deforestation alerts, which would be "made publicly available for all
524 stakeholders to measure and monitor progress on the overall deforestation target" (CFI,
525 2017a, 2017b). Such monitoring systems had not yet materialized two years into the
526 agreement. Some companies such as Barry Callebaut or Cargill went ahead in developing
527 their own satellite monitoring capacities, while others 'monitored' supply chains by tracing
528 their supply chains and mapping out farm boundaries, but had no data on deforestation
529 patterns on those same areas. In the absence of up-to-date deforestation data, CFI
530 implementation to date has mainly been cooperative and focused on restoration and capacity-
531 building by teaching farmers about agroforestry and distributing and planting tree seedlings,
532 rather than reacting to ongoing deforestation issues. This likely increases the policy's equity
533 at the expense of short-term effectiveness in stopping forest conversion (P7).

534 An important exception, and another key example of interdependencies at the heart of the
535 effectiveness-equity tension, is the decision of what should happen to farmers whose plots lie
536 in national parks and forest reserves. In line with the Joint Action Plans, companies
537 committed to excluding farmers found in such areas from their supply chain, and to reporting
538 such farms to governments such that farmers could be resettled elsewhere. Yet, the CFI
539 Framework documents also acknowledge the importance of social inclusion and avoiding
540 negative consequences, and attributes to governments the responsibility to mitigate the social
541 impacts of proposed land use changes, inter alia by ensuring the provision of alternative
542 livelihoods (CFI, 2017a, 2017b). In practice, the operationalization of such social safeguards
543 has been slow, while little information has been forthcoming on concrete plans for alternative
544 livelihood provision. In addition, necessary information such as the geo-spatial boundaries of
545 enclaves and 'admitted farms' (who operate legally in forest reserves) was still outstanding 2

546 years after the CFI was initiated (CFI, 2020a, 2020b). In their progress reports, some
547 companies reported that they were still waiting for relevant social safeguards to be
548 established before complying with their commitments, while others stated that they had
549 ceased purchasing from farms partly or fully within a protected area boundary (and negative
550 socio-economic effects of such decisions were likely not offset). Cote d'Ivoire
551 simultaneously intensified forest police control and surveillance to "secure" classified forests
552 and noted that such interventions had led to the "voluntary departure of farmer[s]" from
553 many such forests, without commenting on equity-related concerns (CFI, 2020b, p. 16). This
554 trade-off continues to be unresolved.

555 ### *5.5. Combining industry agreements and public-private partnerships: The example of*
556 *cattle in the Brazilian Amazon*

557 In 2009 Greenpeace launched a campaign that attributed responsibilities for large swathes
558 of deforestation in the Brazilian Amazon to cattle ranching (Greenpeace, 2009). Following
559 the campaign, the four larger meatpackers operating in Brazil and Greenpeace signed a
560 commitment to not source cattle from farms that deforested after October 2009, encroached
561 upon protected areas and indigenous lands, or employed slave labor (G4) (P1) (Gibbs et al.,
562 2016). In the same year the Federal Public Prosecutor (MPF) of the Brazilian state of Pará
563 launched an investigation addressing pervasive non-compliance with environmental and labor
564 laws among the meatpackers of the state, who were responsible for purchasing cattle farmed
565 illegally (Imazon, 2018). The MPF forced all larger companies to sign the so-called TAC
566 (*Termos de Ajustamento de Conduta*). TAC was an agreement of non-prosecution on the
567 condition that companies monitored and disclosed their suppliers and excluded from their
568 supply base cattle originating from farms that conducted illegal deforestation after August
569 2008, encroached upon protected areas and indigenous lands, or employed slave labor. In
570 2014 TAC was extended to the other states of the Amazon Biome (P1) (Cammelli et al., in
571 review). G4 signatories also signed TAC, such that both agreements today largely overlap,
572 except that G4 targets zero-gross and TAC targets zero-illegal deforestation (Boi na Linha,
573 2021). In the early years of the agreements, only G4 but not TAC signatories had set up a
574 monitoring system. The system relied on triangulating information on environmental crimes
575 from public agencies with self-reported farms boundaries, CAR information (over time partly
576 validated by public environmental agencies), and remotely sensed data about deforestation
577 (PRODES) from the Brazilian spatial agency (INPE), which detects deforestation patches
578 larger than 6.25 ha (Gibbs et al., 2016). In later years and especially after 2015, TAC

signatories started monitoring their suppliers using the same systems developed by G4 signatories, and the MPF started auditing the meatpackers performance on the agreements (Capóssoli Armelin et al., 2020). The monitoring systems employed differed substantially across TAC and G4 signatories and across the several consulting companies implementing the monitoring. In 2020 a unified monitoring protocol was achieved after negotiations involving companies and the MPF and led by NGOs (P6) (MPF, 2020). This protocol will allow the MPF to produce public audits whose results are comparable, rank companies based on compliance to the agreement and establish clear guidelines for non-compliant farmers to regain compliance. Yet all companies were reluctant to disclose their producers' list, reducing opportunities for assessments beyond independent (but long disputed) audits.

Both G4 and TAC are based on negative incentives (P4) and have a top-down design (P5). TAC has been described as cooperative towards meatpackers, but coercive towards farmers (Cammelli et al., in review). Yet neither TAC nor G4 have been fully implemented: to date, only direct suppliers have been monitored and eventually excluded (MPF, 2020), which opens a number of loopholes for cattle laundering across farms of any size (Pereira et al., 2020), yet safeguards equity by preventing fragile smallholder calf producers from being excluded (P7). Current assessments of G4 effectiveness found limited or no effect, due to leakage (Alix-Garcia and Gibbs, 2017). To date the effectiveness of TAC is unassessed.

In 2020 and 2021 the two largest meatpackers committed to extend monitoring to their indirect suppliers, as well as to provide some forms of technical assistance to foster productivity and compliance, and to secure a sufficiently large supply base. To date technical assistance is limited to a few pilot projects (P2-P3) (Marfrig, 2020). In addition, both companies aim to extend monitoring to the Brazilian savannas (Cerrado), aiming for zero net and zero illegal deforestation respectively.

5.6. Certification schemes: The cases of RA, RSPO, and RTRS

One of the most common ways for downstream companies with zero-deforestation commitments to operationalize their commitments is to source goods certified under third-party certification schemes such as the Rainforest Alliance (RA) standard (commonly used for cocoa as well as coffee and other tropical commodities), the Roundtable on Sustainable Palm Oil (RSPO), and the Round Table on Responsible Soy (RTRS) certifications. Out of 553 companies that disclosed information about how they tackle commodity-driven deforestation in 2019, 71% had a target related to certification adoption (CDP, 2021).

As they were not originally designed to provide deforestation-free guarantees, some standards have had to fundamentally reinvent themselves. For instance, RSPO introduced a new zero-deforestation criterion during its standard revision in 2018, while the Rainforest Alliance in its 2020 standard revision aligned its cut-off date for ecosystem conversion with company commitments (Rainforest Alliance, 2020a). Today, all three standards that we examine – RA, RSPO, and RTRS – include zero-gross deforestation rules (P1). In addition, the multi-stakeholder procedures of such standards ensure a modicum of co-production and consultation with producers (P5), although smallholder farmers are frequently underrepresented in standard development and governance compared to other industry actors or NGOs (Bennett, 2017; Schouten et al., 2012). While there is little direct government involvement in rule-setting (P6), standards do refer to national legislation and some allow for 'national interpretations' that make them more context-appropriate (P3).

However, there are other features in the ways that standards have traditionally functioned that put them at odds with ZDC implementation in a strict sense. One element common to all three standards is that to date, the majority of volume has been traded under 'mass balance' rules, in which certified product is mixed with conventional product at some point in the supply chain. This process does not allow for traceability and may mean that illegal or deforestation-associated products continue to flow into committed buyers' products. In response, standards also offer options for segregated and/or identity protected certified products; in the case of cocoa and soy, however, this is only applied in a negligible share of supply to date (Rainforest Alliance, 2020b; RTRS, 2020a). The palm sector provides a mixed picture. While in 2019, Sime Darby sold 73% of its RSPO-certified palm oil under segregated or identity preserved rules and only 27% as Mass Balance, the proportion of certified palm oil sold under Mass Balance rules was 51% for Musim Mas, 66% for Wilmar, 87% for GAR, and 100% for Apical (RSPO, 2021a). Thus, not all actors involved in a companies' supply chain are necessarily covered by certification rules (P1).

A second concern is that the compliance monitoring model applied by standards – centered on yearly audits, which may be done on a sample of farmers in group certifications – is not well suited to comprehensively monitor deforestation in real time. Some certification schemes until recently did not record farm boundaries, especially of smallholder farmers operating in groups, and few use satellite monitoring to verify compliance. To better tackle cocoa-driven deforestation, RA recently embarked on a mission to strengthen its code compliance, among other things by asking for GPS locations of farms, and subsequently

found that 84 of their certified groups included farmers with land (illegally planted) in protected areas. Another 30 groups were suspended for not providing geospatial information (Rainforest Alliance, 2020c). To be effective for the purposes of ZDCs, compliance systems thus need to be strengthened through quicker response times and better technological monitoring solutions (P7). In addition, certification schemes tend to be adopted first by the most advanced farmers, and may be dominated by farmers that have cleared in the past or have no immediate plans for expansion, putting into question the additionality of schemes (Garrett et al., 2016).

Finally, the inclusion of smallholders has been a consistent struggle especially for the RSPO and RTRS, where independent smallholder farmers contribute 0.9% and 0.8% of total certified supply, respectively (RSPO, 2021b; RTRS, 2020b). To tackle this gap, certification organizations have aimed to simplify standards, introduced group certification, and offered (limited) funding opportunities to assist farmer groups in covering audit expenses and investments in capacity building. For example, between 2014 and 2018, the RSPO Smallholder Support Fund, funded from 10% of the revenue generated from the trade of Certified Sustainable Palm Oil (CSPO), could be used to support smallholders with the costs incurred for training, project management, High Conservation Value (HCV) and Social and Environmental Impact Assessment (SEIA), audit costs, as well as the tools and techniques to support smallholder development, and benefitted over 28'000 individual smallholders. Similarly, the Rainforest Alliance Rainforest Alliance's Africa Cocoa Fund (ACF), launched in 2021, is a three-year, $5 million fund to support cocoa farmers and help preserve the local landscapes in West and Central Africa. It aims to create measurable, long-lasting positive impact by building the capacity of those certified cocoa farmers who most need assistance to implement RA certification standards.

Yet, access to such capacity building support is often mediated via NGOs or strong producer institutions. The vast majority of certified smallholders learn about schemes and their requirements via NGOs and/or firms (P2), and rely on such external assistance both to reach standards and to maintain certification over time, which may affect the longevity of certification impact (Brandi et al., 2015; Lemeilleur et al., 2015) (P3). Finally, a key benefit of certification schemes – at least in theory – is that they are able to compensate producers for enhanced practices via price premiums (P4). In practice, the extent of premium payments varies dramatically both between standards and producers. Given an oversupply of certified goods, premium erosion, and a recognition that most adjustments costs have historically been

borne by producers, some standard organizations have begun to respond by mandating an annual increase in uptake by participating buyers (see the RSPO Shared Responsibility guidelines) or setting minimum "sustainability differentials" to be paid to farmers, as RA is introducing in the cocoa sector (Rainforest Alliance, 2020d).

6. Discussion and conclusions

In order to reach global goals for conservation and sustainable livelihoods, private supply chain policies such as zero-deforestation commitments have to be designed in a way that allows for effectiveness as well as equity in access for producers with varying adaptive capacities. In this piece, we have provided the first comprehensive conceptualization of access equity in the context of supply chain policies, identified policy design principles that allow for synergies between effectiveness and access equity, and used these principles to evaluate the leading implementation mechanisms for zero-deforestation commitments in the most prominent forest-risk commodities: palm oil, cocoa, soybeans, and beef cattle. Our work posits that synergies between the two goals are possible when deforestation prevention goals remain ambitious and comprehensive, but suppliers with lower adaptive capacity are supported in becoming compliant through widespread awareness raising actions, financial and in-kind support for targeted capacity building, and differentiated compliance enforcement that distinguishes between unwillingness and inability to comply. It is furthermore important to involve affected actors in the co-production of implementation mechanisms and enforcement solutions, and to support alternative rural development paths in areas where commodity-driven development is undesirable due to the forest conversion risk.

When assessing the leading ZDC implementation mechanisms against these criteria, we found that some showed encouraging signs of synergistic design choices that work to strengthen both effectiveness and access equity, especially as companies have strengthened their investment in raising the awareness of suppliers and other forms of outreach. Figure 3 shows the evaluation results, aggregated across the 28 evaluated initiatives, by ZDC design principle. At least on paper, there is greatest commitment to synergies in coordinating policies across private and public actors; disseminating ZDC rules to suppliers of all sizes; and aiding suppliers with lower adaptive capacities in overcoming barriers to compliance (though many such efforts are still in pilot phases and need to be scaled up significantly).

[Figure 3 about here]

Yet, more commonly we found that tensions between effectiveness and access equity occurred through one of four main avenues:

1. Many companies choose not to monitor smaller or indirect suppliers, while only taking compliance enforcement action when non-compliance (i.e., forest clearing) was detected. This arguably mitigates access equity concerns, but only at the expense of effectiveness and potential further clearing.
2. In many instances corporate actors state that they prefer engagement over exclusion in the case of smallholders, but simultaneously focus on smallholder capacity building activities that have only limited links to the issue of commodity-driven deforestation, such as productivity improvements or on-farm tree planting. While commendable in avoiding unfair market exclusion, such activities are unlikely to reduce forest conversion rates by these smaller actors.
3. We find select instances where actors with lower adaptive capacity are likely to be excluded without being provided with support for alternative livelihoods. This is most often the case when identifying patterns of illegal deforestation (e.g. in national parks), where responsibility is pushed back onto (unresponsive) state actors, as well as when positive proof of compliance is required (as in the case of using certification schemes).
4. Across the board we find few examples of policy co-production with affected suppliers or needs-based incentive setting or benefit sharing.

Figure 3 further shows that initiatives tend to favor effectiveness over access equity in designing commitments (P1), as few make mention of compensatory mechanisms or support for alternative development paths. Yet, we also observe a high share of "neither" responses – denoting design choices that do not support policy effectiveness, but also do not explicitly target or improve access equity and may be examples of green washing or at least weak commitment implementation. This demonstrates that there continues to be a large implementation gap between commitments and best-practice suggestions for effectiveness which also rely on the large-scale inclusion of producers (see also Garrett et al., 2019). We thus identify more potential win-win outcomes than instances where committed actors are forced to choose between ZDC effectiveness and access equity.

In the absence of sustained supplier engagement that puts the regulated – that is, farmers and plantation companies – at the center and focuses on instigating targeted behavioral changes, there is a high risk that supply chain policies will lack effectiveness (Jopke and

741 Schoneveld, 2018) and leave more marginalized actors, such as smallholder farmers, behind
742 (Colchester et al., 2016; Garrett et al., 2016; Haggar et al., 2017). We encourage further
743 systematic research on ZDC design, implementation, and impacts in the field, with an eye to
744 testing the proposed synergistic policy recommendations. Field-level verification is
745 particularly important for assessing how many of the aimed-for synergistic steps identified in
746 the policy documents (e.g., regarding coordination of public and private actors, or rolling out
747 smallholder support) are consistently implemented in practice. Transdisciplinary research
748 may also assess to what extent the proposed more ambitious design principles (e.g., regarding
749 the support of alternative development paths, or of needs-based incentive setting) may
750 feasibly be implemented in existing ZDC implementation mechanisms, or what other forms
751 of support and alignment (such as regulatory policy from importing countries or the
752 leveraging of blended finance) would be necessary to attain these goals.

753 Another interesting future research area is the timing and prioritization of effectiveness
754 versus access equity considerations. In times of rapid ecosystem and biodiversity loss, it
755 might be normatively acceptable to first focus on reigning in large-scale (corporate)
756 deforestation actors and only later turn to questions of smallholders and more marginalized
757 farmers, as has been done in practice in the palm oil sector. However, the palm sector also
758 presents a cautionary example. Emerging evidence indicates that large-scale actors
759 increasingly shift blame to smallholders and other unregulated actors, undermining the
760 functioning of current ZDC enforcement systems (Gaveau et al., 2017; Larsen et al., 2018).
761 As new initiatives emerge and old ones are revised, future work could delve more deeply into
762 temporal questions of effective and equitable policy design.

763 One limitation of the present study is that it did not explore the interactions between ZDC
764 design and contextual factors. ZDC effectiveness and access equity outcomes, their synergies
765 and tradeoffs are likely mediated by existing public policies (e.g. environmental regulation
766 and enforcement, institutional environment, monitoring infrastructure), commodity specific
767 features (e.g. perishability, transportability), civil society, social and market structures
768 affecting ZDC companies, as well as their interaction with each other and with their suppliers
769 (e.g. the number of supplier tiers, the level of market integration, length of the supply chain,
770 information asymmetries, poverty, education and producers organization). For instance, it is
771 likely that synergistic outcomes also rely on state actors in both importing and exporting
772 regions favoring coordination of supply chain zero-deforestation efforts. Future research
773 should highlight the interaction between ZDC design features and such contextual factors in

774 determining ZDC effectiveness and access equity (Garrett et al., 2021), and might aim to
775 determine 'ideal' ZDC implementation models that maximize synergies between
776 effectiveness and access equity in a given context.

777 A further limitation is that due to our study's scope, our principles and assessment criteria
778 have focused on potential market exclusion stemming from the implementation of supply
779 chain policies. Future studies may aim to take a broader focus to also capture alternative
780 forms of access inequities (e.g. focused on gender, social status, or age) that interact with
781 supply chain policy implementation, or to examine other dimensions of equity (Klein et al.,
782 2015). Nevertheless, given the range of contexts spanned by existing forest-risk commodities,
783 our present analysis sets the basis for developing generalizable insights across multiple
784 commodities and supply chain, especially within the tropics. This heterogeneity also makes
785 existing initiatives ripe for future empirical analyses to explicitly examine the importance of
786 particular contextual factors in a comparative fashion.

787 Stepping back, we acknowledge that the market-based solutions analyzed above must
788 only be an intermediate strategy in the journey toward developing more sustainable
789 economies and food systems, as any sectoral efforts will ultimately reflect participatory
790 inequities and further entrench industry narratives about the role of corporations in
791 sustainable development (Dauvergne, 2018; Delabre et al., 2020). Longer-term solutions
792 require rethinking the reliance of tropical economies on agricultural exports for economic
793 growth and development and for high-income countries in the global north to assume greater
794 responsibility for their consumption footprints.

795

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8. Tables

Table 1. Top five firms handling forest-risk commodities, by sector and volumes sourced/used/capacity

Palm oil	**Soybeans**

Company	Volume sourced in 2019 (million MT; % of world trade)	Company	Volumes sourced in 2017 (million MT; % of world trade)
Wilmar International Ltd.	24.7 (44%)	Archer Daniels Midland	15.9 (10.6%)
Golden Agri Resources Ltd	9.4 (17%)	Cargill	14.5 (9.7%)
Musim Mas	9.1 (16%)	Louis Dreyfus Company	13.0 (8.7%)
Apical Group Ltd.	8.7 (15%)	Cofco	12.0 (8.1%)
Sime Darby Bhd.	3.4 (6%)	Bunge	9.3 (6.3%)
Cattle		**Cocoa**	
Company	**Brazilian slaughtering capacity in 2017 (heads/day; estimated % of total capacity)**	**Company**	**Volumes used in 2019 (million MT; % of world trade)**
JBS	34'420 (42%)	Barry Callebaut	1.03 (25%)
Minerva	11'880 (14.7%)	Olam	1.0 (24%)
Marfrig	10'000 (12.4%)	Cargill	0.82 (20%)
Mercúrio	2'000 (2.5%)	Ecom	0.74 (18%)
Masterboi	1'700 (2.1%)	Sucden	0.50 (12%)

Notes: Palm volumes sourced (in metric tonnes, MT) represent all palm oil and palm oil products, including crude palm oil, crude palm kernel oil, derivatives refined from CPO and CPKO, and crude palm kernel expeller. From RSPO ACOP (RSPO, 2021a). Soy volumes (in MT) sourced from Voora et al. (2020). Cocoa volumes used (in MT) represent all cocoa products, using ICCO conversion rates: cocoa beans 1.0, cocoa butter 1.33, cocoa paste/liquor 1.25, cocoa powder and cocoa cake 1.18, from Fountain and Hütz-Adams (2020). Palm, soy, and cocoa world trade volumes approximated via global aggregate imports (palm oil and palm kernel oil; soybean; cocoa bean), in MT, from FAO Stats (FAO, 2021). Given extensive inter-company trade between large companies, percentage values should not be read as mutually exclusive (and thus not summed to arrive at market coverage).

Table 2. Barriers to sustainable market access and policy design criteria to avoid unfair market exclusion

Barrier type	Examples	Counteracted by…	References (selected)
Education and access to information	Knowledge about initiatives, openness toward innovation	Outreach, awareness raising	(Adhikari and Boag, 2013; Brandi et al., 2015; Jia et al., 2018; Loconto and Dankers, 2014; Prokopy et al., 2008; Tröster and Hiete, 2018)
Technological capacity	Good agricultural practices, book keeping, access to correct inputs	Simplify criteria, offer technical assistance, integrate trainings and capacity building	(Adhikari and Boag, 2013; Brandi et al., 2015; Jia et al., 2018; Loconto and Dankers, 2014; McDermott, 2013)
Financial resources	Assets, capital available for sustainable investments	Financial support, premium payments	(Adhikari and Boag, 2013; Brandi et al., 2015; Jia et al., 2018; Loconto and Dankers, 2014; Prokopy et al., 2008;

			Sorice et al., 2018; Tröster and Hiete, 2018)
Legal standing	Land rights and tenure, adherence to land use designation	Simplify criteria, assistance in attaining correct legal documents, lobbying for regulatory alignment	(Adhikari and Boag, 2013; Brandi et al., 2015; McDermott, 2013; Schoneveld et al., 2019b)
Organizational scale and quality	Farm size, group membership	Simplify criteria, support group formation	(Adhikari and Boag, 2013; Brandi et al., 2015; Loconto and Dankers, 2014; Prokopy et al., 2008; Tröster and Hiete, 2018)
Attitudes, values and norms	Pro-environmental attitudes, non-monetary values and behavioral norms toward conservation	Participatory program design; norm-based rather than financial policy framings; community-level implementation	(Prokopy et al., 2008; Sorice et al., 2018; Tröster and Hiete, 2018)

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1213 *Table 3. Seven design principles for effectiveness-access equity synergies and associated*
1214 *evaluation criteria*

	Design principle	Evaluation Criteria
1	ZDCs should be stringent and cover all producers, regions, and substitutable products to undercut leakage opportunities, but be accompanied by commitments to support alternative developments paths (i.e., with development aid or value-added industry) to offset negative economic impacts resulting from exclusion choices, from the individual to national scale.	1.1. Deforestation reduction target 1.2. Policy scope (actors) 1.3. Policy scope (regions) 1.4. Cut-off date 1.5. Offsetting of negative impacts resulting from exclusions
2	ZDCs should pursue active dissemination of rules via trainings that are adapted to the particular capacity gaps and concerns of various suppliers.	2.1. Evidence of active policy dissemination
3	ZDCs should further include active removal of barriers to compliance via differentiated and locally targeted capacity-building measures, and both financial and in-kind support.	3.1. Capacity building 3.2. Legal alignment
4	ZDCs should provide benefit-sharing schemes for compliance through price or non-price mechanisms and consider payments to offset lost income, especially for farmers living in poverty.	4.1. Evidence of benefit sharing
5	ZDCs should involve the co-production of rules and implementation procedures with supply chain members and surrounding communities.	5.1. Evidence of co-production of policy operationalization

6	ZDC actors should further coordinate with other actors (private and public) to enhance the inclusivity and complementarity of policies.	6.1. Evidence of coordination of public and private actors
7	ZDCs should use inclusive oversight, equal monitoring, but differentiated enforcement.	7.1. Inclusive monitoring 7.2. Enforcement approach

Table 4. Overview of most common ZDC implementation mechanisms in forest-risk commodities. It should be noted that there may be overlap between various mechanisms in the same region, and that initiatives may change from one type to another over time (e.g. from industry agreements to public-private partnerships, if state support is added)

New CSR tool	Application in the context of ZDC implementation	Example of implementation approach (location and associated commodity, where not evident)	Operationalization of commitment	Monitoring of commitment	Enforcement of commitment	Incentive mechanism
Individual firm endeavors (with potential NGO partnership)	Corporate ZDC policies translated into supplier codes of conduct and time-bound action plans (may include collaboration with NGOs to map, monitor, and engage with suppliers)	No Deforestation, Peat, and Exploitation (NDPE) policies (global, palm oil) Forest protection supply chain policies (global, cocoa)	Firm-wide policy (with potential design input from NGOs) Supplier code of conduct ZDC requirement integrated in purchasing contracts	Satellite monitoring Supplier self-reporting Supplier audits (with potential third-party involvement)	Supplier education workshops One-on-one trainings Grievance procedures (verified non-compliance leads to action plans or market exclusion)	Negative: threat of sanctions, e.g. market access exclusion, for non-compliance (albeit potential support for movement toward compliance)
Industry (association) codes of conduct and agreements	Industry-wide agreements, bans, or moratoria	G4/G6 Zero Deforestation Cattle Agreements (Brazil) Soy Moratorium (Brazil)	Collective agreements to avoid sourcing from high-risk regions or non-compliant suppliers	Supply chain tracing Satellite monitoring	Acceptance of product predicated on provenance or producer behavior	Negative: market access exclusion
Public-private partnerships	Collaboration with public policy actors to support policy enforcement	Termo de Ajustamento de Conduta (Brazil, cattle) Cocoa and Forests Initiative (Ghana, Côte d'Ivoire)	Alignment of corporate policy to local legal framework	Satellite monitoring	Acceptance of product predicated on legality	Negative: market access exclusion for illegal products
	Jurisdictional approaches to sustainable sourcing regions	IDH Verified Sourcing Area pilots (global; palm oil, cattle)	Public-private commitment to action plan that reduces deforestation in the region	Agreed-upon KPI assessed by multi-stakeholder group, likely reliance on governmental data	Follow-through on targeted investments or preferential sourcing	Positive: provision of targeted investments or preferential sourcing
Non-state market-driven private sector hard law	Third-party certification schemes	Roundtable on Sustainable Palm Oil Round Table on Responsible Soy Rainforest Alliance (cocoa)	Integration of ZDC definitions into rules of third-party certification	Third-party (sample-based) auditing of certification rules	Preferential sourcing of certified over non-certified products	Positive: Improved market access and/or price premiums for certified products

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9. Figures

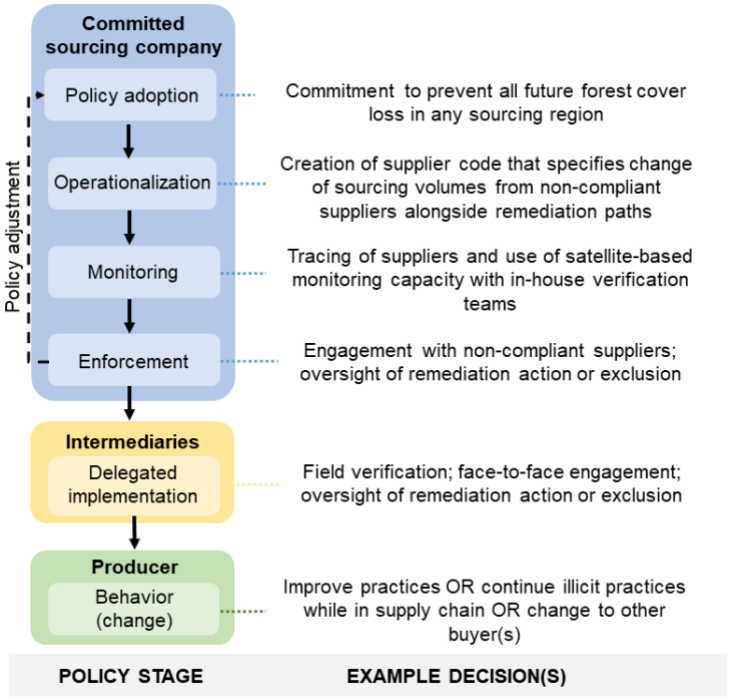

Figure 1. The stages of ZDC implementation along a stylized supply chain

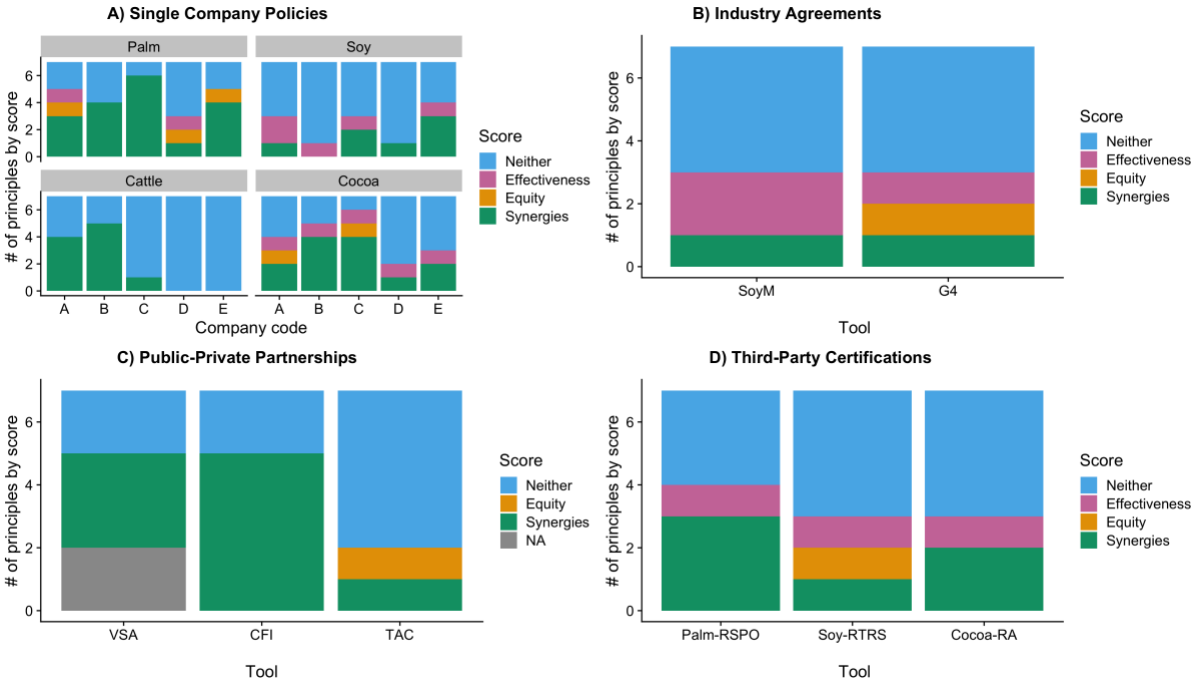

Figure 2. Overview of alignment of main ZDC implementation mechanisms with design principles for effective and equitable zero-deforestation policies. The scoring evaluates to

what extent ZDC implementation mechanisms in the four forest-risk commodities are aligned with the synergistic design principles (Synergies), favor effectiveness over access equity (Effectiveness), favor access equity over effectiveness (Equity), or do not contribute to either goal (Neither). Each mechanism is evaluated for the seven design principles (P1-P7). As the VSA has only just started, we were only able to evaluate 5 out of 7 principles.

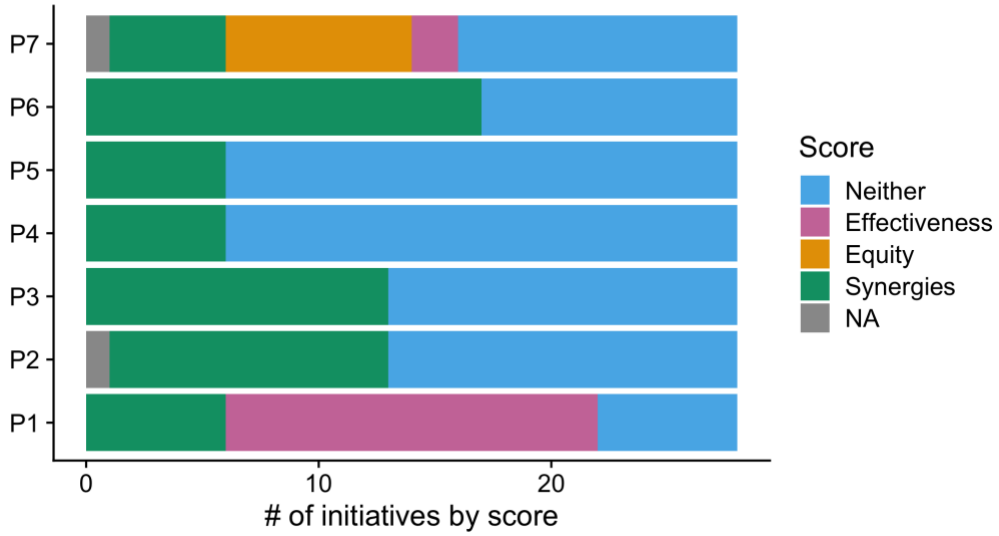

Figure 3. Evaluation of seven design principles for synergies between ZDC effectiveness and equity in access in 28 examples of ZDC implementation. The scoring evaluates to what extent ZDC implementation mechanisms are aligned with the synergistic design principles (Synergies), favor effectiveness over access equity (Effectiveness), favor access equity over effectiveness (Equity), or do not contribute to either goal (Neither). In one case, P2 and P7 were unable to be scored as the initiative is still under development.