Archetype analysis of forest policies and measures: towards a new typology

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1 Introduction

Deforestation, particularly in tropical regions, is the most important source of greenhouse gas emissions from the land-use sector, and accounts for approximately 10-12% of global emissions (Griscom et al. 2017). In this context, decision makers such as governments of forest-rich countries, governments of countries importing forest-risk commodities, and private companies operating in the supply chains for these commodities have committed to actively combat tropical deforestation (Lambin et al. 2018).

These decision makers have relied on a large and heterogeneous set of policies and measures to curb deforestation and forest degradation. Despite these efforts, tropical deforestation continues and even increases in some regions (Vancutsem et al. 2021). As one of many possible explanations, policies and measures are not implemented in contexts in which they are likely to be most effective. For example, payments for ecosystem services (PES) schemes are often implemented in buffer areas of protected areas (Chervier and Costedoat 2017). However, PES schemes are more effective when implemented away from protected areas (Robalino et al. 2015).

The burgeoning scientific literature on the impact of forest policies and measures on deforestation is generating an increasing evidence base on the way context influences policy impact (Börner et al. 2020). This literature suggests that the causal impacts of policies stand in a complex relationship to context and policy characteristics (Ferraro et al. 2011; Börner et al. 2017; Chervier and Costedoat 2017; Cisneros et al. 2022). However, there is no synthesis of which contextual or policy characteristics hinder or strengthen the impacts of conservation policies. This leaves policymakers with virtually no tools to make informed decisions. Either they will fall into the trap of a "one-size-fits-all" approach or pursue a general call for "context matters" without the knowledge base to design and implement approaches based on that context (Ostrom et al. 2007; Ostrom and Cox 2010; Young et al. 2018).

This paper forms part of a larger study on deforestation diagnostics, which seeks to identify middle-ground theories on the way context characteristics influence the effectiveness of forest policies and measures. Middle-range theories enable identification of common causal mechanisms and conditions that trigger, enable, or prevent policy effectiveness across diverse settings (Meyfroidt et al. 2018; Oberlack and Eisenack 2018; Hoffecker 2021). This diagnostics approach has, in turn, three main building blocks (Angelsen 2022): (i) a set of deforestation context archetypes, (ii) a set or typology of relevant policies and measures, and (iii) a pool of evidence on the effectiveness of policies and measures implemented in particular contexts.

This paper deals with the second building block of the diagnostics approach. Establishing a typology of forest policies and measures is necessary because of the large diversity of policies and measures available to decision makers in the real world and the limited pool of evidence of the impact of each specific policy and measure. It is, in turn, justified by the commonalities in the underlying theory of change (ToC) of some forest policies and measures that, once identified, could be used to make assumptions about common contexts of effectiveness. Studies that have attempted to create typologies of forest measures and policies usually rely on predefined policy types. Hence, they do not describe methods and criteria used to categorize forest policies and measures into broader types (Angelsen 2010; Börner et al. 2017; Agrawal et al. 2018; Pirard et al. 2019)either by neglecting extension, marketing, and infrastructure, generating alternative income opportunities, stimulating intensive agricultural production or by reforming land tenure. The second set aims to increase either extractive or protective forest rent and—more importantly—create institutions (community

forest management. They also generally fail to cover the diversity of policies used to achieve their deforestation reduction commitments.

In this paper, we develop and apply an archetype analysis to identify a typology of forest policy and measures. Archetype analysis is a methodology to create typologies based on identification of "reappearing but nonuniversal patterns that hold for well-defined subsets of cases" (Eisenack et al. 2021). A comprehensive archetype analysis characterizes each type by three elements, namely "a configuration of attributes, a theory or hypothesis that explain the relation between the attributes, a set of cases where it holds" (Eisenack et al. 2021). Archetype analyses have been used on an increasing range of topics in sustainability research, including land systems and deforestation (Meyfroidt et al. 2018; Buchadas et al. 2022), governance and institutional change (Oberlack and Eisenack 2018) and social-ecological systems (Pacheco-Romero et al. 2022). However, to the best of our knowledge, this is the first application of archetype analysis to the underlying ToCs of forest policies and measures.

2 Empirical approach for the archetype analysis

In this section, we build on Eisenack et al. (2021) to characterize the three elements based on which the policy typology will be created. We frame the universe of cases of policies and measures considered, create a generic ToC of forest policies, and finally identify attributes of forest policies and measures we will use. To characterize these elements, we reviewed the scientific literature that produced typologies of forest policies and measures. We also reviewed various national and subnational strategies from three major tropical forested countries, namely Peru, Indonesia, and the Democratic Republic of Congo (Appendix 1 presents the list of references reviewed).

2.1 The universe of forest policies and measures considered

The universe of forest policies and measures used in existing typologies is generally narrow. For example, some studies focus solely on policies influencing either the demand (Bager et al. 2021) or the supply of the forest-risk commodities' supply chains (Pirard et al. 2019). Reviewed typologies also tend to focus on policies and measures directly affecting land use. Few studies also include more general development policies that are known to significantly but indirectly affect land-use change (Angelsen and Rudel 2013; Pfaff et al. 2013), or supply chain policies and measures (Lambin et al. 2018).

Defining the boundaries of the universe of relevant forest policies and measures is a balancing act. On the one hand, a narrow definition of forest policies and measures is problematic because it does not reflect the diversity of policies and measures used by decision makers to reduce deforestation in the real world. For example, some national or subnational deforestation reduction strategies of major tropical forested countries include measures linked to avoiding road construction or promoting family planning that are rarely included in reviewed typologies. On the other hand, a too broad definition of forest policies and measures is also irrelevant from a deforestation diagnostics perspective. Most public policies affect forest use directly or indirectly. As an example, devaluation/depreciation of national currencies may stimulate the export of deforestation commodities (Arcand et al. 2008). However, it would be unreasonable to suggest that exchange rates could be considered a forest policy as the effect is largely unintentional.

In our case, we use the following encompassing definition of forest policies and measure: *any policy, programme, or action aimed at changing or significantly affecting the behaviour of forest-related actors and thereby directly or indirectly contribute to avoiding deforestation*. The primary objective of policies and measures included in our study is hence not necessarily to reduce deforestation but rather to influence the behaviours of actors who impact, directly or indirectly, the fate of tropical forests (see Table 1). As a result, we include policies and measures such as agricultural policies, rural development policies, and infrastructure development (roads) to the extent they are implemented in forested landscapes and thus influence the behaviours of forest dwellers. Using this definition, we identify a broad universe of forest policies and measures in the literature reviewed (including key strategies in target countries), as presented in Appendix 2. We acknowledge this list is not exhaustive and could be supplemented in the future.

2.2 A generic theory of change of forest policies and measure

Some studies reviewed classify forest policies and measures according to a specific theoretical framework. For instance, Angelsen and Rudel (2013) use the forest transition theory in combination with a von Thünen-inspired land rent theory. They emphasize the structural drivers of deforestation and their evolution over time to classify forest policies according to which main driver they target. Alternatively, Börner et al. (2020) build on an institutionalist approach to human behaviour. This conceptualizes multiple types of rationality underlying the adoption of pro-environment behaviours to define three types of forest policies: incentive, disincentive, and enabling.

Our approach is also theory-based. On the first level, we rely on a ToC to help identify patterns in the way they are supposed to bring about change. At a second level, theories (e.g., theories of human behaviour) are used to characterize the various parts of our generic ToC (cf. the next subsection). Overall, this approach allows that policy solutions are rarely influenced by a single type of theory or paradigm, as illustrated with the case of PES (van Noordwijk et al. 2012)the non-provisioning part of ecosystem services, target alignment of microeconomic incentives for land users with meso- and macroeconomic societal costs and benefits of their choices across stakeholders and scales. They can interfere with or complement social norms and rights-based approaches at generic (land-use planning.

Given the diversity of policies and measures considered in this study, we need to work at a relatively high level of abstraction (Börner et al. 2020). We organize a generic ToC according to the main steps identified in the theory-based evaluation literature (Weiss 1997; White 2009; Niel et al. 2019; Börner et al. 2020)design, and implementation, our theory of change explicitly acknowledges context. Screening over 60,000 abstracts yielded 136 comparable normalized effect sizes (Cohen's d. A ToC is indeed conceptualized as a way to formalize causal mechanisms in a logical order, from actions implemented (inputs) to their direct consequences (outputs), their intended results (intermediary and long-term outcomes), and ultimately their final desired social and/or biophysical impacts (final impacts) (Niel et al. 2019). Our generic ToC is presented in Figure 1, and the specific content of each step is described below. It differs from other ToC of forest policies and measures formalized in the literature (Niel et al. 2019; Börner et al. 2020; Tritsch et al. 2020). Specifically, it emphasizes the activation of psychological precursors (motivations) as the direct consequence of implementing policies and measures (see below and in section 2.3).

Reading Figure 2 from left to right, we first consider that the implementation of forest policies and measures corresponds to our **generic input**. Second, we argue that forest policies and measures are generally implemented to modify the decisional environment of target actors to trigger specific psychological precursors conducive to behavioural change less detrimental to forests (**generic output**). In this paper, we build on the Self-Determination Theory (SDT) and the concepts of intrinsic motivation, extrinsic motivation, the internalization of extrinsic motivations, and human basic needs to account for the diversity of psychological precursors targeted by forest policies and measures (Deci and Ryan 1985). The SDT has been widely applied in the field on natural resource conservation and management (Rode et al. 2015; Ezzine-de-Blas et al. 2019). Appendix 3 summarizes concepts from the SDT used to build our typology of forest policies and measures. Third, we conceptualize behavioural change as our **generic intermediary outcome**. The nature of the behaviour targeted depends on the actor targeted by a given policy or measure. Fourth, forest policies and measures aim to mitigate at least one *assumed* cause of deforestation and forest degradation in the long run, either directly or indirectly (Roe et al. 2015). We refer to *assumed* causes to recognize that some policies and measures may target causes for which no consistent link with deforestation has been scientifically demonstrated (Busch and Ferretti-Gallon 2017). Following the literature using the open standards for the practice of conservation (Eshoo et al. 2018; Boshoven et al. 2021, 2022) we thus consider the mitigation of causes of deforestation as our **long-term outcome**. Lastly, the targeted **generic main impact** of all forest policies and measures that we include in our study (as per our definition) is deforestation and forest degradation reduction.

Inputs	Outputs	Short-term intermediary outcomes	Long-term intermediary outcomes	Impacts
Forest policies and measures implemented (transfer of material incentives or information)	Motivation targeted	Change in behaviour of targeted stakeholder(s)	Cause of deforestation mitigated	Deforestation and forest degradation reduced

Figure 1. Generic theory of change of forest policies and measures

Source: Authors' construction.

2.3 Attributes and sub-attributes characterizing forest policies and measures

The literature reviewed identifies an important difference between common approaches to archetype analysis. Archetypes can be identified either at the level of building blocks (e.g., attribute of policies' causal mechanisms) or at the level of cases (e.g., policies themselves) (Oberlack et al. 2019). For example, Agrawal et al. (2018) follow a "building blocks" approach. After defining three main dimensions of forest policies – information, institutional, and incentives – they concede that most real-world examples of forest policies are a mix of these dimensions or ideal-types. Following a "cases" approach, Pirard et al. (2019) categorize each policy by exactly one archetype. We opt for a "cases" approach to archetype analysis that builds on the description of attributes of cases to create mutually exclusive types of forest policies. Such an approach is more informative and more easily used by policymakers, who usually make decisions at the level of policies and measures.

We consider three attributes of forest policies and measures that characterize the three central steps of our generic ToC: actors, psychological mechanisms, and the forest threat targeted. We do not identify an attribute for the first and last steps because the first step (inputs) corresponds to the object of our analysis, i.e., the forest policies and measures that we want to classify. Meanwhile, the last step (impacts) is common to all policies and measures included in our study (no variability). In turn, we create a list of sub-attributes for each of these three main attributes (Table 1) using the SDT (Deci and Ryan 1985; Grolnick et al. 1997; Deci and Vansteenkiste 2003), the literature synthesizing the various actors targeted by deforestation reduction policies and measures (Bager et al. 2021) and the theoretical literature synthesizing causes of deforestation (Kaimowitz and Angelsen 1998; Geist and Lambin 2002; Angelsen and Rudel 2013; Busch and Ferretti-Gallon 2017).

We acknowledge that a given forest policy and measure can be characterized by several sub-attributes of the same attribute. Nevertheless, to be able to categorize each policy and measure into a single type, we identify a dominant sub-attribute for each forest policy and measure and each of the three central steps of the ToC. As a result, we can characterize each policy or measure as a combination of three dominant sub-attributes based on which we will build our typology.

Table 1. Attributes and sub-attributes used to create a typology of forest policies

Actors targeted by forest policies and measures	
Producers (three subgroups)	Land/forest owners and users producing forest-risk or forest-friendly commodities and products, in three main subgroups: (i) small-scale, subsistence-oriented farmers, (ii) medium/large-scale market-oriented farmers, and (iii) companies.
Supply chain actors	Stakeholders involved in the value chains of forest-risk or forest-friendly commodities and products who are not producers or consumers (e.g., input suppliers, slaughterhouse, agro-industrial multinational companies, etc.).
Consumers	End-users of forest-risk or forest-friendly commodities and products, including private individuals and public entities in producing and importing countries.
Governments and public actors	National and subnational governments, as well as national and subnational public administrations, ministries, offices, agencies of forest-rich tropical countries that have mandates related to land use.
Finance actors and investors	Actors involved in the movement of capital, assets, and financial resources that eventually affect land-use changes in tropical countries. Includes private and public entities, such as banks, investors, insurance companies, asset managers, and pension funds.
Motivations targeted by forest policies and measures	
Getting external rewards	One of the main externally regulated motivations in the SDT (Appendix 3) is that people behave to increase access to a reward that is often in the form of material benefits. This mechanism is associated with policies such as subsidies or PES.
Avoiding external punishment	One of the main externally regulated motivations in the SDT (Appendix 3) relates to the idea that individuals respond to fear of punishment for not complying with standards or restrictions set by laws or norms (Karp and Gaulding 1995). Authority figures such as the state typically have the power to induce obedience or compliance through coercion. This motivation is generally associated with command-and-control policies such as protected areas.
Satisfying the need for social relatedness	This is linked to one of the basic needs of the SDT (Appendix 3): that humans try to satisfy a feeling of social belongingness, i.e., a subjective feeling of inclusion or acceptance into a group of people. Thus, they tend to conform to behaviours they believe are valued by peers or society at large (Leary and Cox 2008). It includes sources of motivation such as social approval, image, shame, pride, guilt, reputation, and honour, which are triggered by this mechanism (Rode et al. 2015). This type of motivation is typically associated with informational policies such as consumer awareness campaigns or disclosure initiatives that aim at revealing a mismatch between a company's behaviour and broader societal values.

Table 1. Continue

Satisfying the need for competence/ self-efficacy	This is linked to one of the basic needs of the SDT (Appendix 3). It assumes that people try to satisfy a feeling of competence, i.e., to be effective in their interactions with their environment. It is very much linked to the concept of self-efficacy, i.e., "people's beliefs in their capabilities to exercise control over their own functioning and over events that affect their lives" (Bandura 1977). It is also linked to the idea that people are more likely to implement a given behaviour if they feel competent enough to do it successfully. This mechanism is typically associated with capacity-building initiatives, such as technology extension programmes.
Causes of deforestation mitigated by forest policies and measures	
Limited (captured) values of forests and benefits of forest-friendly activities	These policies and measures aim to increase perceived or captured use and non-use values of standing natural forests (Pascual et al. 2010) or increase the benefits of forest-friendly activities that contribute to reducing deforestation and forest degradation (e.g., sustainable timber harvesting practices, agroforestry) and/or enhance the provision of forest ecosystem services.
Large benefits from forest-degrading activities	These policies and measures aim to reduce the benefits of activities that generate deforestation, forest degradation or loss of forest ecosystem services, including agricultural expansion and unsustainable logging.
Weak governance	These policies and measures aim to address underlying drivers of deforestation and forest degradation associated with governance failure such as weak law enforcement, corruption, and open access conditions.
Inadequate human development	These policies and measures aim to address underlying drivers of deforestation and forest degradation associated with human and economic development, such as lack of alternative income sources and growing population.
Inadequate demand for forest-related commodities	These policies and measures aim to address underlying drivers of deforestation and forest degradation associated with inadequate levels of demand for forest-risk (too high) and forest-friendly (too low) commodities and products.

Depending on the purpose, the various attributes can be further split into subcategories, e.g., different subgroups of producers, supply chain actors or end-consumers. In some cases, this may be critical for policy impacts. A typical example is the differentiated response by subsistence vs. commercially oriented farmers to policy or market changes e.g., Angelsen (1999). The introduction of higher yielding agricultural technologies among subsistence-oriented farmers may reduce the need for agricultural land expansion. Meanwhile, it provides market-oriented farmers with an opportunity to increase profits by expanding their agricultural land area.

3 Typology of forest policies and measures

This section presents results of the classification of the policies and measures identified in the references in Appendix 1. The 35 policies and measures included in this study are listed in Appendix 2. We present two levels of aggregation, with two and three common dominant sub-attributes, respectively. Increasing the level of aggregation reduces the within-type homogeneity of underlying ToCs. However, it allows for reducing the number of types and thus increasing the likelihood of identifying enough evidence for the impact of each type.

3.1 Low level of aggregation

Our classification is based on the characterization of each policy or measure included in our sample with three dominant sub-attributes. To avoid a subjectivity bias, each author individually identified the dominant sub-attributes of each forest policy and measure independently. Results of this coding process were compared and any difference was discussed until an agreement was reached. Some policies such as multistakeholder forums or taxes target a particularly large spectrum of stakeholders, making it impossible to identify a dominant type of actor targeted. In these cases, we add a "multiple" category. Results are summarized in Table 2.

At a first level, Table 2 (column 5) presents 20 different combinations of dominant building blocks. These 20 combinations correspond to disaggregated but homogeneous types of policies and measures. All policies and measures in a given type share the exact same three dominant sub-attributes (see Table 2).

Table 2. Summary of disaggregated and broad types of forest policies and measures identified (n=35)

| Actor targeted	Motivation targeted	Cause of deforestation mitigated	Policies and measures	Disaggregated types (n=20)	Broad types (n=10)
Producers	Rewards	Forest values and benefits	PES, conservation ecotourism, certification schemes, conservation easement	1	1
Producers	Rewards	Development conditions	Conditional cash transfers		1
Producers	Punishment	Benefits from other land use	Offsetting schemes, government moratoriums, monitoring systems	4	2
Producers	Punishment	Governance	Protected areas, land-use zoning	5	2
Producers	Belongingness	Forest values and benefits	Environmental education programmes	6	3
Producers	Competence	Benefits from other land use	Infrastructure development	7	4

Table 2. Continue

Producers	Competence	Forest values and benefits	Conservation concessions, tenure recognition, community forest schemes, logging concessions	8	4
Producers	Competence	Development conditions	family planning, ICDP	9	4
Multiple	Belongingness	Governance	Bilateral agreements, multistakeholder forums	10	5
Government	Rewards	Governance	Ecological fiscal transfers, debt relief, conditional loan	11	6
Government	Competence	Governance	Decentralization, anti-corruption policies	12	6
Consumers	Belongingness	Demand	Consumer campaigns	13	7
Consumers	Competence	Demand	Technology extension to curb demand (e.g., improved cookstoves)	14	7
Supply chain	Rewards	Demand	Procurement policies	15	8
Supply chain	Punishment	Demand	Due diligence policies	16	8
Supply chain	Belongingness	Demand	Public disclosure initiatives	17	8
Finance	Rewards	Demand	Blended finance	18	9
Multiple	Rewards	Forest values and benefits	Subsidies and tax reduction, conditional credit access	19	9
Multiple	Punishment	Benefits from other land use	Supply chain moratoriums, taxes	20	10

3.2 Higher level of aggregation

To identify types at a higher level of aggregation, we ran a cluster analysis on our three attribute variables using RStudio (Version: 2022.07.2+576) and the Cluster package. We use the Gower distance to calculate the dissimilarity matrix (Gower 1971) and then run a bottom-up approach to cluster analysis (agglomerative). The Gower distance measure is recommended for categorical variables. Figure 2 shows the results of the cluster analysis, including the short names of our policies and measures at the bottom. Depending on the height at which we cut the dendrogram, we obtain a number of policy types that ranges from 20 at height=0 (our disaggregated types) to 5 at height=1. We chose an intermediary level of aggregation that corresponds to a height of approximately 0.6 in Figure 2. This provides the best balance between (i) within-type homogeneity – types that share at least two common attribute levels, and (ii) a relatively low number of types – 10 broad types. These broad types are described below following numbers reported in Figure 2 and in the last column of Table 2.
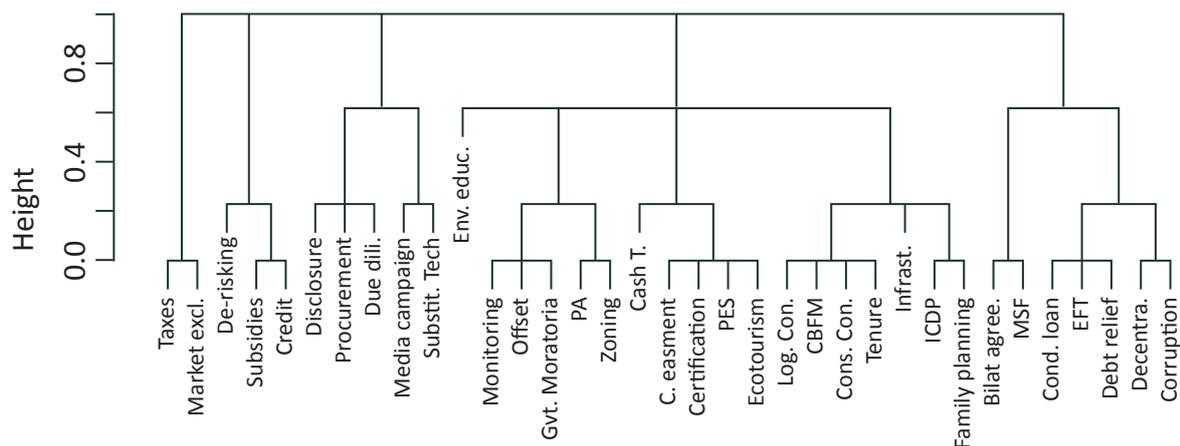
Figure 2. Results of the agglomerative cluster analysis based on Gower distance applied to forest policies and measures

Four broad types target producers in forest-rich countries:

- **Type 1** includes policies and measures targeting the prospect of rewards as a source of motivation, typically economic incentives such as PES.

- **Type 2** includes all policies and measures associated with the setting of restrictions on land use and a punishment mechanism for producers who do not comply with these restrictions, typically command-and-control measures such as protected areas.

- **Type 3** includes only one policy, namely environmental education. It differs from other policy types targeting producers as it relies on a different type of motivation, i.e., the satisfaction of social belongingness.

- **Type 4** includes includes policies and measures aimed at changing producers' behaviours by influencing their competencies/capabilities. All policies and measures based on a clarification or transfer of tenure rights such as community forestry schemes fall under Type 4. It also includes policies with a strong development aspect such as integrated conservation and development projects (ICDPs) and infrastructure development. This classification of policies targeting producers reflects how paradigms underlying the conservation of natural resources evolved from command-and-control to economic incentive solutions (Gómez-Baggethun et al. 2010; Boisvert et al. 2013), before slowly integrating lessons from the psychology literature to diversify solutions (Belinga et al. 2021; Gutierrez-Castillo et al. 2022).

Two broad policy types target government actors or multiple stakeholders that include government actors and aim to improve the governance of tropical forested countries:

- **Type 5** encompasses policies and measures that intend to bring about change by increasing linkages between multiple stakeholders, especially in multistakeholder platforms. The literature has heavily advocated for collaborative environmental governance and solutions (Bodin 2017; Reed et al. 2020) and increased linkages between actors have proved to influence deforestation outcomes locally (Wright et al. 2016).

- **Type 6** encompasses policies that specifically target government actors of forest-rich countries and are aimed at improving governance. This type reflects the recognition that national and

subnational authorities play a major role in tackling deforestation. This can be tracked in the literature on decentralization of natural resource governance (Larson 2002) and the more recent literature on jurisdictional approaches (Seymour et al. 2018). Policies and measures belonging to Type 6 aim to improve governance by implementing good governance principles such as accountability or participation (Lockwood 2010) or by creating economic incentives to curve policymakers' decisions (Busch et al. 2021).

Two broad types encompass forest policies and measures aimed at curving demand for forest-related commodities and products:

- **Type 7** targets end-consumers, thus reflecting the increasing recognition of the role played by public opinion and consumption behaviours in driving change, especially among intermediate supply chain actors' behaviours (Lambin et al. 2018; Belinga et al. 2021).

- **Type 8** encompasses policies and measures targeting intermediate supply chain actors, recognizing the importance of international trade in driving deforestation and the increasing role played by a relatively small number of multinational traders and retailers in forest-risk commodities' supply chains (Walker et al. 2013).

The two last broad types can both be used to influence the behaviour of a broad spectrum of actors.

- **Type 9** encompasses policies and measures aimed at limited captured values of forests and benefits of forest-friendly activities through the transfer of economic rewards. Unlike Type 1, Type 9 policies and measures target a larger spectrum of supply chain actors, especially investors and intermediate supply chain actors.

- **Type 10** corresponds to policies and measures to reduce the benefits of forest-degrading activities through use of economic sanctions and that can target a broader range of supply chain actors, i.e., generally producers and intermediate supply chain actors.

4 Concluding remarks

Middle-range theories can be formulated to summarize the conditions under which forest policies and measures are effective in halting deforestation and forest degradation. A key element towards such middle-range policies is a typology of forest policies and measures. Forest policies and measures sometimes share common characteristics or theoretical underpinnings about how they are supposed to bring about change, which makes it possible to cluster them in a way done in this paper. We have demonstrated how archetype analysis as a methodological approach can advance the study of the diversity of forest policies and measures. This is similar to how it has proved well-suited to develop middle-range theories of institutional diversity (Oberlack and Eisenack 2018). Our approach adds to the forest policy typology literature because it is based on a methodology that is bottom-up, systematic, replicable and that can accommodate a large number of cases.

Overall, we identify and characterize 10 broad types of forest policies, as reported in Table 2 and Figure 2. The pool of policies and measures used in our archetype analysis is not exhaustive. However, it is arguably large enough for the types identified to be relatively robust to the inclusion of new cases under the current conditions of policy diversification. We anticipate the typology identified may evolve as new forest policies and measures emerge to consider scientific advances and changing societal conditions. For example, the same analysis 15 years ago might not have found the same typology. In particular, we might have missed demand-side policies or policies triggering 'alternative' psychological mechanisms such as social belongingness. These have only recently emerged following the intensification of international trade combined with a swelling knowledge base that quantifies distant causes of deforestation (Munroe et al. 2019), and the multiplication of attempts to apply social psychology theories to the field of natural resource management (Stenseke 2018).

Breaking down forest policies and measures into attributes and sub-attributes linked together by a generic ToC is at the heart of our archetype identification strategy. This feature makes our empirical approach suitable for integration into a diagnostic framework aimed at analysing the conditions of effectiveness of forest policies and measures. A diagnostic framework aims to support identification of the specific causes of a problem and the conditions under which this problem develops that are key from a problem-solving perspective (Young 2002). An essential aspect of a diagnostic framework is its ability to break down complex systems into relatively independent lower-level elements. This facilitates characterization of complex systems and analysis of patterns of interactions between sub-elements and how these interactions affect overall system performance (Ostrom et al. 2007). Conducting an archetype analysis of forest policies and measures is one step towards completing such a diagnostic framework and eventually formulating middle-range theories about what policy works in what context.

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Appendixes

1. List of references reviewed to design our empirical approach

A. Academic literature reviewed

#	Reference
1	Agrawal A, Hajjar R, Liao C, Rasmussen LV, Watkins C. 2018. Editorial overview: Forest governance interventions for sustainability through information, incentives, and institutions. *Current Opinion in Environmental Sustainability* 32: A1–A7. https://doi.org/10.1016/j.cosust.2018.08.002
2	Angelsen A and Rudel TK. 2013. Designing and implementing effective REDD + policies: A forest transition approach. *Review of Environmental Economics and Policy* 7(1): 91–113. https://doi.org/10.1093/reep/res022
3	Angelsen A. 2010. Policies for reduced deforestation and their impact on agricultural production. *Proceedings of the National Academy of Sciences* 107(46): 19639–19644. https://doi.org/10.1073/pnas.0912014107
4	Bager SL, Persson UM, dos Reis TNP. 2021. Eighty-six EU policy options for reducing imported deforestation. *One Earth* 4(2): 289–306. https://doi.org/10.1016/j.oneear.2021.01.011
5	Pirard R, Wunder S, Duchelle AE, Puri J, Asfaw S, Bulusu M, Petit H, Vedoveto M. 2019. *Effectiveness of forest conservation interventions: An evidence gap map.* Bogor, Indonesia: CIFOR. 68.
6	Börner J, Baylis K, Corbera E, Ezzine-de-Blas D, Honey-Rosés J, Persson UM, Wunder S. 2017. The effectiveness of payments for environmental services. *World Development* 96: 359–374. https://doi.org/10.1016/j.worlddev.2017.03.020
7	Börner J, Schulz D, Wunder S, Pfaff A. 2020. The effectiveness of forest conservation policies and programs. *Annual Review of Resource Economics* 12(1): 45–64. https://doi.org/10.1146/annurev-resource-110119-025703
8	Pfaff A, Amacher GS, Sills EO. 2013. Realistic REDD: Improving the forest impacts of domestic policies in different settings. *Review of Environmental Economics and Policy* 7(1): 114–135. https://doi.org/10.1093/reep/res023
9	Lambin EF, Meyfroidt P, Rueda X, Blackman A, Börner J, Cerutti PO, Dietsch T, Jungmann L, Lamarque P, Lister J, et al. 2014. Effectiveness and synergies of policy instruments for land use governance in tropical regions. *Global Environmental Change* 28: 129–140. https://doi.org/10.1016/j.gloenvcha.2014.06.007
10	Lambin EF, Gibbs HK, Heilmayr R, Carlson KM, Fleck LC, Garrett RD, le Polain de Waroux Y, McDermott CL, McLaughlin D, Newton P, et al. 2018. The role of supply-chain initiatives in reducing deforestation. *Nature Climate Change* 8(2): 109–116. https://doi.org/10.1038/s41558-017-0061-1
11	Reed J, Ickowitz A, Chervier C, Djoudi H, Moombe K, Ros-Tonen M, Yanou M, Yuliani L, Sunderland T. 2020. Integrated landscape approaches in the tropics: A brief stock-take. *Land Use Policy* 99: 104822. https://doi.org/10.1016/j.landusepol.2020.104822

12	Seymour F, Boyd W, Stickler C, Duchelle A, Nepstad D, Bahar NH, Rodriguez-Ward, D. 2018. *Ending tropical deforestation: Jurisdictional approaches to REDD+ and low emissions development: Progress and prospects*. Washington, DC: World Resources Institute.
13	Walker N, Patel S, Davies F, Milledge S, Hulse J. 2013. *Demand-side interventions to reduce deforestation and forest degradation.* London: International Institute for Environment and Development. 27.
14	Wunder S, Börner J, Ezzine-de-Blas D, Feder S, Pagiola S. 2020. Payments for environmental services: Past performance and pending potentials. *Annual Review of Resource Economics* 12: 209–234. https://doi.org/10.1146/annurev-resource-100518-094206
15	Meyfroidt P, Rudel TK, Lambin EF. 2010. Forest transitions, trade, and the global displacement of land use. *Proceedings of the National Academy of Sciences* 107(49): 20917-20922. https://doi.org/10.1073/pnas.1014773107
16	Niel B, Laurans Y, Lapeyre R, Motel PC, Combes J-L. 2019. *Why do anti-deforestation policies succeed or fail? Review of the theory of change emerging from the existing literature*. https://halshs.archives-ouvertes.fr/halshs-02090658
17	DeValue K, Takahashi N, Woolnough T, Merle C, Fortuna S, Agostini A. 2022. *Halting deforestation from agricultural value chains: The role of governments*. Rome: Food and Agriculture Organization of the United Nations.

B. Policy documents consulted

Country	Document	Link/Source
Brazil	LEAF Initiative for subnational efforts	https://leafcoalition.org/resources/
Democratic Republic of Congo	National REDD+ Strategy	https://medd.gouv.cd/strategie-cadre-nationale-redd-de-la-republique-democratique-du-congo/
	LEAF initiative Tshopo	https://leafcoalition.org/resources/
Indonesia	Forest Carbon Partnership Facility Carbon Fund. Emission Reductions Program Document (ER-PD). East Kalimantan Jurisdictional Emission Reductions Program, Indonesia	https://www.forestcarbonpartnership.org/system/files/documents/ERPD_Indonesia%20FINAL%20VERSION_MAY_2019.pdf
	Updated National Determined Contribution – Republic of Indonesia	http://ditjenppi.menlhk.go.id/reddplus/images/adminppi/adaptasi/dokumen/Updated_NDC.pdf
Peru	List of REDD+ Actions, defined by the Environment Ministry.	https://dar.org.pe/minam-publico-los-lineamientos-de-las-acciones-redd/
	LEAF initiative for subnational efforts	https://leafcoalition.org/resources/

2. Definitions of the forest policies and measures included used in the archetype analysis

A. Definitions

Policy name	Description
PES	"Voluntary transactions between service users and service providers that are conditional on agreed rules of natural resource management for generating offsite services" (Wunder 2015). Encompass both user and government-financed PES.
Conservation ecotourism	"Ecotourism is a specific kind of tourism, distinguished from nature tourism and outdoor recreation by its conservation and development goals. Tourism, when designed and practiced as ecotourism, can benefit wildlife and biodiversity, create incentives to protect landscapes, and support local communities" (Stronza et al. 2019).
Certification schemes	Programmes that "accredit goods and services that have met defined process standards meant to protect the environment and social welfare in the places of origin" (Lambin et al. 2014). Generally associated with either a premium price or a preferred market access incentive. Include private schemes such as sustainable palm oil certifications by the Roundtable for Sustainable Palm Oil or sustainable timber certified by the Forest Stewardship Council (FSC) and geographical indications.
Conservation easements	"a negotiated, legally binding agreement between individuals who own property and a second-party organization (e.g., state agency or nongovernmental organization such as a land trust). A conservation easement restricts specific activities on the property in order to meet the owner's goals and the organization's conservation objectives" (Farmer et al. 2011).
Ignore infrastructure development	Avoiding the construction of new road infrastructures or favouring the closing of existing roads to avoid deforestation or impact on biodiversity-rich areas (Angelsen 2010).
ICDPs	"Initiatives that aim to manage and conserve natural resources including biodiversity with socioeconomic development components or goals" (Brandon and Wells 1992). Some have understood this as conservation approaches that include the use of socio-economic investment tools to achieve conservation objectives" (Minang and van Noordwijk 2013).
Conditional cash transfers	Transfer of income to poor households that is conditional on taking specific actions, usually related to education and health. "Conditional cash transfers aim to enhance human capital and thereby reduce the intergenerational transfer of poverty" (Ferraro and Simorangkir 2020).

Offsets/cap and trade	"Compensating for losses of biodiversity components at an impact site by generating (or attempting to generate) ecologically equivalent gains, or 'credits', elsewhere (i.e. an offset site). Offsets can be achieved in two main ways: (1) via averted loss from ongoing or anticipated impacts (e.g., avoided deforestation or degradation) at a site through the removal of threatening processes and (2) by enhancement of a degraded site through restoration and rehabilitation ('restoration offsets')" (Maron et al. 2012). The Environmental Reserve Quotas (CAR) was conceived as an offset mechanism (Soares-Filho et al. 2016).
Government Moratorium	Government measure aimed at imposing limitations on land-based development activities by enacting a temporary suspension of new land-related rights by public authorities. A prominent example is Indonesia's moratorium on new oil palm, timber, and logging concessions (Busch et al. 2015).
Protected areas	"A clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Dudley 2008). "The term embraces a wide range of different management approaches, from highly protected sites where few if any people are allowed to enter, through parks where the emphasis is on conservation but visitors are welcome, to much less restrictive approaches where conservation is integrated into the traditional (and sometimes not so traditional) human lifestyles or even takes place alongside limited sustainable resource extraction. Some protected areas ban activities like food collecting, hunting or extraction of natural resources while for others it is an accepted and even a necessary part of management" (Dudley 2008).
Land use zoning	"Land use zoning results from a spatial planning process that divides a territory into zones with different rules and regulations for land use, management practices, and land cover change. In and of itself, zoning does not promote sustainability but supports legal land use regulations for different units of a landscape" (Lambin et al. 2014). It includes setting the boundaries for forest estate.
Environmental education	"Encompasses approaches, tools, and programs that develop and support environmentally related attitudes, values, awareness, knowledge, and skills that prepare people to take informed action on behalf of the environment" (Ardoin et al. 2020). It targets numerous groups, including those that may be marginalized.
Conservation concessions	"Comprise public land of which the access, management and exclusion rights are granted to non-government actors for conservation purposes, typically for a specific period of time" (Schleicher 2018). It is generally associated with the prospect of direct payments made to keep the forest intact.
Tenure recognition	Policies that promote recognition of tenure rights. Recognition, in this context, implies a legal process aimed at formalizing, through law or de jure process, rights that are already being held through customary, informal or de facto mechanisms (Fitzpatrick 2005).
Community Forest Management	Forest management approaches where governance is devolved to local community groups or institutions, to varying degrees (Bowler et al. 2012).

Logging concessions	Scheme through which the state "gives a company the exclusive right to exploit timber resources over clearly-defined boundaries in its private domain for a specified period. In return, concessionaires must meet several requirements in terms of taxation or provision of public goods" (Lescuyer et al. 2012).
Family planning programs	Interventions that promote the use of family planning in order to lower fertility rates (Sellers 2017).
Ecological fiscal transfers	Schemes that "transfer public revenue between governments within a country based on ecological indicators. Here, 'ecological' refers to ecological public functions of governments, which encompass both nature conservation and abatement of environmental pollution. EFTs may transfer revenue 'vertically' from higher-level to lower-level governments or 'horizontally' between governments at the same level. EFT may be 'general-purpose' transfers to subnational government budgets that can be spent on any priority of recipient jurisdictions, whether ecological or non-ecological. Or they may be 'specific-purpose' transfers earmarked for a particular ecological use, for example, reforestation or water treatment" (Busch et al. 2021).
Conditional debt relief	"Debt to foreign countries and to international banks may encourage forest loss. Debt-for-nature swaps try to address this by reducing international debt, typically in exchange for establishing a conservation trust fund within the debtor nation" (Pfaff et al. 2013).
Conditional loan or oversee development aid	Conditional loans attach specific reforms – improved law enforcement, expanded parks areas, economic policy changes – to lending from governments and multilateral financial institutions (Pfaff et al. 2013).
Political decentralization	"Any political act in which a central government formally cedes powers to actors and institutions at lower levels in a political-administrative and territorial hierarchy" (Ribot et al. 2006). "Political decentralization involves the transfer of power to actors or institutions that are accountable to the population in their jurisdiction" (Ribot et al. 2006).
Anti-corruption policies	Policy reforms aimed at influencing benefits and costs from corruption linked to the use of forests, including in particular to reduce opportunities to generate excessive private rents through bribes, increase penalties and/or the likelihood of being discovered and punished (by increasing accountability and transparency) (Tacconi et al. 2009). In Brazil, exposing corrupt politicians by making results from financial publicly available records reduced their reelection chances (Ferraz and Finan 2008).These reforms often need to take place outside the forest sector to regulate how political parties are financed, regulating lobbying, judicial reform, the establishment of anti-corruption commissions and free media (Tacconi et al. 2009).
Procurement policies	The criteria governments set for their purchases of forest-risk products (Brack 2013). An example is the EU Renewable Energy Directive (EU RED) according to which all biofuels used in the EU must comply with sustainability criteria (Walker et al. 2013).

Due diligence requirements on industry	"Requirements on industry, requiring companies to put in place procedures to minimize the chance of them handling illegal products, as in the EU Timber Regulation and the Australian Illegal Logging Prohibition Act" (Brack 2013).
Public disclosure initiatives	Initiatives, which involve public and/or private attempts to increase the availability of information on behaviours harmful to the environment (Tietenberg 1998). "Disclosure initiatives have been instituted by civil society, often with the backing of financial institutions (banks, pension funds, asset managers, insurance companies and foundations), to emphasise the importance of full information and disclosure throughout the supply chains" (Walker et al. 2013) and by governments (Cisneros et al. 2015).
Consumer/ social media campaigns/ boycotts	Marketing strategy aimed at changing consumption (i.e., reducing the consumption of deforestation-risk products or increasing the consumption of forest-friendly products) by increasing consumers' awareness about environmental sustainability and informing them about the benefits and risks of products and services (Dangelico and Vocalelli 2017). This can lead to boycotts, i.e., an organization calling on consumers to avoid purchasing a particular product or brand (Walker et al. 2013).
Extension programmes to curb demand for timber products	Programmes aimed at enhancing the adoption of technologies and practices that reduce the demand for timber such as cookstoves (Chan et al. 2015) or increase the supply of off-forest timber such as agroforestry (Minang et al. 2014).
Blended finance initiatives	A model that directs public finance to de-risk and mobilize private or other sources of finance for sustainable development, concessional finance, and green bonds. This can be used to access private capital to fund more sustainable agricultural practices (DeValue et al. 2022).
Monitoring tools	Satellite-based system for real-time detection of deforestation. Such free deforestation alerts reduce the cost to policymakers of monitoring forests, thereby reducing the cost of implementing deforestation policy (Moffette et al. 2021). The act of monitoring can encourage compliance with laws (Rasmussen and Jepsen 2018). It is the key tool for targeting law enforcement activities in the Brazilian Amazon (Assunção et al. 2017).
Bilateral agreements	"Bilateral agreements between consumer and producer countries to establish licensing systems designed to ensure that only legal products enter trade between the two, and improve forest governance in the producer country, such as the voluntary partnership agreements currently being negotiated and implemented under the EU Forest Law Enforcement, Governance and Trade (FLEGT) initiative" (Brack 2013). Such a programme "is intended to reinforce producer-country government reforms that aim to improve forest governance" (Pfaff et al. 2013).
Multi-stakeholder forums	"Purposefully organized interactive processes that bring together stakeholders to participate in dialogue, decision-making and/or implementation regarding actions seeking to address a problem they hold in common or to achieve a goal for their common benefit" (Sarmiento Barletti et al. 2020).

Tax relief and environmental subsidies	Environmental subsidies are economic transfers by a legislator intended to reduce the costs of activities that help protect the environment or reduce the use and extraction of natural resources (European Union 2015). Tax relief measures are "arrangements and provisions in general tax schemes, with the explicit aim of providing positive financial incentives steering the taxpayers' behaviour in a more biodiversity-friendly direction" (Ring and Schröter-Schlaack 2011). "Usually applies reduced rates or exemptions conditional on certain 'biodiversity-friendly' requirements that the taxpayer should fulfil" (Ring and Schröter-Schlaack 2011).
Environmental tax, user fees and reduced subsidies	Tax levied on an agent causing an environmental externality (environmental damage) as an incentive to avert or mitigate such damage (Hansen and Lund 2018). This also includes tariffs, i.e., a tax to be paid on a particular class of imports or exports. In this category, we also include both user fees (economic mechanisms that secure revenues from users of biodiversity and ecosystem services) and the reduction of subsidies (for agriculture in particular).
Conditional access to credit	Policy that makes the concession of rural credit conditioned upon proof of compliance with legal requirements that contribute to protect the environment. A prominent example is Resolution 3545 published by the Brazilian Central Bank in 2008 (Assunção et al. 2020).
Moratoriums/ standards associated with market exclusion	In these agreements, brokered by civil society, a significant proportion of an industry agrees to avoid purchasing products arising from a particular area or from deforestation in a specific area (Walker et al. 2013). "The soy moratorium in Brazil took shape shortly after an NGO report linking illegal deforestation to soy fed to chickens sold in major fast food chains" (Lambin et al. 2014).

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3. Concepts of the self-determination theory used to build our typology of forest policies and measures

Summary of the concepts used

At a fundamental level, the SDT distinguishes intrinsic from extrinsic motivations. Intrinsically motivated behaviours "are performed out of interest and require no separable consequence, no external or intrapsychic prod, promise, or threat" (Deci et al. 1996). In contrast, being extrinsically motivated involves "performing an activity with the intention of attaining some separable consequence" (Deci et al. 1996).

In turn, the SDT distinguishes between fully extrinsic motivations (or externally regulated) and a continuum of at least partially internalized external motivations (Deci and Ryan 1985). Internalization is here understood as the process by which individuals progressively transform external regulations into personal attributes or values. Externally regulated motivations are associated with behaviours controlled by contingencies overtly external to the individual and involve doing something to get an **external reward** or **avoid a punishment**. A typical example of partially internalized extrinsic motivations involve behaviours that are motivated by "internal prods and external pressures such as threats of guilt, shame or self-esteem-relevant contingencies" (Deci et al. 1996).

Finally, the SDT suggests that basic need satisfaction is important for promoting the internalization process. In particular, people take in regulations because "they feel **related to important others** who advocate the behaviours and because they feel **competent** and effective in functioning within the social world" (Deci and Vansteenkiste 2003). Indeed, as its core idea, the SDT suggests people have inherent psychological needs in three areas: competence, relatedness, and autonomy. Satisfaction of these needs is associated with higher well-being but also with decisions that are more intrinsically motivated. The need for competence corresponds to the desire to be effective in one's interactions with the environment, to express or exercise one's abilities and to overcome challenges (White 1959; Deci and Ryan 2000). The need for relatedness corresponds to the desire to connect with others, to receive care and attention from people important to oneself, and to belong to a community or social group (Baumeister and Leary 1995; Deci and Ryan 2000). Finally, the need for autonomy relates to the need for individuals to be at the origin of their own behaviours, to experience volition and to act according to their own interest or values (DeCharms 1968).

Additional SDT used for Appendix 3

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Decision makers have access to a large and growing toolbox of policies and measures that can, in theory, contribute to reducing deforestation and forest degradation. Middle-range theories can be formulated to summarize the conditions under which forest policies and measures are effective in halting deforestation and forest degradation. Such a diagnostics approach can, in turn, provide useful information to help decision makers avoid the trap of one-size-fits-all policy solutions and implement well-informed, context-specific policy solutions. A key element in this approach is the construction of a typology of forest policies and measures. Here we develop and apply an archetype analysis of forest policy and measures as a systematic, bottom-up and replicable way to build such a typology. Our empirical approach is based on three key elements: a broad universe of cases of forest policies and measures, a generic theory of change (ToC) of forest policies and measures, and a list of attributes characterizing this theory of change. Overall, we identify and characterize 10 broad types of forest policies. On the one hand, these encompass historical solutions aimed at changing producers' behaviours such as command-and-control policies and economic incentives. On the other hand, they encompass emerging demand-side policies and policies triggering psychological mechanisms such as social belongingness.

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