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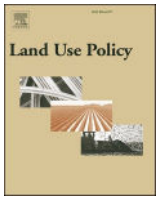

Public and private sector zero-deforestation commitments and their impacts: A case study from South Sumatra Province, Indonesia

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ABSTRACT

In Asia, Africa, and Latin America, complex drivers of deforestation have sparked mandatory and voluntary initiatives, including moratorium policies, zero-deforestation pledges and certification systems. The impacts of these different commitments, which aim to reduce deforestation, have yet to be documented or analytically scrutinized. Using South Sumatra as a case study, we used the Institutional Analysis and Development (IAD) framework to identify the context and impacts of public and private sector commitments. Public sector commitment was assessed by examining political will reflected in government policies and regulations, while private sector commitment was assessed by looking at compliance with mandatory and voluntary certification schemes. South Sumatra lost 63% of its natural forest between 1990 and 2019. Deforestation is driven by expansion of large-scale commercial plantations, as well as illegal logging and clearing. Our study indicates that public and private sector commitments do matter. Statistically, we found sufficient evidence that private sector commitments were able to significantly reduce deforestation from year of commitments to 2019, at a 90% confidence level. Efforts to support zero-deforestation commitments must involve radical shifts in current policy and practice, with stricter law enforcement to combat illegal activities, greater transparency to inform progress, and the development of strategic and actionable plans.

1. Introduction

Global deforestation is driven by direct, i.e. human, activities, as well as indirect or underlying drivers, i.e. complex social, economic, political, cultural, and technological interactions at multiple scales (Kissinger et al., 2012). In the tropical forests of Indonesia, these drivers are spatially and temporally dynamic, with large-scale oil palm and timber contributing to deforestation before 2016, followed by other types of conversion of forest to open land after 2016. Small-scale plantations and agriculture contribute about one fifth to the forest loss (Austin et al., 2019). Deforestation has occurred both inside and outside state forest zones *(SFZ - kawasan hutan negara)* since the 1970 s. After the President Soeharto administration in the late 1990 s, the Government of Indonesia reduced forest loss by issuing targeted regulations aiming to halt continued deforestation and degradation, promoting forest management reforms, and prosecuting illegal activities (Scholte, 2019). Although the current rate of deforestation has significantly decreased (Scholte, 2019), Indonesia still suffers from illegal activities, signaling the threat of continued deforestation, and of underlying drivers that demand stricter law enforcement (Tacconi et al., 2019).

In its first Nationally Determined Contribution (NDC) under the United Nations Framework Convention on Climate Change (UNFCCC), the Government of Indonesia (2016) stated that with business-as-usual, the country would see planned and unplanned deforestation between 2013 and 2020 of an estimated 0.92 million hectares (Mha)/year. This assessment follows modeling around the rate of planned and unplanned deforestation under business-as-usual and two climate mitigation scenarios for 2021–2030, whereby deforestation is assumed to decrease by 0.33 Mha/year (under the climate mitigation scenarios) to 0.82 Mha/-year (business-as-usual). The model neglects to include unplanned

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deforestation that is likely to occur beyond 2030, which is beyond the control of the government. Implementation of the NDC to date has seen a lack of support due to significant gaps, disconnects with local regulations, different perceptions of climate change regulations among national and subnational actors (Sulistiawati, 2020), and persistent competing interests for land use across different sectors. President Joko Widodo's *Nawacita* (nine priority agendas) positioned the agricultural sector as the engine of national development. Following this agenda, the Ministry of Agriculture (2020a) developed a strategy that included an increase in the availability and utilization of land, with the aim of achieving food security and sovereignty. Despite the increased land use targets, Indonesia has been able to continue reducing deforestation, which averaged 0.11 Mha/year during the 2019–2020 period.

Oil palm plantations in Indonesia now occupy an estimated 16.4 Mha, which represents about a 40% increase from 2011 (Ministry of Agriculture, 2020b, 2020c). The increasing demand for palm oil has resulted in massive expansion of plantations and associated forest conversion (Koh and Wilcove, 2007; Hansen et al., 2009; Margono et al., 2014; Vijay et al., 2016; Gaveau et al., 2018). If managed sustainably, agricultural commodities like palm oil have the potential to be an important source of regional development and economic growth. Sustainable management, however requires a hybrid approach, which spans both public policy and private standards (Purnomo et al., 2018). While certification schemes have potential to curb deforestation, previous studies have shown that alone the Roundtable on Sustainable Palm Oil (RSPO) and Indonesia Sustainable Palm Oil (ISPO) schemes have had limited effects in curtailing oil palm plantation-driven deforestation (Hidayat et al., 2018; Amalia et al., 2019), and leakage from certification can reduce deforestation in certain zones but increase it in others (Heilmayr et al., 2020). Furthermore, certified palm oil producers are not yet able to get premium prices from the market to justify certification costs (Hutabarat et al., 2018). The economic incentives for certification have not been in place. As a result, only 10.33 Mtons of CPO and PKO (20%) or 2.1 Mha (13%) of oil palm plantations are certified in Indonesia (Statista, 2019; Investor Daily, 2019). In response, a growing zero-deforestation movement has gained momentum and capitalized on multi-stakeholder work and partnerships at all levels (Pirard et al., 2015; FAO, 2018).

Pledges to combat deforestation are reflected in the New York Declaration on Forests (NYDF), which set targets to reduce deforestation by 2020 and end it by 2030 (NYDF, 2020). One of these efforts is the adoption of sustainable practices by both the private and public sectors. Private initiatives include payment for environmental services (PES), and price premiums relating to certified market and sustainability standards. Public sector initiatives include mandatory certification for forestry and oil palm, mainstreaming green growth, adopting sustainable development goals (SDGs) and reducing emission from deforestation and forest degradation plus (REDD+). Some initiatives have been identified as particularly effective in combatting deforestation, including the role of NGOs as intermediaries; hybrid governance that combines jurisdictional and value-chain based interventions; private initiatives; and public policies. However, with the deadline now passed, evidence shows it has been impossible to achieve the 2020 targets (Pacheco et al., 2018; NYDF Assessment Partners, 2019).

The operationalization of zero-deforestation commitments has faced many challenges. While these commitments affect supply chain actors, actions are often ineffectively coordinated (FAO, 2017a). Previous studies indicate overlapping initiatives (Ludwig, 2018), resulting in inconsistencies amongst corporate actions across both supply chain and commodities (CDP, 2014). While there is a high degree of complementarity among public and private sustainability initiatives at the agenda setting stage, later stages are marked by tensions, particularly played out between authorities at different levels (Luttrell et al., 2018). Public sector agencies have faced competing political agendas and conflicting objectives, causing the legal framework for commitment implementation to be partially misaligned (Pirard et al., 2015). As such, only a few governments have seen results for their efforts (FAO, 2018). In general, despite commitments made by powerful high-level actors, clear rules and approaches are lacking for implementation (Ludwig, 2018). Deforestation-related terms like 'deforestation free', 'zero deforestation', 'zero gross deforestation', and 'zero net deforestation' are used interchangeably without any clarity, generating confusion among those who have committed to implement initiatives (Brown and Zarin, 2013). On the private sector side, little is known on how the progress of companies can be judged or justified (FAO, 2018). There have been studies on zero deforestation of private sector commitment (FAO, 2017a; Jopke and Schoneveld, 2018; Lambin et al., 2018; Taylor and Streck, 2018; Garrett et al., 2019), oil-palm driven deforestation (Austin et al., 2017), impact of zero deforestation ton rural livelihoods (Newton and Benzeev, 2018), governance aspects (Pirard et al., 2015; Ludwig, 2018), and impact or progress of zero deforestation with a focus on countries other than Indonesia (Piketty et al., 2017; Ermgassen et al., 2020) as well as global overviews (Ludwig, 2018). This study assumes that the commitment is formulated and followed up with actions to reduce deforestation. How much of the zero-deforestation commitments made by both public and private sectors impact on forest cover, however, is not well known and studied particularly in developing countries like Indonesia. It is clear that operationalizing zero-deforestation commitments is best understood by looking at specific jurisdictions.

This study focuses on South Sumatra, a province on the island of Sumatra. Sumatra has seen significant primary forest loss amounting to 7.54 Mha, with an additional 2.31 Mha being degraded, making South Sumatra one of the Indonesian provinces that has lost over 50% of its primary forest between 1990 and 2010 (Margono et al., 2012). Using this key area as a case study, we investigate how binding and voluntary initiatives to halt deforestation work on the ground. Using voluntary and mandatory certification as proxies for private sector zero-deforestation commitments, we reviewed relevant public policies that attempt to avoid further environmental damage and reduce deforestation. We carried out interviews and focus group discussions, based on specific indicators and criteria. We then performed statistical and spatial analyses to assess the effectiveness of zero-deforestation commitments and initiatives that aim to reduce deforestation.

2. Research framework and methods

2.1. Research framework

South Sumatra Province extends across 8.67 Mha. The province includes 17 regencies with Ogan Komering Ilir (OKI) Regency accounting for 19.6% of the province land area (Fig. 1). South Sumatra is primarily dominated by lowlands with about 76.5% of its land between 0 and 100 MASL (Meters Above Sea Level) (BPS-Statistics of South Sumatra Province, 2020), particularly in the eastern parts, with mountainous terrain dominating the west. South Sumatra's forests have been widely converted into commercial large-scale plantations of rubber, timber and palm oil, which has also resulted in degraded landscapes. Studies report more than 50% of forest habitat has been lost for at least six species of primate in Sumatra Island, including those in South Sumatra Province (Supriatna et al., 2017). Deforestation and forest degradation have also left the landscape susceptible to fire; in 2015 and 2019, 25% and 20% of Indonesia's most severe fires occurred in South Sumatra (MoEF, 2020). The objective of this study is to explain how private initiatives and public policies have been implemented, and how they have affected zero-deforestation efforts. We approached this objective through assessing: (1) spatial and statistical analysis of South Sumatran deforestation over time; and (2) public and private sector perspectives and initiatives.

The Indonesian government, as stated in Law No. 41/1999, defines forest as an integrated ecosystem dominated by trees. Forest area is administratively defined as a particular region assigned or designated by the government as permanent state forest. State forests are classified into

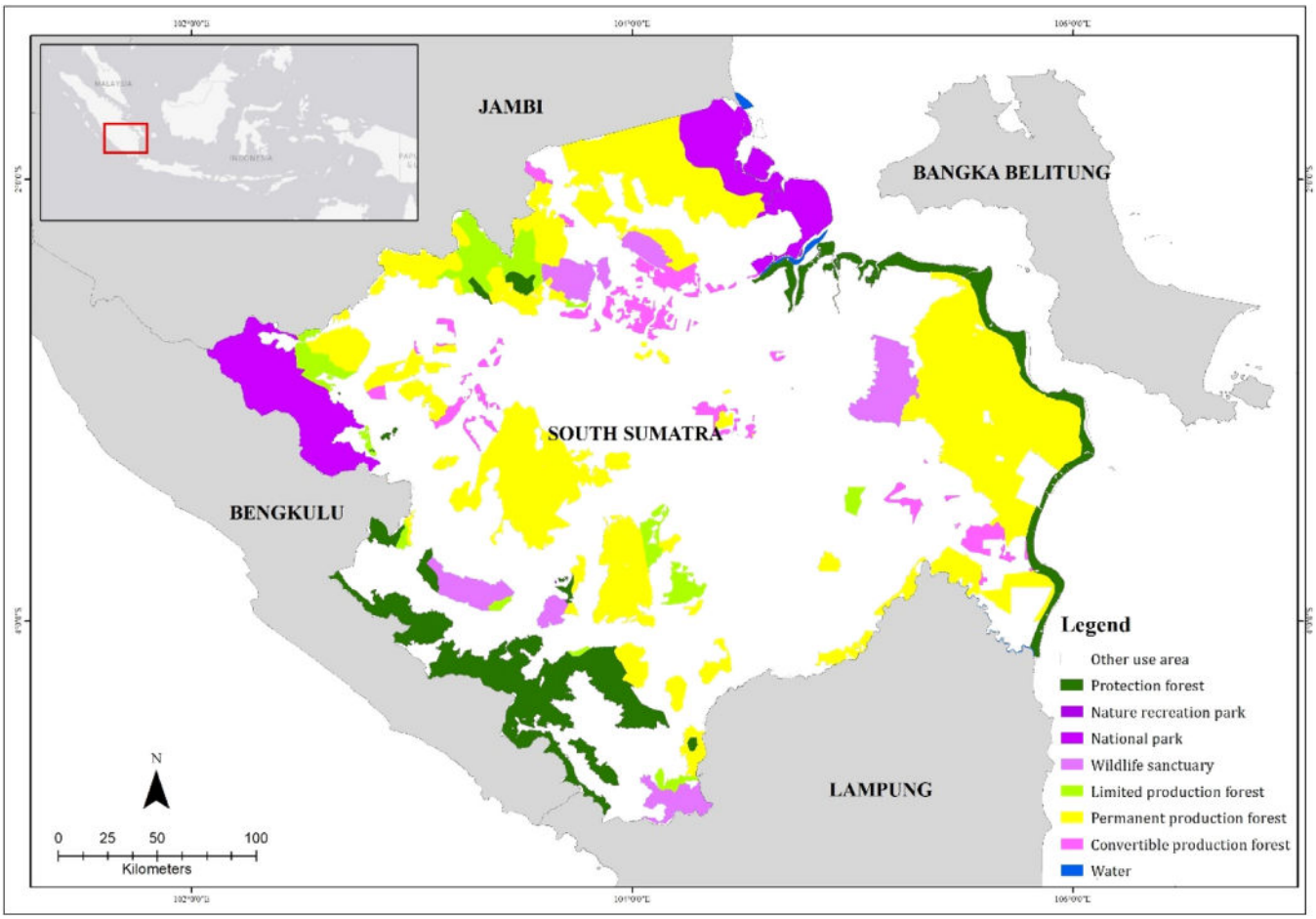

Fig. 1. South Sumatra Province Forest zoning map.

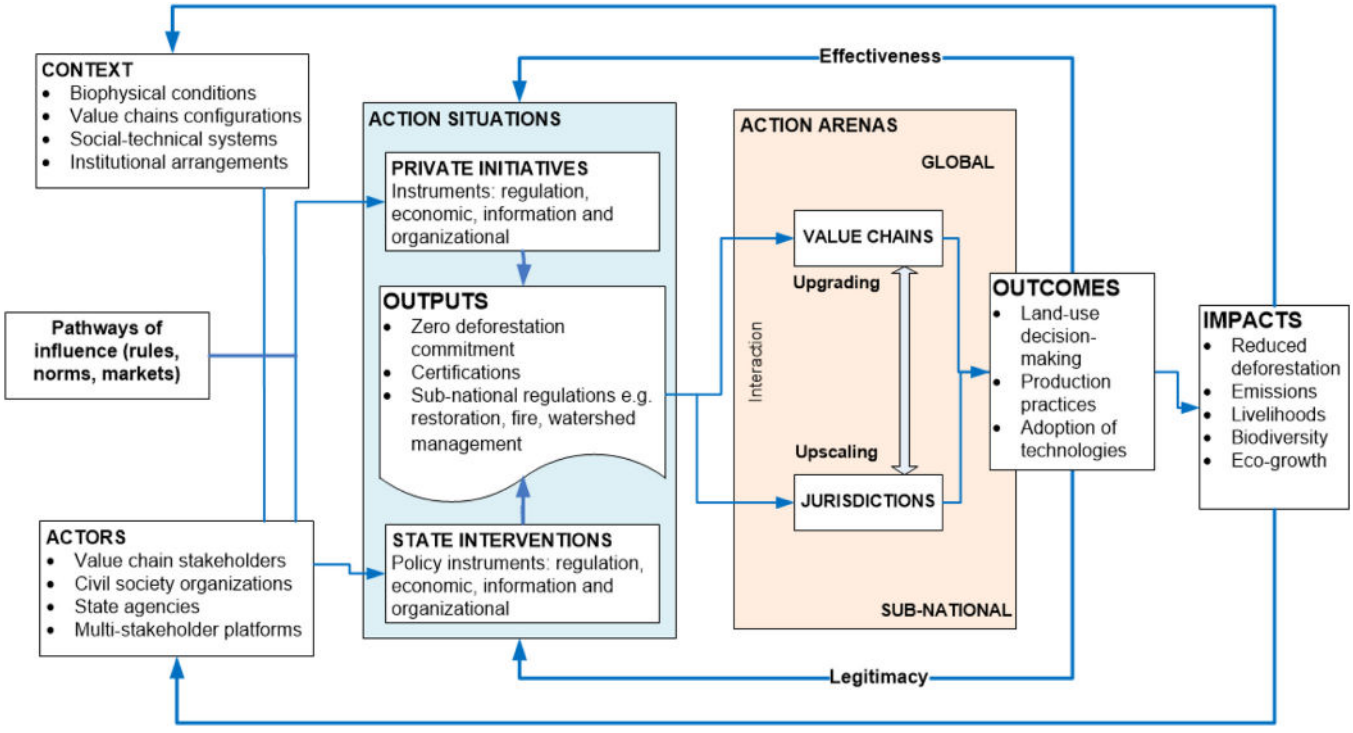

Fig. 2. Analytical framework.
Adapted from Pacheco et al., 2018.

protection, production, conservation forests. This definition differs from that of the FAO (2020), which defines forest in biophysical terms, using a threshold of 0.5 ha of land, comprised of trees higher than 5 m and with canopy covering more than 10%. On deforestation, we refer to the FAO definition (2020) of deforestation as "the conversion of forest to other land use independently whether human-induced or not, including permanent reduction of the tree canopy cover below the minimum 10% threshold, but excluding areas where trees have been removed as a result of harvesting or logging". Similarly, the NYDF adopted the Accountability Framework Initiative (2019), which defines deforestation as "loss of natural forest as a result of conversion to agriculture or other non-forest land use; conversion to a tree plantation; or severe and sustained degradation". These definitions of deforestation refer to 'gross deforestation'. 'Net deforestation', or as the FAO refer to it (2020), 'forest area net changes', refers to the difference in forest area between two reference years. This considers gains and losses between reference years as a proxy. In this study, we employed spatial measurements combined with statistical analysis to determine the relationship between net deforestation and various public and private sector attempts to prevent environmental destruction and reduce or halt deforestation.

We adapted the institutional analysis development (IAD) framework of Ostrom (1990, 2005) and further adapted by Pacheco et al. (2018) to understand: biophysical, social and economic conditions, institutions and value chain configurations, as categorized under 'Context' (Fig. 2); and an array of actors along the value chain involved in the development, production, and trading of agriculture commodities, grouped under 'Actors'; as well as the interplay between the two. Both are assumed to shape 'Action Situations' whereby private initiatives and state interventions produce outputs influencing locations of activity or 'Action Arenas.' Interactions between the 'Jurisdictions' (i.e. South Sumatra) and palm oil and pulp and paper 'Value Chains' of different companies produce 'Outcomes' that lead to 'Impacts'. We seek to answer how these 'Outputs' can produce 'Outcomes' leading to 'Impacts'.

2.2. Research steps

We carried out five steps: (1) conducting spatial analysis of land cover and uses across the province to comprehend deforestation trends (representing 'Context'); (2) reviewing private and public sector commitments to zero deforestation and the areas involved (representing 'Actors', 'Action Situation', and 'Outputs'); (3) interviewing key public and private sector actors on their commitment to zero deforestation (representing 'Action Arena' and 'Outcomes'); (4) statistical analysis on the impact commitments have on deforestation (connection between 'Outputs' and 'Impacts'); and (5) gaining further information through a focus group discussion.

2.2.1. Spatial analysis of forest cover changes

In the first step, we performed spatial analysis of land use and land cover changes between 1990 and 2019, using dataset from the Ministry of Environment and Forestry (MoEF), comprising 23 classes of land uses. We aggregated the 23 land classes into eight (Table 1). For clarity, we changed the wording 'plantation forest' to 'pulpwood plantation' and 'plantation' to 'oil palm plantation', since plantation forest mostly refers to pulpwood concessions, and plantation refers to oil palm plantation. To further understand the land status, we also analyzed land use/land cover maps with spatial planning and concession areas (Table 2), by overlaying forest spatial planning maps in MoEF Decree SK.822/Menhut-II/2013, and concession maps obtained from WRI Global Forest Watch (accessed 16 August 2020). In this study, we understand 'deforestation' to be 'net deforestation' where the difference in forest area is estimated between two dates, considering both losses from deforestation and gains from forest regeneration and/or tree plantations, as defined by the FAO (2020).

Table 1
Aggregated land use/land cover classification.

Aggregated classes	Original classes
Natural forest	Primary dryland forest, secondary dryland forest, primary swamp forest, secondary swamp forest, primary mangrove forest, secondary mangrove forest
Pulpwood plantation	Plantation forest
Oil palm plantation	Plantations
Shrubland	Shrub, swamp shrub
Cropland	Dryland agriculture, dryland agriculture mixed with shrub, rice field
Grassland	Grassland
Bareland	Bareland
Other	Settlement, fishpond, airport/harbor, transmigration, mining, swamp

Table 2
Aggregated land status classification.

Original classes	Code	Aggregated forest zone classes
Other use area	APL	Non-forest zone
Permanent production forest	HP	State Forest zone - Production
Limited production forest	HPT	State Forest zone - Production
Convertible production forest	HPK	State Forest zone - Production
Wildlife sanctuary	SM	State Forest zone - Conservation
Protected forest	HL	State Forest zone - Conservation
Nature recreation park	TWA	State Forest zone - Conservation
Nature conservation/preservation area	KSA/KPA	State Forest zone - Conservation
National park	TN	State Forest zone - Conservation

2.2.2. Review of private and public sector commitments to zero deforestation

In the second step, we assessed how private and public commitments to zero deforestation have translated into actions. First, we identified the various initiatives, policies and programs that were relevant to the province's efforts to avoid and reduce deforestation and to restore degraded forests and lands. In the public sector, we reviewed key strategies, policies and regulations issued by the national, provincial, and regency governments and identified other initiatives taken by NGOs and other development-related bodies. Using network analysis, we analyzed 12 policies at the national, provincial, and regency level, assessing the interconnectedness between those policies and mapping the network of their relations and interactions. This analysis further reinforced our understanding of the context and the interactions of policies issued by different public actors. We used Kumu software to map this network and measure centrality and eigenvector metrics (Kumu, 2021).

To understand private sector commitments, we identified the sustainability policies and initiatives of forest and land-based enterprises, like pulpwood and oil palm plantation companies, and assessed how well they have adopted sustainable certification, which is a common proxy for eliminating deforestation from supply chains (FAO, b, 2017a). Then, we reviewed the principles, criteria and indicators of certification schemes used in South Sumatra, to understand the extent to which the certification supports zero-deforestation commitments. We reviewed both mandatory and voluntary certification schemes for pulpwood and palm oil, including PHPL (Sustainable Production Forest Management), SVLK (Timber Legality Assurance System), RSPO (Roundtable on Sustainable Palm Oil), ISPO (Indonesia Sustainable Palm Oil), FSC (Forest Stewardship Council), and ISCC (International Sustainability and Carbon Certification).

Following this review, we developed two questionnaires, targeting

private sector actors (Jopke and Schoneveld, 2018) and public sector actors (Jopke and Schoneveld, 2018; Climate Focus, 2016). The questionnaires help guide our interviews with stakeholders and enabled us to measure their level of commitment quantitatively based on the set of criteria and indicators developed by the study. We developed 15 criteria and 56 indicators to assess private sector commitments and 15 criteria, 32 indicators and 94 sub-indicators/explanators to assess public sector commitments (Appendix 1). Each of the criteria was scored from zero (absent) to five (maximum), indicating the increasing level of commitment towards certain indicators. We then classified commitment into 'no commitment' (private sector: 0–100, public sector: 0–176), 'low commitment' (private sector: 101–150, public sector: 177–264), 'medium commitment' (private sector: 151–200, public sector: 265–352), and 'high commitment or fully committed' (private sector: 201–250, public sector: 353–440).

2.2.3. Interview of key public and private sector actors on their commitment to zero deforestation

In the third step, we interviewed 13 key informants in December 2019 using questionnaires. Private sector respondents were affiliated with the Association of Indonesia Forest Concession Holders (APHI) and a timber plantation company, while public sector respondents were affiliated with provincial (South Sumatra Province) and regency level government (Ogan Komering Ilir (OKI) Regency). The public sector included representatives of the Regional Development and Planning Agency; Plantation Office; Environmental Office; Forestry Office; Protection Forest Management Unit of Lempuing Mesuji and Sungai Lumpur; Peat Restoration Team; and the local government of OKI. We analyzed then weighed up each questionnaire response with a score, before clustering and categorizing commitments into the categories listed above.

2.2.4. Statistical analysis on the impact of the commitments on deforestation

In the fourth step, we identified 41 private companies, and profiled their operations, the years they were in operation, the type of certification and year obtained, and the extent of forest loss occurring in their concessions. We assessed public sector commitment by identifying 12 policies and the extent of forest loss occurring in the province. We then performed dependent t-test inferential statistical analysis to assess the deforestation rate difference before and after commitments were made by public and private sector actors. The null hypothesis is that there is no difference in deforestation rates between before and after the commitments. As the proxy of time becomes a crucial point of comparison, we performed the test under different models that set specific timelines, and identified the best model to inform statistical differences, thus determining whether a commitment made a difference or not. In terms of timeline, for the private sector we defined 'before commitment' as the period between the concession permit being issued and the year the certification was obtained. We defined 'after commitment' as the period after the certification was obtained until 2019. For the public sector, we defined 'before commitment' as the period prior to the issuance until the year where the policy issued. We defined 'after commitment' as the year the policy was issued until a specific timeframe described in the model. Challenges existed when determining the impact of commitments. Impacts refer to the decline of deforestation rate. Impacts may occur immediately after a commitment is made, or they may take some time. As such, we formulated four models of statistical analysis:

a) Model #1 where a zero-deforestation commitment generated immediate impact in the same year;
b) Model #2 where a zero-deforestation commitment generated impact one year later;
c) Model #3 where the zero-deforestation commitment generated impact two years later; and
d) Model #4 where the zero-deforestation commitment generated impact three years later. We then chose the model which informed significant impact to the zero-deforestation commitment using 90% confidence interval.

2.2.5. Focus group discussion

In the final step, we conducted a focus group discussion to verify and explore different stakeholder initiatives to reduce deforestation and restore degraded land. We brought together key actors and participants representing different provincial and regency-level government institutions, private sector companies (pulpwood and oil palm plantation), business associations, i.e. Association of Indonesia's Forest Concessionaires (*Asosiasi Pengusaha Hutan Indonesia*, APHI) and Indonesia Palm Oil Association (*Gabungan Pengusaha Kelapa Sawit Indonesia*, GAPKI) and non-state actors (academia, NGOs, think-tank organizations). We presented the preliminary findings for their feedback and solicited views of stakeholders on how they perceived deforestation and how measures to halt deforestation could be more effective.

3. Results

IAD framework helped to understand the deforestation context which include the exogenous variable, action arena, interaction patterns, output and evaluation criteria to assess actor commitment impact to zeroing deforestation. Using spatial analysis, our study found that nearly 30 years, South Sumatra has 63% its natural forest covers due to land conversion. The rate of deforestation significantly declined but most of the forest have been converted into pulpwood plantations, croplands and oil palm plantations (Exogenous Variable). With policy and commitment analysis, we found that the public and private sector have pledged for commitment that leading to efforts in reducing deforestation and greenhouse gasses emission. Public sector regulation and commitment to green growth are critical in influencing practices on the ground. This shown through development of multistakeholder platform that streamline coordination and implementation of action on the ground to support green growth plan. In the private sector, the commitment shown through adoption of voluntary certification which 'required' by the market and mandatory certification which required by the government. These certifications enforce their compliance with best practices and sustainability standards (Action Arena, Interaction Pattern). The commitment is scored and marked against criteria and indicators, which allow us to assess the statistical significance of the commitment and its measures. Our study found that public sector commitment require time to show significant impact in deforestation reduction. Meanwhile, there is a sufficient evidence in deforestation reduction due to the private sector's commitment (Output, Evaluation Criteria). Detailed result of the study is described in this section.

3.1. Land cover dynamics and deforestation

South Sumatra predominantly consists of low-lying plains covered with plantations, marshes, mangroves and remnants of natural forests. Most of the forests have been converted to monocultural rubber, oil palm and pulpwood plantations. Temporal analysis from 1990 to 2019 shows natural forest cover decline in South Sumatra (Fig. 3). In 1990, natural forest covered 2.1 Mha, about 25% of South Sumatra's total area, then significantly declined in the following years. South Sumatra lost almost half of its natural forest between 1990 and 2000, leaving just 1.1 Mha in 2000. Natural forest continued to decline at a lower rate for the next period, with an area of 1 Mha in 2011 and 0.8 Mha in 2019. The largest natural forest cover loss occurred in 1996–2000 with an annual deforestation rate of around 15%. Of the approximately 1 Mha of forest lost in 1996–2000, 63% was turned into low use shrubland. Over this period, the largest forest loss occurred in the regencies of OKI and Musi Banyuasin, where natural forest losses accounted for 0.35 and 0.30 Mha of the total forest lost, respectively.

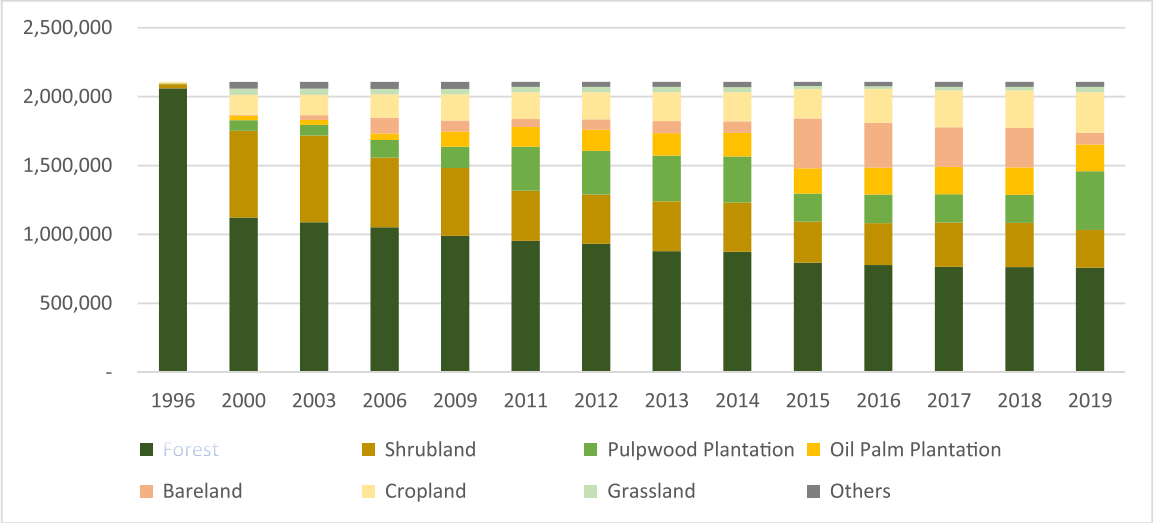

Fig. 3. Land use and land cover distribution (hectare) in areas that were previously natural forest in 1990.

Most natural forest areas are transformed into shrublands, pulpwood plantations, oil palm plantations, and croplands. Shrublands constitute the largest portion of land cover change in 2000, before this proportion slowly decreases as pulpwood and oil palm plantations and croplands start to expand. The dynamics indicate that a part of the natural forest were converted into shrubland before that shrubland is then transformed and used for pulpwood plantations, croplands, and oil palm plantations. Oil palm plantation areas significantly increased from 0.90 Mha in 2014–1.40 Mha in 2019. By the end of 2019, natural forest area was around 0.79 Mha. Based on the natural forest area of 2.10 Mha in 1990, South Sumatra lost 63% of its natural forest cover between 1990 and 2019 (Fig. 4).

We overlaid government forest spatial planning maps (SK.822/Menhut-II/2013) with concession maps to identify natural forest cover area across different types of land status (Fig. 5). In line with deforestation trends between 1996 and 2000, areas with high losses of natural forest cover were located in state forest zones (SFZ). After the massive deforestation that occurred during 1996–2000, natural forest in SFZ, both within and outside of concessions, continued to decline, while other areas of land uses remained relatively constant. Within concessions, natural forest cover loss was associated with the expansion of pulpwood and oil palm plantations. However, natural forest cover also declined outside concessions, indicating possible illegal deforestation activities. In 2019, the largest remaining areas of natural forest were located inside state conservation forest areas, as well as SFZ located outside of forestry concessions.

The decline of natural forest was followed by an increase in pulpwood and oil palm plantations (Fig. 6). During 1996–2019, the annual expansion rates of pulpwood and oil palm plantations were 6.78% and 4.98%, respectively. The expansion of pulpwood plantations mostly occurred in areas that were in 1990 covered by natural forest; oil palm plantation expansion however occurred more frequently in areas that were shrubland in 1990. From a total oil palm plantation area of 1.4 Mha in 2019, 0.19 Mha (14%) was natural forest in 1990. For pulpwood plantation, from a total of 0.61 Mha in 2019, about 0.42 Mha (69%) was previously natural forest in 1990.

3.2. Commitment through policy and certification

3.2.1. Public sector

The public sector plays a critical role in making and enforcing policies or rules, providing economic incentives and disincentives, and motivating stakeholders to eliminate deforestation and restore degraded forests or lands. Policies at the national level influence subnational level policies. Often, subnational level policy refers to national policies within its points of consideration. For example, at the national level, a key policy was the 2011 Presidential Instruction (INPRES) on Moratorium, an order for national and subnational government action to postpone the issuance of new concession licenses. Hence, this national policy affects the licensing at the subnational level. At the subnational level, a variety of regulations, initiatives, and programs were then issued by the government aimed at environmental and landscape sustainability. Regional Regulations (*Peraturan Daerah*, PERDA) are legally binding regulations passed by provincial or regency-level parliaments and heads, generally aiming to provide further detail on national laws. Governor Regulations (*Peraturan Gubernur,* PERGUB) and Regent Regulations (*Peraturan Bupati,* PERBUP) are passed by either the governor or head of regency, and act as operational rules to guide the technical implementation of mandates stated at a higher level, like PERDA. Commitments to zero-deforestation were reflected in political statements and regulations stating authorities' intention to protect and maintain environmental sustainability and prevent damage to both environmental and social capital; these were enacted through national, provincial and regency-level regulations (Table 3).

Specific policies were intended to be *regulative*, designed to ensure compliance with certain standards or procedures. For example PERGUB 16/2017 requires investors to follow the governor's Green Growth Strategy, and PERDA OKU 20/2011 requires investors to obtain a business permit before starting a plantation business. Most policies reviewed in this study required *allocative* actions whereby relevant government institutions allocate budget and human resources to implement and monitor the planned activities. It is noteworthy that policies, programs and activities laid out in short- and mid-term development plans (e.g. RPJMD enacted as PERDA) are prioritized for implementation and given financial support through provincial and regency budgets.

Our focus on subnational policy also considers key national policies that are highly relevant to zero-deforestation commitments, namely the Presidential Instruction on Moratorium, which ended the issuance of new business licenses targeting natural forest and peatland. The moratorium policy was initially issued in 2011 then amended several times before being made permanent in 2019. South Sumatra's public commitment to tackling climate change can be traced back to 2012 when the governor issued a regulation on the province's actions to reduce greenhouse gas emissions. This formed part of provincial contributions to national efforts to reduce emissions. Some years before that regulation was issued, fire incidents led to other regulations, issued in 2008, aiming to control fires across the province that significantly

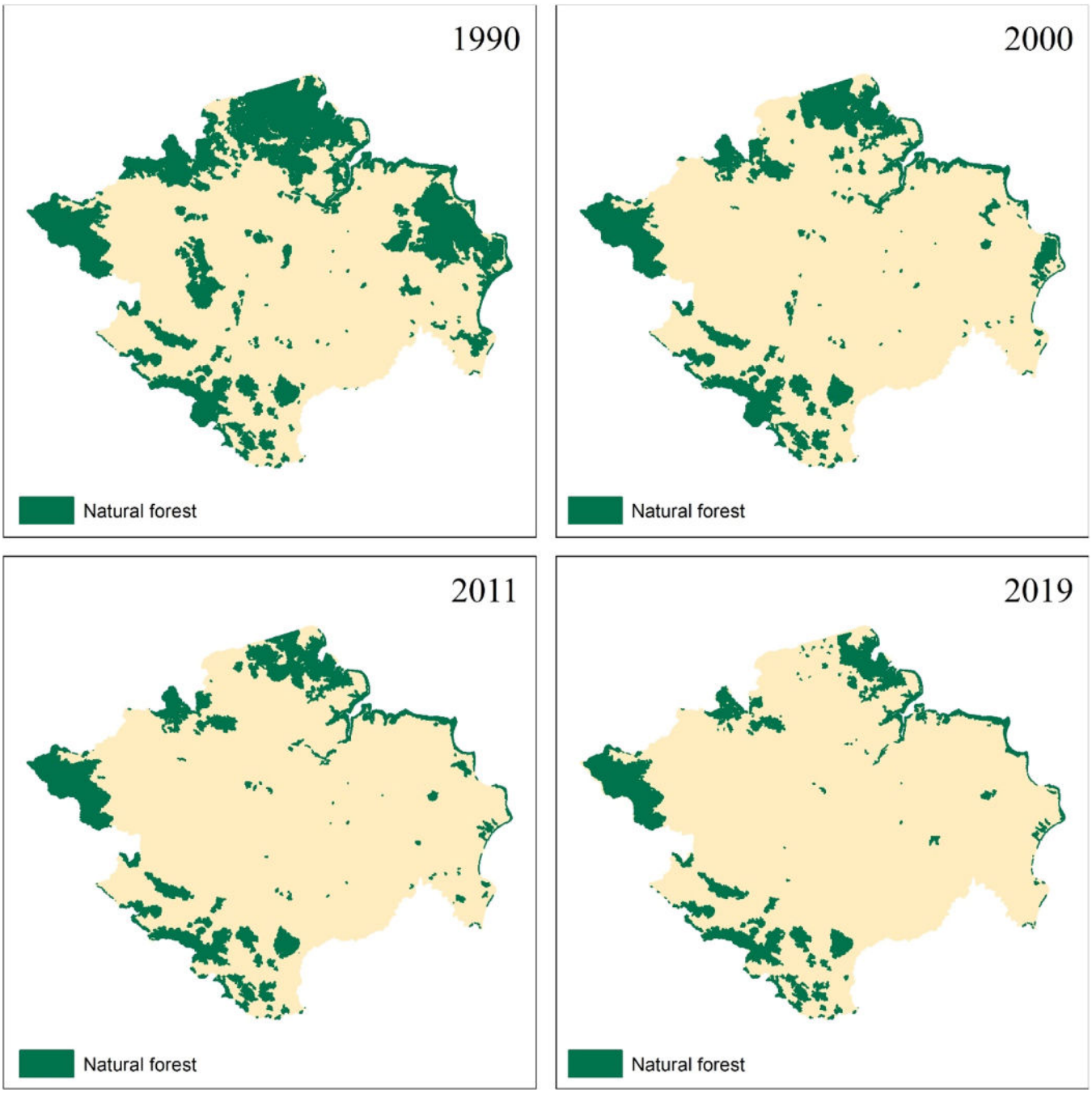

Fig. 4. State of natural forest in South Sumatra 1990–2019.

contributed to forest loss. Around the period when the NYDF was made in 2014, the province, as well as certain regencies in the province, issued policies strengthening their efforts to restore degraded forests and lands, and devised an integrated strategy for watershed management (2013). Additional measures since have ensured more stringent rules on the protection and management of environment (2013, 2016), including peat ecosystems (2018) and fire control (2016).

Out of all South Sumatran regencies, three in particular caught our attention as demonstrating their political commitment to sustainable development and the prevention of deforestation. Our assessment of the province's commitment to protect forest cover (Fig. 7, Appendix 2) indicated that out of 17 South Sumatran regencies, at least two (Musi Rawas and OKU Regencies) demonstrated political will to regulate environmental protection and management (OKU), estate crop business licensing (OKU), and permits for collecting forest products (Musi Rawas). Musi Rawas and OKU respectively lost 58.2% and 23.3% of their forest cover between 1990 and 2019. Other regencies have yet to show such political will. This is concerning, because forest cover loss occurred in almost all South Sumatran regencies between 1990 and 2019 (i.e. 63% of forest cover loss across South Sumatra).

Subnational regulations have direct links to higher regulations at the national level, through references to the higher regulations in question (Fig. 8; Appendix 3). Provincial, governor and regency regulations (OKU and Musi Rawas Regencies) are mostly connected to other policies, indicated by their larger spot size in Fig. 8. This is in accordance with Law No. 12/2011 (and Law No. 15/2015) on Legislation Making, stating that sub-national regulations shall be developed based on hierarchy and conformity principles (Art 5) and elaborate further stipulations of a

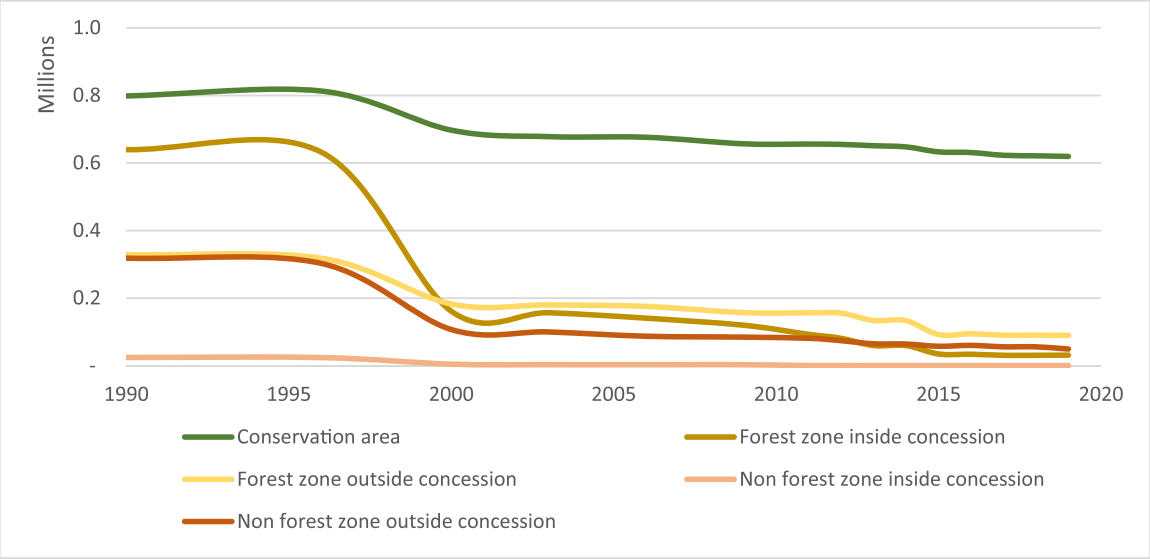

Fig. 5. Natural forest cover (hectare) in forest and non-forest zone according to land status.

higher regulation and how decentralized and delegated affairs are to be further implemented (Art 14). We also analyzed policies (using eigenvector values), to understand their specific influence within the network. We found that the ten policies with the largest eigenvector values included a range of national regulations, along with provincial and governor regulations. Policies issued at the provincial and governor level were considered important, as indicated by their consistently high values in terms of both eigenvector and degree centrality. These policies were: PERDA No. 17/2016 on environmental protection and management; PERGUB No. 21/2017 on the Green Growth Masterplan for economic development in South Sumatra; PERDA No. 8/2016 on forest/land fire control; and PERGUB No. 38/2018 on the provincial action plan to reduce greenhouse gas emissions by 30%, by 2020. Although the moratorium (INPRES No. 5/2019) is a critical policy, it appeared to have no apparent links with other regulations. That said, local regulations (like the Green Growth Masterplan) include this moratorium as one of the strategies for reducing deforestation. This is because an INPRES (Presidential Instruction) is simply an executive order guiding or instructing the Ministries, Cabinet Secretary, Head of Agency, Governor, and Head of Regent/Municipality in carrying out their duties. In order for important policies to create impact, they have to be consistently translated into actionable plans and supported with budget allocation and programs led by the relevant jurisdictions (i.e. provincial and regency governments).

The commitment of the South Sumatra provincial government was strengthened by the issuance of Governor Regulation No. 21/ 2017 on the Green Growth Masterplan, which outlines major strategies and activities to be undertaken between 2017 and 2023. The plan is meant to synergize economic development and environmental conservation, through measures targeting low carbon and environmental impacts and multi-stakeholder participation. It was initiated in 2014, then presented by the Governor of South Sumatra at a high-level meeting at the Bonn Challenge in 2015 and the Bonn Challenge Latin American meeting in 2016 (Asmani, 2017). The Governor issued Regulation No. 16/2017 that established institutions to implement the Green Growth Masterplan and landscape management partnership. The regulation also enables the government to allocate funding from the regional state budget and other sources. The plan provides a roadmap towards the realization of green growth development goals, including seven key strategies and 52 interventions. Strategies relevant to deforestation and forest restoration include voluntary and mandatory certification schemes, integrated forest and land management, moratorium of oil palm plantations on peatland, and zoning of pulpwood plantations. Although deforestation is not specifically mentioned within the regulation, it was regarded as a driver for land-use changes resulting from the expansion of agricultural plantations, rubber-coconut agroforestry, settlements, and roads. The regulation was then also used as an indicator of performance on the part of relevant actors, with regards to how they are halting deforestation in response to the masterplan.

Although context, actors and action situations play a critical role in shaping zero deforestation impact, the 'action arena' is where all elements come together and are contested (as shown in the analytical framework in Fig. 2). In the interplay between jurisdictional and value chain actors, all have different levels of power, resources and legal means to affect outcomes and impacts, through their interactions. The way South Sumatra's public institutions play their roles in tackling climate change and deforestation-related issues can be direct, as well as indirect. Relevant government administrative units (e.g. forestry, agriculture and plantation offices) implement programs and activities mandated via PERDA; they also facilitate the private sector to turn sustainability policies into actions and get their plantation and mills certified, for example.

PERDA (20/2011) on Estate Crop Business Licensing (IUP) enabled the OKU Regency to both grant palm oil businesses with licenses to operate their plantations or mills, and to oblige them to comply with environmental rules aiming to anticipate and prevent adverse environmental and social impacts from their operations. To comply with the Ministry of Agriculture's regulation on plantation assessments (No. 7/2009), certified officials from South Sumatra province and regency plantation offices take part in assessing whether particular growers or mills are ready for ISPO certification. Only those plantations or mills with grade A, B or C (of five grades) can pursue ISPO certification.

Environmental protection and management plans (RPPLH) and strategic environmental assessments (KLHS) prepared by the regency government, as mandated in OKU's PERDA (4/2013), are viewed as essential instruments for guiding the development of investments (e.g. no-go areas for development, anticipated impacts).

These public sector commitments are supported by partnerships and projects established by the Governor of South Sumatra. A multi-partner platform – the Partnership for Ecoregion Landscape Management of South Sumatra (*Kolega Sumsel*) – was established through Governor Decree No. 16/2017 as a non-structural institution to support the management of integrated natural resources for sustainable landscapes and green growth. It comprised of non-state actors like the Zoological

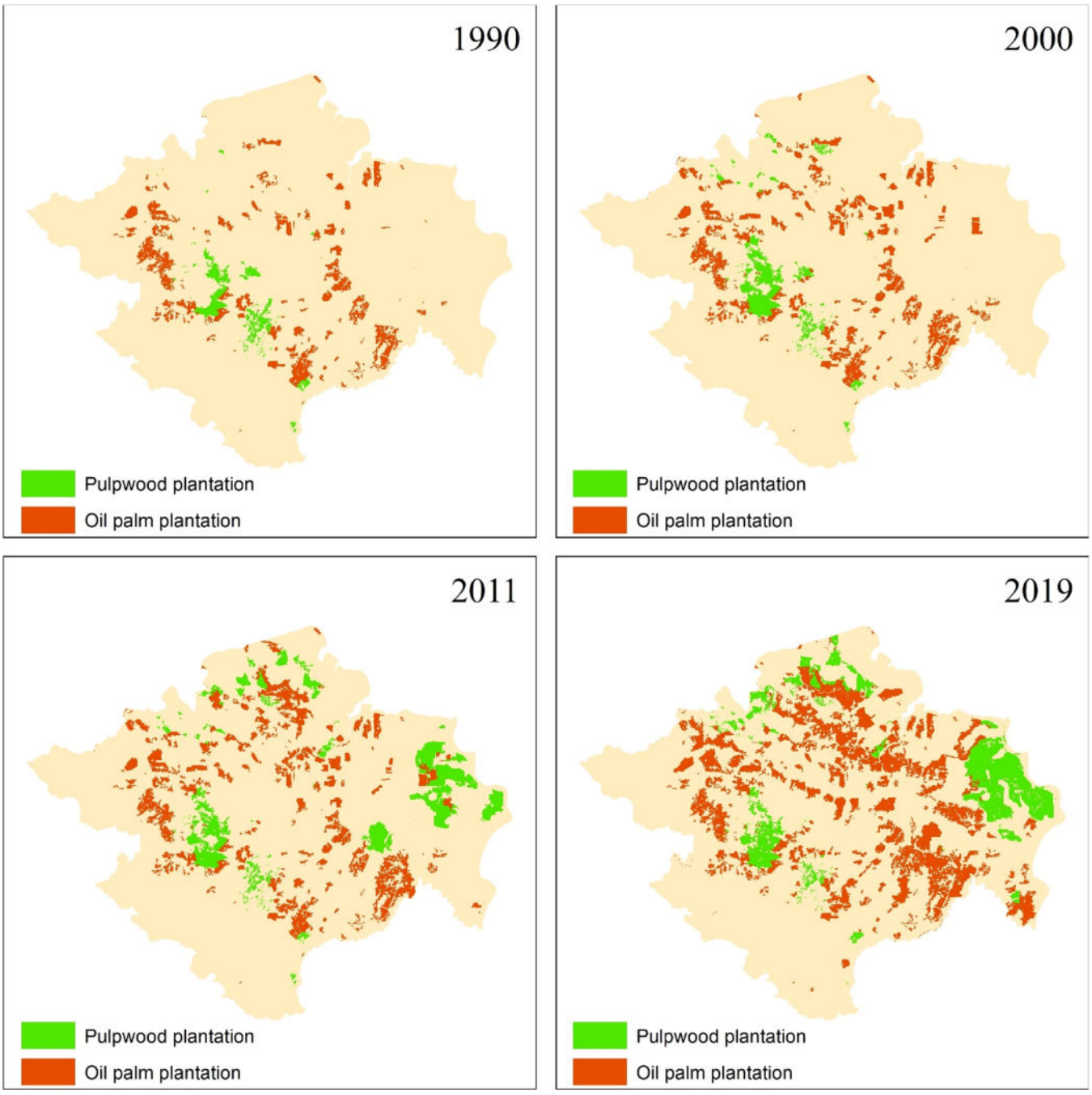

Fig. 6. Pulpwood and oil palm plantation expansion.

Society of London (ZSL), World Resources Institute (WRI), Hutan Kita Institute (HAKI), Belantara Foundation, Sustainable Trade Initiative (IDH), Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ), World Agroforestry Center (ICRAF), Watershed Forum (Forum DAS), and Forum Dangku Meranti. The South Sumatra government, along with IDH and other stakeholders, developed a landscape coordination structure serving as an umbrella for all activities related to green growth initiatives in the province.

Another partnership platform supporting public sector commitment is Kelola Sendang, a multi-partner landscape management project that aims to use private sector sustainable sourcing commitments, in combination with traceability and supply chain management solutions, to reduce agricultural and land speculation pressure on natural habitats (Luttrell et al., 2018). This is run by a consortium of ZSL, IDH, SNV, Daemeter, FPP and Deltares, working closely with provincial and local governments. In line with the efforts of South Sumatra to reduce the high rate of deforestation, Kelola Sendang has identified areas around target villages considered to be of high conservation value, put together a protection and management plan, and collaborated with companies to develop a peatland restoration model, as well as traceability systems for oil palm fruit fresh bunches.

At the regency level, there is Sahabat MuBa – a multi-stakeholder taskforce assisting jurisdictional certification in Lalan. Members of Sahabat MuBa include the Rainforest Alliance, SPKS, HaKi, Daemeter Consulting, SNV and IDH. Another non-state actor supporting public sector commitments is ICRAF who, alongside the South Sumatran government, developed a plan for a multi-stakeholder approach, and modelled diverse scenarios in the development of land-based sectors,

Table 3
Public policies issued by South Sumatra provincial and regency governments, which directly or indirectly address deforestation.

No.	Policy number	Policy title/concern*	Level	Year of issuance
1	INPRES No. 5/2019	Termination of new license issuance (**moratorium**) and improving governance of primary natural forest and peatland	National	2011–2019 **
2	PERDA No. 1/2018	Protection of **peat ecosystems**	Province	2018
3	PERDA No. 8/2016	Forest/land fire control		2016
4	PERDA No. 17/2016	**Environmental protection and management**	Province	2016
5	PERGUB No. 21/2017	**Green Growth Masterplan** for economic development in South Sumatra	Province	2017
6	PERGUB No. 16/2017	The **Green Growth Masterplan's** institution and landscape management partnership	Province	2017
7	PERGUB No. 34/2012	Regional action plans for **reducing greenhouse gas emissions**	Province	2012
8	PERGUB No. 38/2018	Provincial action plan on **reducing greenhouse gas emissions** by 30%, by 2020	Province	2018
9	PERGUB No. 1/2019	South Sumatra 2019–2023 **mid-term development plans**	Province	2019
10	PERDA of Ogan Komering Ulu No. 4/2013	**Environmental protection and management**	Regency	2013
11	PERDA of Ogan Komering Ulu No. 20/2011	Estate crop **business licensing** (IUP)	Regency	2011
12	PERDA of Musi Rawas No. 10/2012	**Permits for the right** to collect forest products	Regency	2012

* The phrases in bold are focus/concern of the policy.
** The policy was amended every two years. Our study limits national policy to include only policy which significantly impacts subnational practices.

along with their likely economic, social, and environmental impacts. ICRAF also helped Musi Banyuasin and Banyuasin regencies to translate a spatially explicit land-use plan; a plan which will support stakeholders to develop priority areas for action and interventions contributing to green growth, as well as to identify policy changes that may be required.

Many of the above structures and mechanisms were established relatively recently by the public sector and non-state actors. As such, their impact on deforestation rates up to 2019 – if any - is understandably weak and will require time to mature and take effect.

3.2.2. *Private sector*

South Sumatra has 21 pulpwood plantation companies (MoEF, 2017), one restoration ecosystem company, and 143 oil palm companies (BPS-Statistics Indonesia, 2017). The adoption of voluntary and mandatory certification schemes by plantation growers and mills, and resulting certificates, are used as proxies for private sector commitment to zero deforestation. Ten pulpwood companies had been certified with PHPL and eight with SVLK, the Indonesian government's mandatory certification schemes for the forest and wood product sectors. Only one pulpwood company in the province had voluntary certification (Forest Stewardship Council, FSC). In terms of oil palm plantations, 13 companies had been ISPO-certified (mandatory), six companies hold RSPO certification and three were ISCC-certified (voluntary). Since one company can obtain more than one certification – i.e. both a mandatory and multiple voluntary certifications – the total number of commitments was limited to the sum of certifications obtained (Table 4). The mandatory and voluntary certification schemes, as expressed in their respective principles, criteria and indicators, address deforestation issues directly or indirectly, as discussed further below. Companies that have fulfilled the required prerequisites for certification must follow best practices and comply with the standards. As such, the presence of certification is a common and straightforward proxy to measure the commitment of companies, in addition to their internal policies on sustainability.

Mandatory certification such as PHPL and SVLK is regulated through MoEF Decree No. P.30/2016, which was recently updated to become MoEF Decree No. P. 21/2020. The latest update highlights: government support for small enterprises to access the timber legality assurance system certification; simplification of criteria and indicators for surveillance; changes in the timeframe for surveillance and the validity of certification; and synchronization with other regulations (Prayoga, 2020). While the decree regulates general matters, it was followed up with another decree regulating technical implementation matters. Although specific monitoring criteria and indicators are not made available to the general public and non-certification bodies, the technical decree (the General Director of Sustainable Production Forest Decree No. P.15/2016) specifies that the audit covers assessment of performance and verification of timber legality. This includes due diligence, supplier declarations of conformity, and verification of the legality of raw materials. The limited public access to these details makes it difficult to assess the effectiveness of the mandatory scheme results.

In terms of voluntary forestry certification, zero-deforestation commitments to FSC standards on forest management were represented by FSC Principle #5 on benefits from the forest; Principle #6 on environmental values and impacts; Principle #9 on High Conservation Values (HCV); and Principle #10 on implementation of management activities. Each of these principles have criteria that refer to the need to: harvest products to sustainable levels; include positive and negative externalities within management plans; have measures to mitigate risks and impacts that negatively affect the environment; put in place conservation measures to protect environmental values; maintain or enhance the high conservation value (HCV) area; minimize and prevent disturbances to the ecosystem and landscape; prohibit conversion from natural forest; and regenerate vegetation cover. The public availability of audit information gives the voluntary system reasonable credibility. As only one of the 18 forest plantation companies has FSC, the performance in this sector is difficult to assess.

In the palm oil sector, the mandatory ISPO certification scheme specifies different sets of principles and indicators for palm oil growers, mills, businesses with integrated units for plantation and processing, and plasma and independent smallholders. ISPO indicators, criteria and principles for integrated plantations are similar to those given for plantations in non-state forest zones (APL), convertible production forest (HPK), customary land, and other types of land which are relevant to land regulations. Should a plantation come from primary natural forest or peatland, ISPO set strict criteria requiring documents on forest release and location permits. ISPO explicitly acknowledge the moratorium on new issuance of oil palm plantation licenses, as well as moratorium on primary natural forest and peatland conversion. ISPO also indicates that plantations should have environmental management and monitoring systems and practices in place, including mitigation of Greenhouse Gases (GHG) emissions, management of protected area, and obtaining environmental permits. Most of the principles, criteria, and indicators are similar for all plantations, except for the plasma and independent smallholders, for whom requirements are less complex. For plasma and independent smallholders, ISPO certification does not explicitly and implicitly acknowledge the moratorium on new plantation licenses. It only indicates that the business location should be aligned with designated areas, as specified in Regional Spatial Plans.

With RSPO (voluntary) certification, zero-deforestation commitment is represented by RSPO Principle #3 and Principle #7 in the 2018 version of the RSPO Principles and Criteria. These principles, along with RSPO criteria, require: comprehensive Social and Environmental Impact

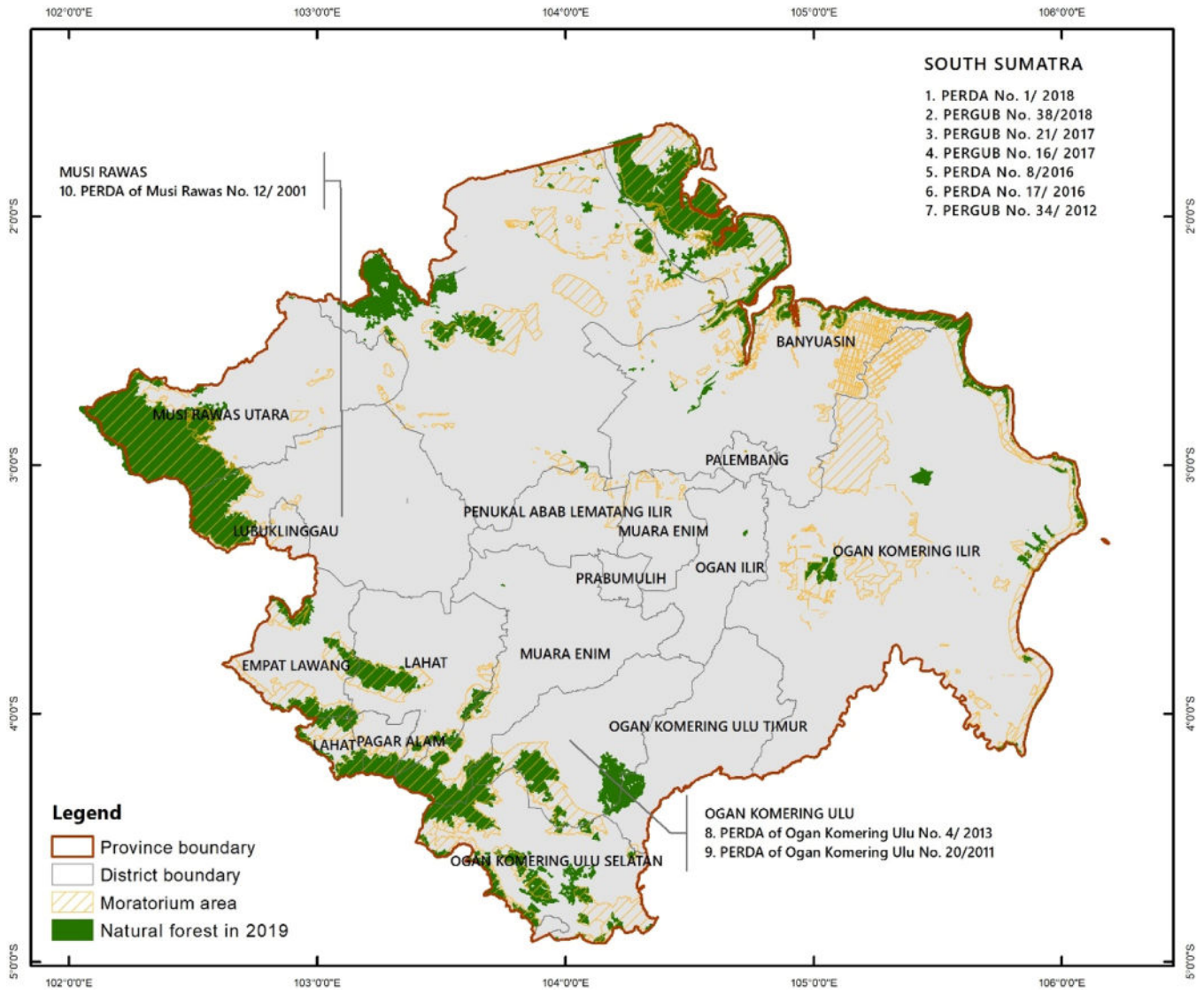

Fig. 7. Map of natural forest cover and public policy commitments made by jurisdictions.

Assessments; regular monitoring of impacts; avoidance of planting in peatland areas and setting aside of peatland conservation areas; avoidance of land clearing in primary forest or high conservation value (HCV) areas; land clearing avoiding deforestation and damage; assessment and prevention of damage in HCV or high carbon stock (HCS) areas; and balance between conservation and development agendas. Another voluntary certification scheme used by oil palm plantation companies in South Sumatra is ISCC. We reviewed ISCC certification 'ISCC EU 202′ on sustainability requirements (v 3.1) and traceability and chain of custody (v 3.1). Principles relating to zero-deforestation commitment can be found in Principles #1, #2, #5 and #6 of the sustainability requirements; these specify: the protection of land with high biodiversity value or high carbon stock; conservation of natural resources and biodiversity; implementation of best agricultural and forestry practices to ensure environmentally responsible production; compliance with environmental impact assessment and protected area laws, among others; and monitoring and continued improvements, with respect to environmental, social and economic sustainability. These sustainability criteria must also be ensured along the supply chain; as such, supply chain actors are also subject to certification in order to issue Sustainability Declarations such as NYDF. The larger proportion of companies with voluntary certification in the oil palm sector, compared to the forest plantation sector, suggests that certification may be a more important proxy for deforestation commitments by oil palm plantation companies (Fig. 9).

3.3. Perceptions of public and private sectors

Reducing deforestation is one of the macro-indicators towards the goals of the South Sumatra Green Growth Masterplan (Government of South Sumatra et al., 2017). Policies and mechanisms for the monitoring, evaluating and reporting of green growth are present in this masterplan, but assessing progress against indicators remains challenging. This is potentially due to the fact that indicators were not translated and internalized into the work plans of administrative units. The Green Growth Masterplan was enacted through a governor regulation rather than a PERDA; which gives it less legal power to fully enforce the implementation of the strategies. Less participation of relevant stakeholders during the deliberation of the masterplan resulted in less ownership and commitments. Certain initiatives, partnerships and activities did indirectly contribute to zero-deforestation efforts, for example through multi-stakeholder and multi-partner platforms like Kolega Sumsel and Kelola Sendang. However, the term 'zero deforestation' was rarely acknowledged and the concept was not fully understood at subnational levels. Despite the term being acknowledged in the Green Growth Masterplan, some province and regency-level respondents found

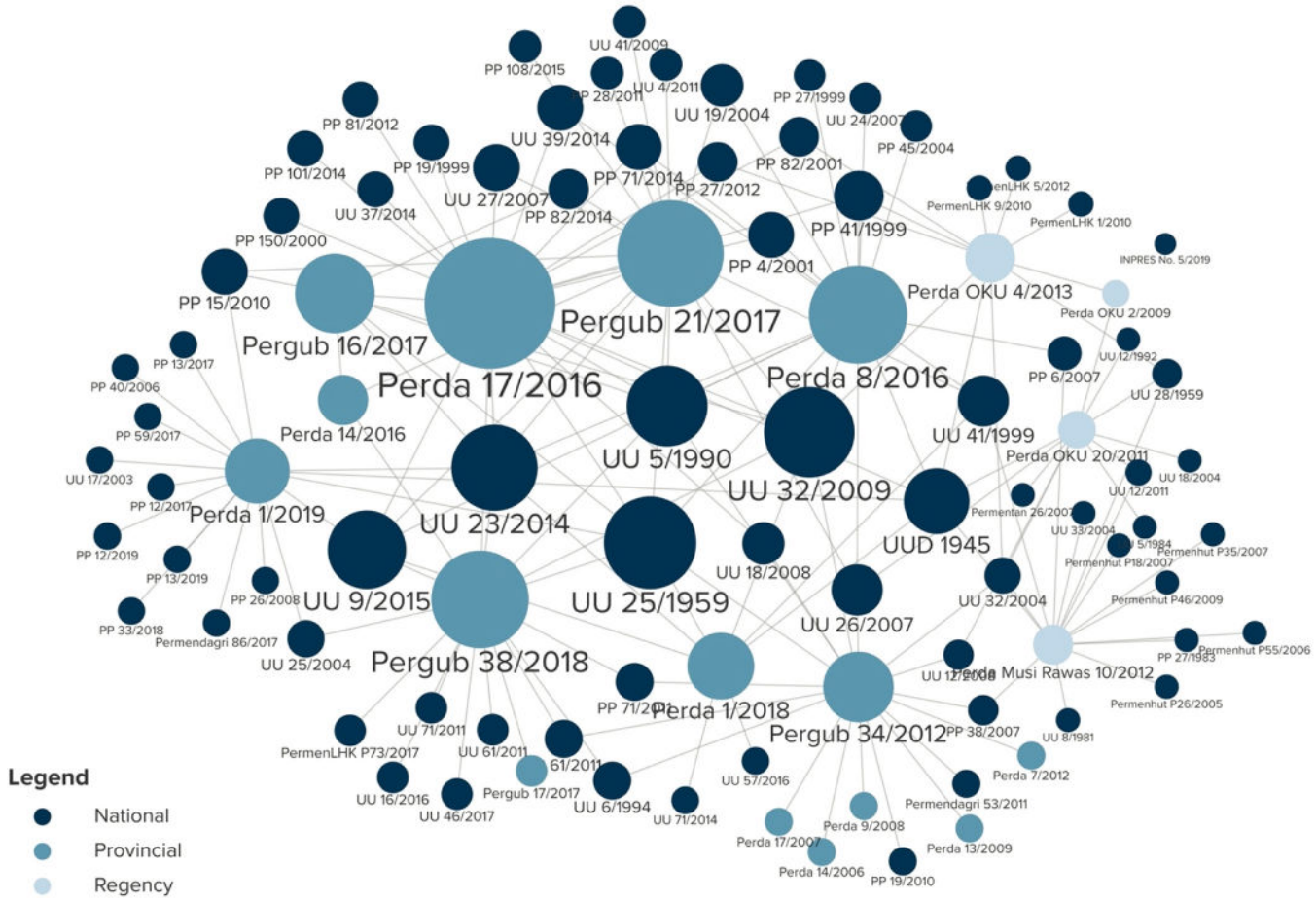

Fig. 8. Policy network analysis on public policies issued by the provincial and regency governments. Note: Larger spot sizes represent higher eigenvector centrality values, which indicate greater connection and influence within the network.

Table 4
Number of certification commitments in the private sector.

Type of company	Type of certification scheme*	
	Mandatory**	Voluntary***
Pulpwood plantation	18	1
Oil palm plantation	13	9

* One company may hold multiple mandatory and voluntary certifications. Total sample: 41 companies.
** SVLK and PHPL for pulpwood plantations and ISPO for oil palm plantations
*** FSC for pulpwood plantations and RSPO and ISCC for oil palm plantations

it difficult to define and comprehend the concept of 'deforestation', despite their affiliated institutions contributing to combatting deforestation through sustainability-related programs. As such, many indirect efforts are difficult to identify, segregate and trace. This made it harder to undertake a more comprehensive evaluation of what and how efforts can be attributed to specific goals of zero-deforestation pledges.

In addition to conceptual challenges around deforestation terminology, we recorded other challenges such as socioeconomic complexities, budget limitations, inflexible bureaucracy, a lack of intersectoral coordination, information transfer gaps, and changes in government structure which may impact the effectiveness of translating commitments/policies into action. One key informant reflected on the coordination between national and subnational governments. The key informant stating some activities fell into the subnational level government's authority or concern. For example, it was the provincial government authority to guide green growth, including reducing deforestation. Hence, at the regency level, there was a limited attention paid to the environmental aspects. However, this informant also perceived that regency and provincial government actors were bound by national and central government policy/regulation, as well as their assigned roles, responsibilities, and authority levels. This key informant also identified that budget at the regency level for the forestry sector was low. Funding limitations were also faced by Forest Management Units (FMUs) in the regency, causing slow progress among many of the (direct and indirect) zero-deforestation-related activities detailed in the FMU's long-term forest management plan (2018–2027). At the provincial level, budget availability and management were much less of an issue, due to the integration and support of international donor-funded multi-stakeholder partnerships. However, other challenges, as described above, were compounded by the declining environmental quality of South Sumatra, indicated by the low environmental index, increase of GHG emissions, land conflicts, and overlap of settlements in forest zones. During the FGD, despite the likely positive impacts of the new public policies, regulations and plans, a key informant viewed the plan of the national government to establish expansive food estates (MoEF Decree No. P.24/, 2020) as complicating subnational efforts to reduce deforestation. It was suggested that thorough impact assessments of food estate projects be completed, so that relevant institutions could prepare mitigation plans to make sure planned activities align with the province's green growth policies and plans to reduce deforestation.

In addition to qualitatively documenting stakeholder perceptions of activity progress through interviews and a focus group discussion, we quantitatively assessed the perceptions of respondents of their efforts, programs and budget against criteria and indicators (Appendix 1,

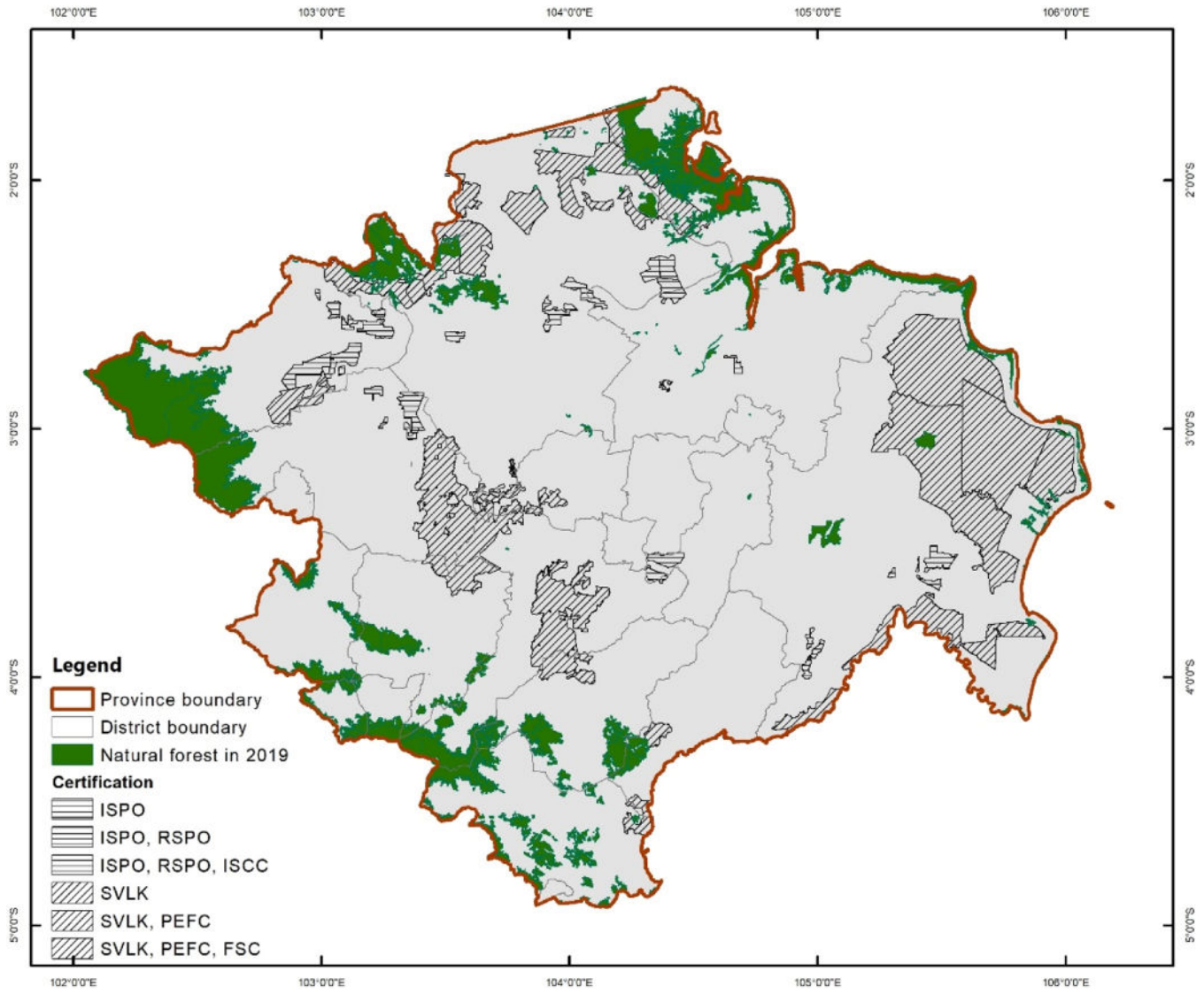

Fig. 9. Private commitments and their coverage areas in South Sumatra.

Fig. 10). A total score was given to determine and classify actor commitment. The study found that about 80% of respondents affiliated with the provincial government were fully committed to zero deforestation, despite confusion around the concept of deforestation. Provincial-level commitment was reflected in strategic plans regarding sustainable development in South Sumatra including efforts to improve environmental quality, prepare disaster resiliency, and reduce emissions as elaborated in the Regional Action Plan of South Sumatra to reduce GHG emission 2010–2030. The level of commitment at the regency level was lower. This was shown by regency-level government actors, including those in forest management units, having medium (17%) and low commitment (83%). These findings contrasted with higher level subnational jurisdictions, which indicates inconsistency around the commitment in conceptualizing zero-deforestation. The reasons why the regency is scored lower may be because this level of jurisdiction has limited authority for forest governance and management. Following the enactment of Law No 23/2014, the central and provincial governments have authority over forestry affairs including forest management. The limited authority of the regency level may reduce incentives to prevent deforestation occurring in State Forest Zones. Lack of capacity and regulatory and financial support have also resulted in the lack of commitment among most regencies to protect forested areas outside State Forest Zones, to which they have authority for. While environmental affairs are under the authority of the regency (Article 12 of Law No. 23/2014), they are in practice often still interpreted as being confined to environmental impact assessment and waste management. As per Presidential Regulation No. 61/2011, only provincial governments are obliged to prepare regional action plans for reducing GHG emissions.

3.4. *Impact of public sector commitments*

Further assessment of commitments is shown in Table 5 and Appendix 5, which aims, through four different models, to understand the extent of public sector commitments had an impact on forest loss. Using policies as a proxy, regardless of the respondent's commitment level, the annual South Sumatra deforestation rate was 1.43% prior to the public sector commitment to zero deforestation. In the same year after the public sector commitment was made, the deforestation rate was 1.31% (Model #1). A year after the public sector commitment was made, there was no change in the deforestation rate (Model #2). Two and three years after the public sector commitment was made, the deforestation rate declined to 0.82% (Model #3 and #4). Although the deforestation rate declined, the public commitment has yet to produce a statistically significant effect to the deforestation rate at the confidence level of 90% based on the observed models (Model #1 to #4). This may be due to

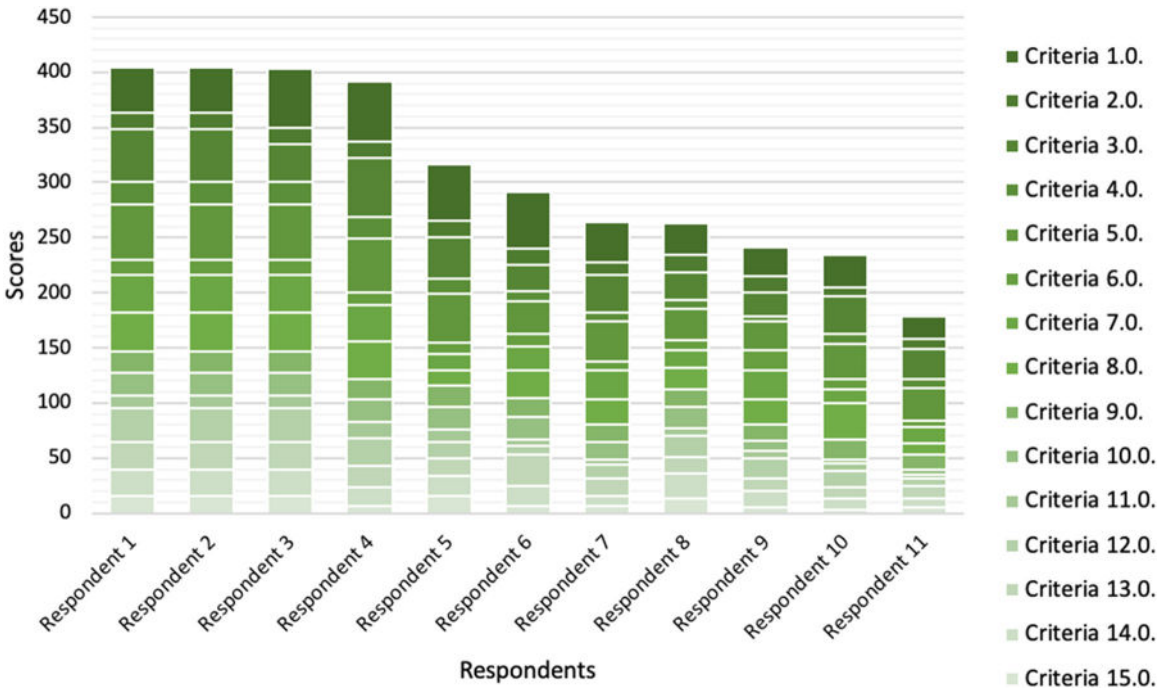

Fig. 10. Score of public sector respondent commitment to zero deforestation, marked against criteria and indicators of zero deforestation commitment (Appendix 1) Respondents on the left represent provincial level government, while those on the right represent regency governments.

Table 5
t-Test of impact on South Sumatra deforestation rates before and after public sector commitments to zero deforestation were made.* (see Appendix 5).

	Model 1 (The same year)	Model 2 (One year after the commitment)	Model 3 (Two years after the commitment)	Model 4 (Three years after the commitment)
Observation	17	17	17	17
Before commitment (%)	1.43	1.43	1.43	1.43
After commitment (%)	1.31	1.43	0.82	0.82
Diff. mean (%)	0.12	0.00	0.60	0.61
Diff. standard error	0.8655	0.9146	0.8734	0.9453
Diff. standard deviation	3.5684	3.7710	3.6011	3.8977
95% confidence interval	-1.7139	-1.9436	-1.2468	-1.3956
	1.9556	1.9340	2.4563	2.6124
H_0 p-value 10%	0.8907	0.9959	0.4986	0.5290
Conclusion	**Failed to reject H_0**	**Failed to reject H_0**	**Failed to reject H_0**	**Failed to reject H_0**

H_0: No significant differences in deforestation rate before and after the public sector commitment.
Confidence level was 90%.
*Different public sector commitments were made in different years.

different levels of commitment across the public sector (Fig. 10), implementation challenges, and confusion around the conceptualization of zero deforestation. There were many substantial efforts related to zero deforestation but yet to show significant impact, at least statistically. Some of the efforts were the national-level technical ministries and government agencies, along with subnational (provincial and regency) leaders, have been ordered to enforce moratorium on primary natural forest and peatland. At provincial level, the Green Growth Masterplan served as guidance for stakeholders carrying out land-based green growth. This green growth commitment was also supported by the provincial-level Forestry Office, which undertook rehabilitation of degraded land, social forestry, and distribution of multipurpose tree species seedlings. The Regional Restoration Team, supported by the Watershed Forum, carried out replanting of degraded peatland and restoration. Meanwhile the Financial Services Authority enforced sustainability financing through insurance companies and banks, requiring companies to implement sustainable finance in their business activities. All such actions formed part of the efforts to realize the national commitment to climate change mitigation, but these will take time to show clear impacts in reducing deforestation.

As well as the actions mentioned above, key informants highlighted the contribution of civil society organizations (CSO) best practice and support, which is rarely acknowledged. CSOs like Kolega Sumsel played an important role in shaping the Green Growth Masterplan, while Kelola Sendang supported the development and establishment of the Partnership Masterplan. WRI developed tools for the planning and monitoring of the Green Growth Masterplan, as well as facilitating the One Map policy and research on social forestry. A consortium of ICRAF, WRI and Wetlands International's Indonesia Program facilitated the development of a peatland ecosystem restoration plan and developed a related database. The Watershed Forum supported peatland restoration through their involvement in developing the peatland ecosystem restoration plan and strategy. Kemitraan (Partnership for Governance Reform) worked closely with Indonesia's Peatland Restoration Agency to facilitate activities in Peat Care Villages. The University of Sriwijaya carried out research projects under the Millennium Challenge Account Indonesia. Many such efforts described by the key informants may have contributed to and affected the extent of impact of public sector commitments. Yet how these efforts are identified, assessed on their progress and achievements to date, and attributed to related measures of success,

remains elusive.

3.5. Impact of private sector commitments

Our study indicates that sampled pulpwood and oil palm plantation companies in South Sumatra obtained concession permits as early as 1990. The number of issued permits increased by 17% each year in 1996, 1999 and 2009, with 2004 seeing an increase of 15%. The year concessions were issued was unknown for 17% of the sampled companies. The majority of concession permits were issued before 2000 (44%). Some concessions, at least eight companies, were a subsidiary of a larger-scale parent company or group. At least six companies were direct suppliers to one of Indonesia's largest pulp and paper groups. One key informant believed that companies, particularly large-scale operations, had high commitment to complying with regulations and acting in a careful manner in their operations. They were motivated by maintaining their credibility and reputation in international markets by pursuing certificates and ensuring sustainable practices. Relating to zero-deforestation commitment, a key informant identified the need for a clearer concept of deforestation. This would be beneficial for promoting a shared understanding when determining the direction of the commitment and guiding the implementation.

We observed that private sector commitment to sustainability, as reflected in corporate pursuit of mandatory and voluntary certification, was absent for most of the 1990 s and early 2000 s. The earliest record of certification was in 2009 with only two companies (5%) obtaining FSC or RSPO certification. Commitment peaked in 2013, 2015 and 2017, when 17%, 29% and 17%, respectively of companies became certified. Key informants agreed that certification positively influenced sustainable practices and was likely to represent private sector commitment. Certification is a rigorous process that requires companies to comply with best practices as stated in the certification criteria and indicators. The certification process is not easy, cheap and instant, which implicitly infers the presence of costs, efforts and time for the company to comply with the standard. One informant associated with a pulpwood company agreed that certification is relatively effective in promoting the adoption of sustainability practices, regardless of the certification type. It also creates changes in business practices. In pulpwood companies, commitment was shown through mandatory certification like PHPL and associated certifications like ISO (International Organization for Standardization), IFCC (Indonesian Forestry Certification Cooperation), SMK3 (*Sistem Manajemen Keselamatan dan Kesehatan Kerja/* Occupational Health and Safety Management System), and OHSAS (Occupational Health and Safety Assessment Series) 18001. In the palm oil sector, one informant stated that efforts of companies and smallholders to make their products sustainable and ISPO-certified have been further encouraged with the issuance of a national action plan for sustainable oil palm plantations, as declared in Presidential Instruction No. 6/2019. However, key informants acknowledged the importance of also getting products certified under voluntary schemes, particularly for entering global markets.

We assessed the impact of commitments, using the certification year as the proxy for statistical assessment, regardless of the commitment level of the private sector respondents (Table 6 and Appendix 6). Our study indicated that in the same year the private sector commitment was made, the deforestation rate was 2.97% (Model #1). One, two, and three years after the private sector commitment was made, the deforestation rate was 2.61% (Model #2), 2.25% (Model #3), and 1.50% (Model #4) respectively. Statistically, there was sufficient evidence that the deforestation rate decreased significantly over time with a 90% confidence level. This finding was consistent with private sector respondents' perceptions that there was a high level of commitment (Appendix 1). The respondents' stated their motivation to comply towards government regulations and maintain performance in accordance with the certification standards. However, private sector progress and efforts were rarely discussed or disclosed. In contrast with public sector respondents who were open to discuss information with outsiders, private sector respondents took cautious measures when sharing information or data and often avoided disclosure. In an interview and focus group discussion, the business association perceived a strong intent and effort by the private sector to comply with government regulations. Despite the limited power to intervene in a company's operational activity or management, the association claims to play an important role in promoting and advocating for concessions to accommodate triple bottom lines of sustainability (environmental, economic and social) within their practices. Approximately 30% of the palm oil companies in South Sumatra were GAPKI members – this highlights the diverse levels of capacity and commitments among growers, and the challenges they faced in adopting sustainable practices. After interviewing a national-level respondent representing a forestry parent company, it was evident that higher level internal actors have authority to enforce subsidiaries to take specific actions. According to the respondent, four of its subsidiaries in South Sumatra had been FLEGT-certified –which means they have fulfilled either PHPL or SVLK - and were in the process of pursuing the Program for Endorsement of Forest Certification (PEFC). Another key informant from the palm oil sector identified that under the moratorium policy, clear boundaries and land rights, improvements to productivity and ISPO certification were some of the key measures in successfully reducing deforestation. Challenges in reducing deforestation and creating deforestation-free supply chains remain, where overlapping and unclear boundaries, both inside and outside state forest zones, have caused uncertainties. At the mill level in particular, the key informant described how oil palm fresh fruit bunches coming from legally permitted areas are mixed with those coming from smallholders' plantations, which were supposedly located in illegal areas or even on land cleared at the expense of forests. Corrective and preventive measures were arduous; many of the state forest zones were no longer forested, and there was a lack of understanding and confusion around

Table 6
t-Test of impact before and after private sector commitments to zero deforestation were made.* (see Appendix 6).

	Model 1 (The same year)	Model 2 (One year after the commitment)	Model 3 (Two years after the commitment)	Model 4 (Three years after the commitment)
Observation	38	38	38	31
Before commitment (%)	6.39	6.39	6.39	6.70
After commitment (%)	2.97	2.61	2.25	1.50
Diff mean (%)	3.42	3.77	4.14	5.20
Diff standard error	1.5629	1.5470	1.4694	2.0021
Diff standard deviation	9.6343	9.5362	9.0579	11.1470
95% confidence interval	0.2523	0.6362	1.1608	1.1081
	6.5857	6.9052	7.1153	9.2856
H_0 p-value10%	0.0351	0.0197	0.0077	0.0145
Conclusion	**Reject H_0**	**Reject H_0**	**Reject H_0**	**Reject H_0**

H_0: No significant differences in deforestation rate before and after the private sector commitment.
Confidence level was 90%
*Different private sector commitments were made in different years.

the terms forest zone and forests.

While certification was widely recognized to promote sustainability efforts, one key informant in the focus group discussion further elaborated a company's efforts to reconcile sustainability and community welfare by engaging community groups surrounding its concessions in social forestry projects, using production management schemes. Another key informant associated with the palm oil sector stated that besides certification, private sector commitment was reflected in strategic partnerships with non-state actors, as well as contributing to the South Sumatran government Green Growth Masterplan, which focused on rubber, oil palm and coffee plantations. The Green Growth Masterplan addressed associated impacts, land suitability and best practices to mitigate negative impacts on forests. The extent to which these programs and partnerships can be attributed to or associated with impacts on deforestation was important to assess the zero deforestation efforts. However, this study used the Green Growth Masterplan as a proxy solely for public sector commitment, while private sector commitments were mainly assessed through certification.

4. Discussions

4.1. Public and private commitments and their impacts

Recent public and private sector commitments can be linked to reducing the high rates of deforestation in South Sumatra. However, not all commitments have shown to have significant impact, at least statistically based on the observed models. Further, current efforts have not been able to achieve their aim of being 'zero deforestation'.

Our study found sufficient evidence that the rate of deforestation decreased after private commitments were made, reflected through certification. Some factors that may explain the impacts are that private companies have greater control over their concessions; that there are imminent pressures through value chain governance arrangements; that their certificates will be under periodic surveillance; and there are civil society organizations that keep eyes of their conducts through various means, such as remote sensing technologies.

Although public sector commitment has yet to demonstrate a statistically significant decrease in the rate of deforestation, efforts have been made at subnational level. Government institutions have implemented deforestation-related regulations through actions, roadmaps, programs or budget allocations, supported by non-state actors through multi-stakeholder and multi-partner platforms. These efforts have reduced deforestation, albeit not in a statistically significant manner. However, we also recognize that the impact of public commitments may not be instantaneous. Policies must be translated to annual programs, and later to budget allocation. Therefore, long-term observation is required. The results of the policy network analysis reveal PERDA 21/2017 on the Green Growth Masterplan as the most connected regulation in South Sumatra. This regulation at the provincial level have connection to the national level. Ideally, it should be adopted by the regencies as well. Therefore, strengthening the implementation of this regulation will influence and strengthen related regulations.

The Government of South Sumatra has set key strategies, as defined in their 2019–2023 mid-term development plan (Regional Government No. 1/2019), to improve the quality of the environment and maintain forest cover, to reduce emissions from forest and plantation sectors, and to adopt sustainable principles in land use and allocations. This gives hope for the future of deforestation avoidance measures. We suggested to carry out further avoidance measures through strengthening law enforcement by inspections, for instance, investigations, and court cases. On the private sector side, the process of obtaining certification requires companies to comply with standards, thus helping to enforce best practice within corporate operations. For large-scale companies, commitment and certification matters for reputation and business efficiency reasons. However, more efforts are required to prevent 'leakage' effects produced by medium and smaller size businesses, whether corporate or smallholder. It remains to be seen how commitment implementation will result in expected outcomes in the years to come.

We also realize that the term zero-deforestation as something that should be applied to every patch, landscape or jurisdiction in Indonesia may be wrong. As a developing country, several areas in Indonesia need space and land for infrastructure and agricultural development so that planned deforestation is unavoidable e.g., Papua and West Papua Provinces. Some other areas should have not only zero deforestation but also afforestation and reforestation like most provinces in Sumatra (Aryono et al., 2018). For Indonesia, zero-deforestation must mean net zero-deforestation which means the sum of deforestation, afforestation, and reforestation must be equal to zero. So not for every patch to achieve zero-deforestation but for the whole area that is defined and mutually agreed upon by the parties.

4.2. Perceptions of zero deforestation

In the context of Indonesia and South Sumatra Province, progress is challenged by how different stakeholders perceive terminologies and contexts, namely 'forest zone' and 'deforestation'. Expected outcomes, in terms of zero-deforestation or effective measures to reduce or even halt deforestation, will unlikely be realized until terminologies and contexts are commonly understood and agreed. There was a lack of acknowledgement and even confusion around zero-deforestation commitments among subnational stakeholders. Differences were evident between provincial and regency-level actors in terms of their level of commitment, whereby provincial-level actors were generally more committed than actors at the regency level. As such, partnerships with non-state actors played critical role in filling this commitment gap. Meanwhile, private sector commitment was high and consistent among actors at headquarter/ national and subnational levels. Implementation of commitments is not without its challenges, which relate to socio-economic complexities, coordination, and structural and organizational capacity and limitations. There were efforts and activities that had clear connections with, and could be attributed to, zero-deforestation commitments, but there was a lack of documentation and attribution to zero deforestation specifically, particularly since different terms are in use around how deforestation is understood and measured. This hindered efforts to comprehensively document and evaluate progress and efforts.

4.3. Completing the knowledge gap

This study helped to measure progress on zero-deforestation commitments using spatial and statistical analysis, combined with qualitative assessment of public and private commitments and perceptions. Commitments were made by national actors in the international arena, with the subnational level being the 'action arena' in which commitments were implemented. For commitments to have impact, monitoring and evaluation will need to be strengthened to understand progress, identify emerging challenges or opportunities, and mobilize resources and networks. Past studies have assessed the outcomes and impacts of zero-deforestation commitments made by the private sector (Jopke and Schoneveld, 2018; Lambin et al., 2018; Ludwig, 2018; Accountability Framework Initiative, 2019b), the building of assessment frameworks and criteria (Jopke and Schoneveld, 2018; Ludwig, 2018; Garrett et al., 2019; Accountability Framework Initiative, 2019a), impacts on rural livelihoods (Newton and Benzeev, 2018) and fauna persistence (Deere et al., 2020). Our study contributes to the literature gap by measuring zero-deforestation commitments made by both public and private sector actors. The study focused on the main objective of zero-deforestation commitments, i.e. measuring impact in relation to the deforestation rate and forest cover loss. We also captured the perceptions of key informants relevant to implementation of these efforts.

The IAD analytical framework provided a useful guide to understand the context around agriculture commodity development and the various actors involved in, and shaping, sustainable supply chains. It also helped

to measure progress, and assess how interactions among private and public actors in the action area led to outcomes then impacts after zero-deforestation commitments had been made. The mixed methodology employed helped to understand the extent of actor commitment, as well as the extent of the actor's impact to reduce or achieve zero deforestation. The combination of spatial and qualitative analysis used in the study proved to be inextricable in terms of producing comprehensive measurements, allowing us to conclude that the commitments made matter, when it came to reducing deforestation.

The working IAD framework can be summarized as follows. First, we identify the exogenous variables where public and private zero-deforestation commitments occur. Biophysical variables involve deforestation, forest and land fires, and climate change. Social and economic conditions imply that local communities and smallholder oil palm and timber plantations cannot participate fairly in the associated value chains. Institutional arrangements involve national and provincial commitments to reduce GHG emissions and illegal logging and various multi-stakeholder forums. Various actors are involved to influence public and private commitments to zero deforestation, they are provincial and district governments in South Sumatra, central government, palm oil and pulp & paper companies, communities, smallholders, academics, research organizations, and various NGOs. Second, actors, both private and public, have made zero deforestation commitments through mandatory and voluntary certification, national and sub-national regulations. The actors act and interact further under this action situation to produce results. Meanwhile, private commitments influence their value chains not only locally but also globally. Public regulations operate under different relevant jurisdictions. Actions through value chains, jurisdictions and interactions can change the behavior of decision makers regarding land use, production practices and technology to be used. This outcome will reduce deforestation and associated GHG emissions.

4.4. Limitations of the study

The study enabled us to assess the progress of zero-deforestation commitments using a mixed method for analysis. It also came with some limitations, however, in terms of data sources, sampling, analytical approach and the dynamics of interactions. Most of the spatial data was sourced from the government data alone. The exception is the concession data, which was sourced from Global Forest Watch. The study is therefore based on the assumption that both the government and Global Forest Watch data represent realities on the ground, accurate, and up to date. We were also challenged by the small number of respondents acting as our sample, as the sensitivity of the issue under discussion influenced respondents' willingness to take part in discussions. We therefore complemented data collection with a focus group discussion to verify the methodology and preliminary findings, as well as to compile more information.

The dependent t-test statistical analysis is commonly used to evaluate the impact of a specific intervention or treatment by comparing the outcomes before and after its implementation (see e.g., Kimport and Hartzell, 2015; Ventura et al., 2021). In our study, we employed the t-test to assess whether there was a significant difference in deforestation rates before and after the commitments made by the public and private sectors. The reliability of the t-test as a method for impact evaluation depends on several factors. Firstly, it assumes that the data used in the analysis are independent and randomly sampled. This implies that the observations are not influenced by systematic biases or confounding factors that could skew the results. Additionally, the t-test assumes that the data are normally distributed.

It is important to note that while the t-test can provide valuable insights into the potential impact of commitments on deforestation rates, it does not establish a causal relationship. Other unmeasured factors or confounding variables may still contribute to the observed differences. To enhance the reliability of our analysis, we took steps to address potential limitations. We clearly defined the time periods before and after the commitments, and we used appropriate data sources to ensure accuracy. Additionally, we acknowledged the assumptions underlying the t-test and provided explanations regarding the limitations and uncertainties associated with our approach.

Our study was also limited to assessing private and public sector commitments separately. We were aware, however, about possible interactions between public and private commitments; that public sector commitments (i.e. regulations) may have influenced private sector practices, e.g. moratorium influences the licensing of concessionaire for the private sector. Further assessment on the dynamic interactions of influence between public sector commitments and private sector commitments remains to be done. In particular, the role of increasing enforcement to reduce deforestation (monitoring, reporting, prosecution) is an important factor to be added to the range of commitments.

Likewise, the roles of non-state actors, especially smallholders, are yet to be investigated, particularly in terms of the extent of their contributions and impact. A detailed assessment of programs and budgets attributed to zero deforestation would also be beneficial. For the private sector, there is a need to assess sustainability policies on the extent to which these have been successful in eliminating deforestation along the supply chain. Although the producer is generally perceived as the actor carrying the biggest burden in terms of commitment, a proportional share of responsibility can and should be divided to supply chain actors, including small producers, local communities and other relevant stakeholders (FAO 2017). Future studies assessing medium and small-scale companies will also be critical to understanding leakage effects.

Finally, the notion of impact should be interpreted cautiously. The focus of the impact lies on the outcome variable, i.e., the statistical difference of deforestation rates between before and after the commitment. The main underlying assumption is that both companies and public sector actors make efforts to fulfill their commitments, but the efforts are not observable. We show that there is no difference of deforestation rates between before and after public commitment. We also show the deforestation reduction between before and after private commitment is statistically significant at 90% confidence interval. We are aware, however, that the significant statistical difference between before and after private sector commitment may be applicable only for the concessions taken into the analysis. There is a lack of data on the status of the pulpwood and oil palm companies in terms of the start of the operation, efforts before and after certification and other key variables, which leads us to focus only on partial data. In addition, other confounding factors that are not part of the implementation of the private commitments may contribute to the impact variable. Making generalized statements on the impact for the whole private sector actor in the province would require more complete data and the application of more rigorous impact assessment tools, such as methods elaborated in Gertler et al. (2016). We recommend these aspects to be the focus of future studies.

5. Conclusions

Increasing commitments to reduce deforestation have been made by both public and private sector actors in South Sumatra, offering the opportunity to improve forest and agriculture commodity supply chain governance. The progress and impact of these commitments should be monitored and evaluated against the clearly-established criteria and indicators. Using the IAD framework, we were able to provide a comprehensive assessment of zero-deforestation commitments made by public and private sector actors, consisting of spatial analysis; perception and commitment reviews; and statistical assessment of commitments. Our study found that legal and illegal deforestation contributed to significant forest loss between 1990 and 2019 in South Sumatra Province. While legal deforestation may be prevented through moratorium, combatting illegal deforestation requires stricter law enforcement and minimizing the leakage effects. Despite confusion and inconsistency

in conceptualizing deforestation, progress showed that there were commitments that had indirectly contributed to zero-deforestation efforts. We found sufficient evidence, at a 90% confidence level, that private sector commitments were reducing the rate of deforestation, but that these commitments were not yet 'zeroing' deforestation. To achieve this target will involve a radical shift in current practices, i.e. broader objectives and stakeholder engagement, radical transparency, developing strategic, actionable plans that are agreed, shared and monitored among stakeholders. Future studies should include stocktaking of past and current zero-deforestation-related programs and budget allocations, assessment of non-state actor contributions, leakage effects produced by small and medium companies, and the dynamic interaction of influences between public-private sector commitments.

CRediT authorship contribution statement

Brady Michael A.: Conceptualization, Funding acquisition, Resources, Supervision, Writing – review & editing. **Kusumadewi Sonya Dyah:** Data curation, Formal analysis, Funding acquisition, Project administration, Software. **Andrianto Agus:** Data curation, Formal analysis, Investigation, Methodology. **Dermawan Ahmad:** Conceptualization, Formal analysis, Methodology, Writing – review & editing. **Puspitaloka Dyah:** Data curation, Formal analysis, Investigation, Validation, Writing – original draft, Writing – review & editing. **Okarda Beni:** Data curation, Formal analysis, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing. **Arlenlilia Luvia:** Data curation, Formal analysis, Investigation, Methodology. **Purnomo Herry:** Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. **Komarudin Heru:** Data curation, Investigation, Project administration, Resources. **Sanjaya Made:** Data curation, Formal analysis, Investigation, Methodology, Writing – review & editing. **Ristiana Nurindah:** Data curation, Formal analysis, Investigation, Methodology, Validation, Writing – review & editing.

Declaration of Competing Interest

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

Data availability

Data will be made available on request.

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