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Article

Just Transition in Biofuel Development towards Low-Carbon Economy: Multi-Actor Perspectives on Policies and Practices in Indonesia

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Abstract: Justice and sustainability are the foundation of fair and equitable biofuel development. Policies and practices are consequently necessary to support a just transition towards a low-carbon economy. Therefore, this study aimed to understand multi-actor perspectives on policies and practices relevant to the just transition in biofuel development. Applying a socio-legal approach based on the JUST framework, this study focused on the Indonesian biofuel industry, which is primarily driven by crude palm oil (CPO) production. This study also added comparative perspectives from Thailand's biofuel industry. The primary data were gathered from in-depth interviews and focus group discussions (FGDs), while the secondary data were from research, policy, and other government archives. Based on the results, oil palm plantations in Indonesia and Thailand are crucial for macroeconomic development. However, smallholder farmers in Indonesia, especially independent ones that do not join farmer groups, remain marginalised by the current regulations. In fact, many benefits from biofuel practices and policies accumulate disproportionately towards large corporations, while marginalised groups bear the costs. The Indonesian Sustainable Palm Oil (ISPO) certification that should induce market accessibility and competitiveness has not fully reached most rural farmers. Furthermore, various overlapping regulations and perplexing data differences exist from multiple ministries and administrative levels. Thus, palm oil stakeholders in Indonesia demand a dedicated institution for integrated regulation and monitoring of the industry, similar to the National Palm Oil Policy Committee in Thailand. The myriad of legal, political, socio-economic, and justice issues thus necessitates all hands on deck to ensure a just transition for all stakeholders of the Indonesian biofuel industry.

Keywords: energy transition; energy policy; renewable energy; energy justice; socio-legal analysis; multi-actor systems; rural development; energy sustainability; bioenergy; fairness and equity

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1. Introduction

The world is gradually shifting from production and consumption activities powered by fossil fuels to a low-carbon economy fuelled by renewable energy sources [1]. Biofuels have a significant role in the energy transition due to their compatibility with existing infrastructure and technologies that are technically difficult to decarbonise [2,3]. As countries attempt to reduce greenhouse gas (GHG) emissions as part of climate change mitigation, biofuels thus act as a crucial bridge between the current fossil fuel-dependent economic systems and a desirable low-carbon future predominantly powered by renewable alternatives [4]. However, the critical role of biofuels in energy transition raises debates revolving around sustainability-related issues. To begin with, biofuel production requires substantial amounts of water and agricultural inputs [5], leading to water scarcity and

pollution from fertilisers and pesticides. It also triggers changes in land use for biofuel crop cultivation or subsequent production processes [6]. Then, the total lifecycle emissions vary significantly depending on the feedstock and production processes used [7]. In some cases, the emissions are comparable to, or even greater than, those of fossil fuels.

Furthermore, biofuel development is traditionally centred on techno-economic issues. Indeed, a solid focus on improving the technical efficiency and cost-effectiveness of biofuels is undeniably important. However, it is increasingly recognised that other issues, particularly those related to justice and sustainability in the pursuit of a just transition, are also crucial [8]. Just transition demands a fair and equitable transition to a low-carbon economy, minimising negative impacts on vulnerable groups and ensuring a fair distribution of benefits [9,10]. It implies how biofuel production and consumption impact various stakeholders [11]. For example, biofuel development can impact rural livelihoods by changing land use, tenure, and access. Smallholder farmers may lose land to large biofuel projects without proper consent or compensation [12], making implementing measures to safeguard local communities essential. Further, labour practices in biofuel feedstock plantations and processing facilities should be ethical and fair, avoiding exploitation [13]. In addition, the benefits of biofuel production and consumption may be overly distributed to major biofuel companies while smallholder farmers struggle daily [14]. It demands structural changes for an equitable sharing of benefits across biofuel value chains.

In industrialised countries [15–17], biofuel development has begun integrating sustainability and justice issues towards a just transition [18]. However, most developing countries, including Indonesia, still struggle with various concerns arising from biofuel production and consumption [19,20]. As the world's largest producer of crude palm oil (CPO) [21], Indonesia has made the CPO industry the main driving force of its energy transition. Shifting to biofuels has helped the country fulfil its commitment under the 2015 Paris Agreement [22,23] and the recently announced Just Energy Transition Partnership (JEPT) [24,25]. However, CPO-based biofuel production in Indonesia has raised various socio-ecological concerns [26,27]. The massive expansion of oil palm plantations has led to significant deforestation [28], biodiversity loss [29], and land conflicts [30]. Further, biofuel production by smallholder farmers is considerably expensive when considering the costs of sustainable production practices [31]. Despite government subsidies, sustainability-related cost competitiveness remains challenging, leading to difficulties in fostering the transition to biofuels. These issues undermine the benefits of biofuels and pose challenges to Indonesia's commitment to Sustainable Development Goals.

Despite hosting massive renewable energy sources [32–34], Indonesia requires substantial transformations of policies and practices for a just transition towards a low-carbon economy. Still, the country's energy consumption between 1961 and 2018 revealed that energy consumption, dominated by fossil fuels, did not have a significant long-term association with GDP growth [35]. In that sense, energy consumption in Indonesia mainly occurred in mere nonproductive activities. It drives biofuel development practices and policies to focus on resolving technical issues and fostering economic growth [36] rather than maintaining socio-ecological balance, making it difficult for a just transition to emerge. Thus, this research aimed to investigate how the biofuel industry in Indonesia could accelerate an energy transition while ensuring justice in the process. Further, this study attempted to identify complex challenges in the country's biofuel industry as the basis of recommendations for the government in achieving a just energy transition. Notably, this research strove to discover how policies and practices could be improved for fairer socio-ecological and financial outcomes towards different stakeholders in the industry and society. This study thus attempted to answer the following questions:

- **RQ1** What framework could be used to understand the complex requirements for the Indonesian biofuel industry to pursue a just transition?
- **RQ2** How do current policies and practices in the CPO-centred biofuel industry support the just energy transition?

- **RQ3** What recommendations can the government follow to improve policies and practices for the country's CPO industry in fostering the just energy transition?

2. Literature Review

2.1. An Overview of the CPO-Driven Biofuel Industry in Indonesia

There are positive correlations between economic growth and carbon emissions [37–39] that, at times, lead to environmental degradation [40–42]. As countries develop their economies, industrial activities accelerate, resulting in increased GHG emissions that contribute to climate change. Indonesia is no exception. Domestically developing clean energy sources provides environmental and economic benefits [43]. Biofuels play a pivotal role in its energy transition by reducing GHG emissions while growing the economy. With volatile global energy markets and abundant renewable energy sources, diversifying energy supplies through domestic sources reduces reliance on imported oil [44]. Since the 2000s, Indonesia has developed biofuels to shift from imported petrol [36], constituting 30% of total domestic demand. The leading biofuel is CPO, which produces biodiesel to substitute fossil-based diesel fuel. The country's CPO industry contributes significantly to economic growth, especially in rural areas [45]. Still, volatile CPO prices negatively impact smallholder planters and rural communities that rely on the CPO industry [21]. The government, to maintain the CPO industry's growth, rural livelihoods, and ecological balance, should thus implement policies and practices to support a just transition.

CPO is derived from oil palm, an extremely productive oil crop that generates up to ten times more oil per hectare than other plants [46]. It can be harvested frequently, up to every 10–15 days, over the tree's long productive lifespan of around 25 years [47]. This exceptional yield and productivity supported the massive development of Indonesian oil palm plantations since the 1970s [48]. By the 1980s, the country had already developed 294,000 hectares of oil palm plantations amid rapid expansion [49], progressively increasing to over 15 million hectares by 2019 [50]. Figure 1 depicts the spatial distribution of oil palm plantations throughout Indonesia. This growth enabled Indonesia to become the world's largest CPO producer. Despite the steady year-on-year production increase, compounded factors have severely constrained Indonesia's CPO trade, resulting in fluctuated exports. Contributing to this trend, India, a major importer, raised import tariffs on CPO by 44% and CPO products by 54% in 2018 [51], reducing demand. Further, EU countries implemented non-tariff barriers, citing environmental concerns about palm oil expansion [52]. The EU also accused Indonesia of unfairly subsidising CPO for biodiesel production [53], prompting anti-dumping inquiries. Then, negative media campaigns portrayed Indonesian palm oil as destructive [54], discouraging consumption.

The EU Renewable Energy Directive (RED) has significantly impacted Indonesia's CPO exports and domestic biofuel development. It was first introduced through the Renewable Energy Directive 2009/28/EC [55] and the Fuel Quality Directive 2009/30/EC [56]. The initial purpose was to act as transitional regulations to prepare for broader biofuel adoption across Europe. A decade later, however, the EU re-evaluated its positioning by issuing a recast (EU Directive 2018/2001; RED II) in December 2018 [57]. The new directive established stricter limits to the production and consumption of biofuels, bioliquids and biomass fuels that have high risks of indirect land use change (ILUC), with a phase-out by 2030 [58]. ILUC refers to clearing land originally destined for crop cultivation and feed markets induced by the diversion of the cropland for biofuel production. RED II targets feedstocks like palm oil that drive deforestation in tropical regions when diverted for European biofuel manufacturing [59]. It directly affects CPO-based biofuels from Indonesia, which are classified as high ILUC risk. With Indonesia being the largest CPO exporter to Europe, the RED II is projected to reduce CPO demand for Indonesia significantly. In response, the Indonesian government has started initiatives to utilise CPO supply, previously meant for export, for domestic biodiesel production.

Recently, the government developed the B30 program as a domestic solution to offset declining CPO exports by absorbing excess supply through biodiesel production [60]. The program mandates 30% biodiesel content in diesel fuel [61], providing a sizable domestic

market for CPO-based biodiesel. In fact, Indonesia is poised to become the world's third-largest biodiesel producer through a successfully implemented B30 program [62]. However, infrastructure limitations, particularly outside Java Island, constrain biodiesel distribution and the utilisation of CPO surpluses nationally. Financial incentives for biodiesel producers could hence encourage investments in infrastructure modernisation to foster the program. While biodiesel development addresses CPO oversupply concerns, long-term growth requires balancing productivity gains with sustainability practices [21]. Proactive engagement with the EU is needed to meet sustainability criteria and restore market access by considering restrictive trade policies like RED II. Sustainability certification would demonstrate Indonesia's commitment to sustainable palm oil production [63], complementing domestic biodiesel policies. Ultimately, implementing the B30 program and instituting sustainability measures pave the optimal pathway for Indonesia's CPO industry to thrive in the global market while bolstering the national energy transition.

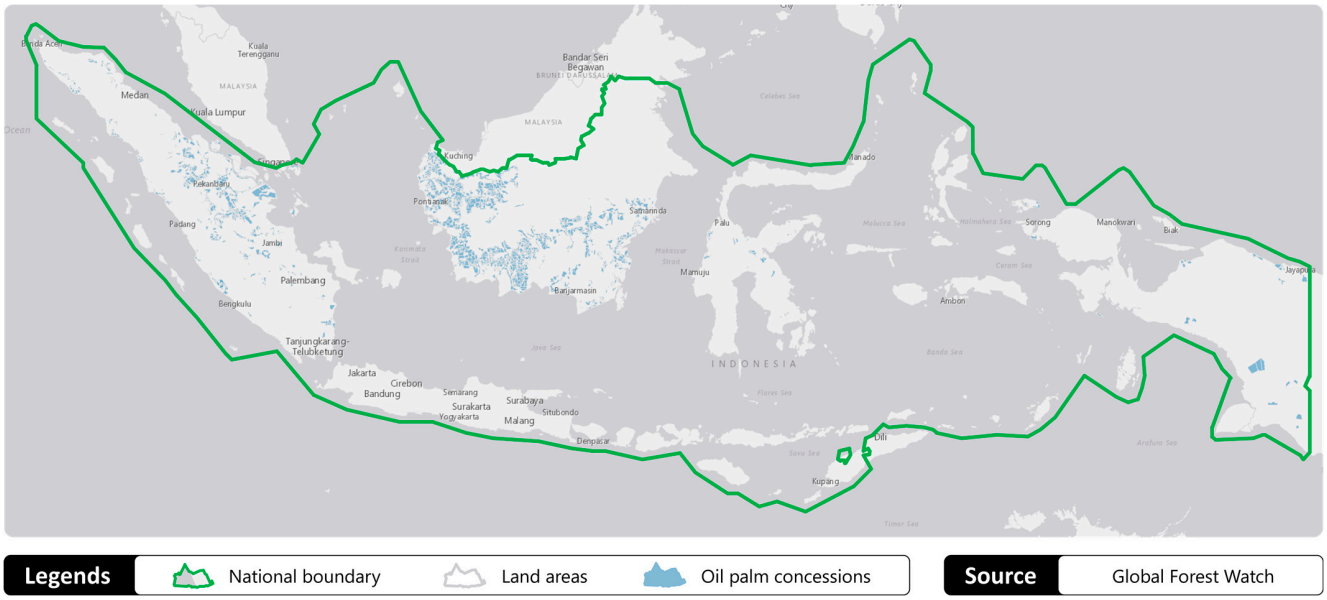

Figure 1. Spatial distribution of oil palm plantations in Indonesia [50].

2.2. Towards Just Transition: The JUST Framework

Looking at the overview, the CPO-driven biofuel industry in Indonesia faces pressing challenges, both domestically and overseas. Invigorating the CPO-biofuel sector requires a holistic approach that will lead to fairer outcomes for all stakeholders. Particularly, applying a holistic framework balancing justice along with sustainability policies and practices will ensure the continued growth of the biofuel industry [8], contribute to Indonesia's energy and climate targets for 2030 [64] and foster a just energy transition [65–67]. At this point, the JUST framework [68] offers a systemic way for a holistic policy analysis of an extractive industry towards a just transition. Basically, the framework [69] accounts for (1) justice at various regional levels, (2) universal forms of justice, (3) all relevant locations of the industry, and (4) timelines for industrial activities, energy transition, and climate targets. The framework aims to foster strong relationships among relevant stakeholders, manage the risk profile of the industry, and eventually ensure mitigation and adaptation measures to lessen environmental impact [70]. Focusing on justice and inclusivity via the JUST framework can ultimately catalyse an equitable and just energy transition [71], benefiting Indonesia and the global community.

The JUST framework [69] is designed to engage with policymakers and financiers for whom the risk profile of an extractive industry is exceptionally crucial. In the decision-making process, it could deliver valuable information to consider whether an extractive industry, i.e., the CPO industry, should proceed financially and acquire a social licence to

operate [70], whether formally or informally. Conceptually, the framework encompasses four key elements [72]: justice, universal forms of justice, space considerations, and time-related issues (Figure 2). Justice (J) involves three sub-elements essential for ensuring sustainable and equitable development from an extractive industry: distributive justice, procedural justice, and restorative justice [73–77]. Distributive justice examines crucial aspects of revenue management and transparency concerning resources management. Meanwhile, procedural justice focuses on the legal and regulatory processes throughout an industrial lifecycle. For the CPO industry, this starts from the initial planning stages of cultivation to utilising CPO as a renewable energy source. Then, restorative justice is fundamentally concerned with restoring oil palm plantations and related lands to their original roles in the local and global socio-ecological systems. Policies and practices under restorative justice should be planned for at the beginning rather than as an afterthought.

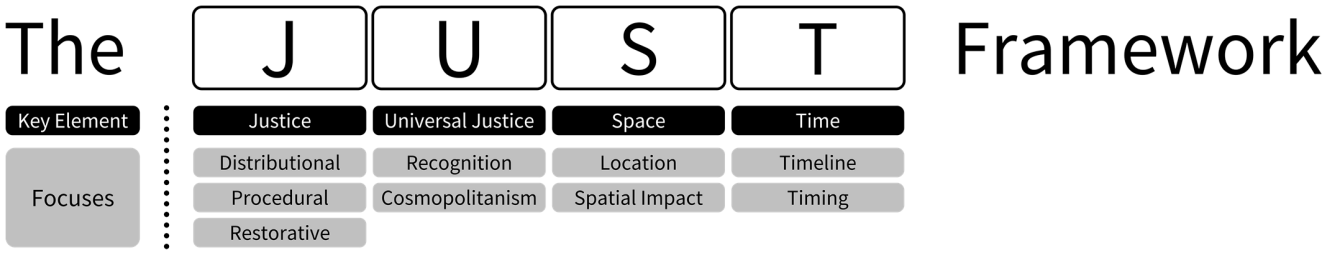

Figure 2. The JUST Framework.

Then, the other three key elements are universal forms of justice (U), space considerations (S), and time (T). The second key element (U) involves recognition and cosmopolitanism [78,79]. Recognition addresses justice concerns at the local level, specifically in terms of recognising and upholding the rights of various groups, including indigenous communities and residents. It is crucial to ensure that these communities are not marginalised or disadvantaged by the development of the extractive CPO industry. Meanwhile, cosmopolitanism is based on the premise of global interconnectedness. In this context, the Indonesian CPO industry supplies the global biofuel value chains, generating cross-border impacts from local and regional activities in Indonesia. Furthermore, the third key element, space, addresses the spatial aspects of an observed industry [80], i.e., where the industrial activities are happening and the interlinks between the "events", the global supply chain, and all relevant stakeholders. Then, the last key element, time, highlights a long-term perspective when assessing an industry [81]. In this case, it assesses how far the country remains on course to meet its energy and climate targets for 2030 and beyond. It is centred on asking whether the extractive industry in question, i.e., the exploration of palm oil as a source of biofuel, can be delivered according to the timelines.

3. Methodology

3.1. Research Design

Founded on the JUST framework as the conceptual basis, this study applied a qualitative socio-legal approach [82–84] through a three-stage research design involving sampling, data collection, and data analysis. The first stage aimed to select potential respondents among relevant stakeholders, including industrial practitioners, palm oil farmers, and local communities. Furthermore, the second stage focused on gathering primary and secondary data. The primary data were designated to discover socio-legal situations regarding the Indonesian CPO industry and biofuels in general. The primary data were gathered through a multi-method approach combining in-depth interviews and focus group discussions (FGDs) [85,86], with a particular focus on collecting primary data relevant to the justice (J) and universal justice (U) elements of the JUST framework. Meanwhile, the space (S) and time (T) elements were investigated through secondary data only since they were typically recorded as part of research, policy documents, or other government archives. In addition, the secondary data collection was designated to gather further perspectives

on the first two key elements (J and U) from relevant documents, adding complementary insights to related primary data [87]. In this data collection stage, the interviewees and FGD participants would also assist this study in searching for information on various non-human actors, such as policy implementation or other practical issues, allowing for a comprehensive qualitative investigation based on multi-actor perspectives [88]. Moreover, the third research stage focused on synthesising primary and secondary data using the four key elements of the JUST framework. It would allow an enhanced direct interpretation of the results for more thorough socio-legal findings on policies and practices in Indonesia's CPO-driven biofuel industry. The three research stages explained above, including their purposes and methods, are visualised in Figure 3.

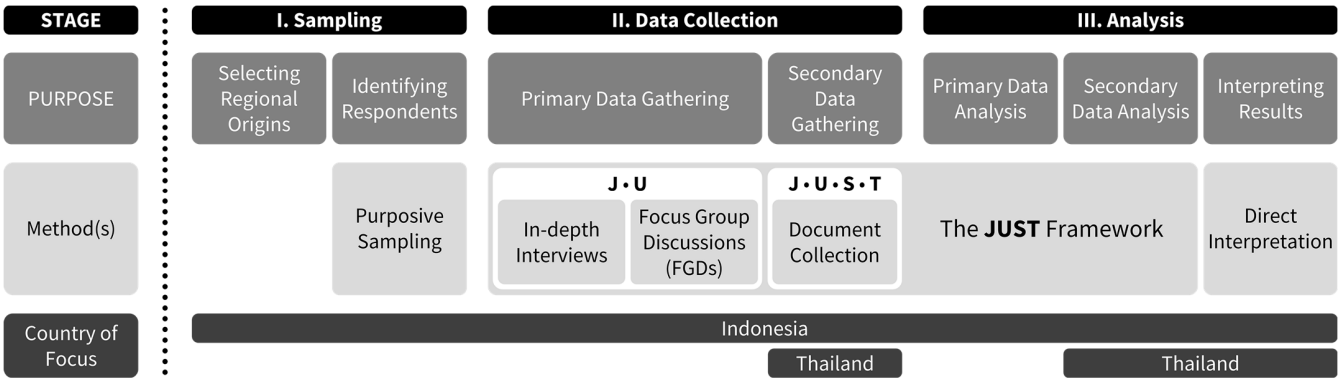

Figure 3. Research Design.

Since the Indonesian CPO industry is stagnating, partly due to less benchmarking against other major CPO producers, this study required alternative insights from another major CPO-producing country. The three world's largest CPO producers are in Southeast Asia, i.e., Indonesia, Malaysia, and Thailand [21,89]. They cover as much as 87.5% of the global CPO production [90], making it logical to run the benchmark among them. However, Indonesia and Malaysia's palm oil industries and CPO markets are interlinked [91] since many of their plantations are co-run by corporations from both countries. Shared industrial chains between Indonesia and Malaysia could lead to co-correlations, making it highly possible to produce biased comparisons. Meanwhile, the Thai CPO industry is technically disjointed from Indonesia, with the extent of correlation only in the global CPO market. Thus, this research added comparative perspectives from Thailand's CPO industry. Since gathering primary data was impossible for technical reasons, this study conducted content analyses on secondary data from the Thai CPO industry. This was made possible since the Thailand CPO industry has been well documented in research, policies, and other official archives to increase accessibility for global CPO consumers. Data from Thailand were comparatively analysed by briefly applying the same framework [69]. The comparison allowed this study to contribute to the literature on biofuels and the energy transition in Southeast Asia, where biofuels have become an integral part of the strategy to accelerate the energy transition and reduce emissions [92–94].

3.2. Data Collection and Analysis

For the primary data collection, this study conducted interviews and FGDs (Figure 3) to build in-depth and fine-grained syntheses of the observed issues according to multiple perspectives [95–97]. The interviews and FGDs involved three common parties in development studies [98–100], i.e., those with issue-specific expertise, community members, and the government. Further, the interviewees and discussants originated from six provinces in Indonesia, i.e., East Kalimantan, Central Kalimantan, North Sumatra, Riau, Jambi, and Aceh, representing Kalimantan (Borneo), northern Sumatra, and central part of Sumatra that host the country's three largest oil palm plantation areas [101,102]. In total, this research employed 22 interviews and 4 FGDs. In terms of interviewees, this

study used purposive sampling [103,104] to choose potential interviewees. This research conducted separate/individual interviews with representatives from industrial organisations/corporations, smallholder planters/farmers, and local communities. In the first category (Table 1), this research involved six (6) people, including four from the GAPKI organisation (Association of Indonesian Palm Oil Corporations; 1A, 1B, 1C, 1E) and two from corporations directly (1D, 1F). For the group of smallholder planters/farmers (Table 2), this study interviewed nine (9) people (2A–2I). This research also interviewed seven (7) people from local communities living around oil palm plantations (Table 3, 3A–3G).

Table 1. Interviewees from industrial stakeholders.

Code	Position	Organisation
1A	Chairman	GAPKI
1B	Vice Chairman for Trade and Sustainability Affairs	GAPKI
1C	Deputy Secretary General	GAPKI
1D	General Manager	PT. Kharisma Iskandar Muda, Nagan Raya, Aceh
1E	Executive Secretary	GAPKI, Chapter Central Kalimantan
1F	Plantation Manager	PT. Hutan Hijau Mas (KLK Group), Berau, East Kalimantan

Table 2. Interviewees from smallholder planters/farmers.

Code	Position	Location
2A	smallholder plantation 1	Paser, East Kalimantan
2B	smallholder plantation 2	Paser, East Kalimantan
2C	smallholder (plasma) plantation 1	Pekanbaru, Riau
2D	smallholder plantation 2	Pekanbaru, Riau
2E	smallholder plantation	Rokan Hulu, Riau
2F	smallholder plantation	Pelalawan, Riau
2G	smallholder plantation	West Tanjung Jabung, Jambi
2H	Berau Smallholder Plantation Association (*Asosiasi Sawit Rakyat Mandiri Berau*)	Berau, East Kalimantan
2I	smallholder plantation	Berau, East Kalimantan

Note: Plasma farmers partnered with oil palm corporations to manage their plantations.

Table 3. Interviewees from local communities.

Code	Position	Location
3A	local communities	Deli Serdang, North Sumatra
3B	a leader of the *Dayak* ethnic group	Berau, East Kalimantan
3C	local communities 1	Berau, East Kalimantan
3D	local communities 2	Berau, East Kalimantan
3E	local communities 3	Berau, East Kalimantan
3F	local communities	Pekanbaru, Riau
3G	local communities	Nagan Raya, Aceh

Furthermore, this study oversaw four separate FGDs with different groups of stakeholders. The first FGD (Table 4) involved eight (8) representatives from GAPKI (4A–4H) to discuss the role of the palm oil industry towards the just energy transition. Meanwhile, the second FGD (Table 5) also involved GAPKI representatives (5A–5C) to discuss the sustainability aspects of the palm oil industry, primarily related to the impact on the environment, including the potential for the overall utilisation of biomass, waste management, and its relation to the circular economy. The third (Table 6) and fourth FGDs (Table 7) involved discussants from two leading NGOs in biofuel research and development (Traction Energy Asia; CoAction Indonesia), Indonesian Biodiesel Producer Association (APROBI), Palm Oil Farmers Union (SPKS), and two government agencies (TNP2K; ESDM). The last two

FDGs focused on the implementation of biofuel regulations and policies, particularly those relevant to the B30 program. The four FGDs complement each other to gather the complete picture of the issues in question.

Table 4. Participants of Focus Group Discussion I.

Code	Position	Organisation
4A	Chairman	GAPKI
4B	Vice Chairman for Trade and Sustainability Affairs	GAPKI
4C	Deputy Secretary General	GAPKI
4D	Head of Sustainability	GAPKI
4E	Executive Director	GAPKI
4F	Executive Board—Board of Trustees	GAPKI
4G	Program Officer	GAPKI
4H	Secretariat	GAPKI

Table 5. Participants of Focus Group Discussion II.

Code	Position	Organisation
5A	Head of Sustainability	GAPKI
5B	Executive Director	GAPKI
5C	Executive Board—Board of Trustees	GAPKI

Table 6. Participants of Focus Group Discussion III.

Code	Position	Organisation
6A	Engagement Manager	Traction Energy Asia
6B	Executive Director	Traction Energy Asia
6C	Research and Development Manager	CoAction Indonesia
6D	Head of Secretariat for Communication and Partnership	National Task Force for the Acceleration of Poverty Reduction (TNP2K)

Table 7. Participants of Focus Group Discussion IV.

Code	Position	Organisation
7A	Coordinator of Bioenergy Investment and Cooperation, the Directorate of New and Renewable Energy, and Energy Conservation	Ministry of Energy and Mineral Resources of Indonesia (ESDM)
7B	Head of Analysis and Evaluation, the Research and Development Division	Ministry of Energy and Mineral Resources of Indonesia (ESDM)
7C	Vice Chairperson	Indonesia Biofuels Producer Association (APROBI)
7D	Secretary-General	Palm Oil Farmers Union (SPKS)

In the primary data collection, the interviews and FGDs were held for approximately 2–3 h. All statements were recorded digitally with permission from the interviewees during the interviews. Semi-structured interviews were held by following a list of questions (Appendix B). After all the interviews were completed, the records were transcribed. Further, the results of FGDs were compiled according to the issues covered. The raw data from interviews and FGDs were then coded and categorised according to the four key elements of the JUST framework. The empirical data were analysed using NVivo version 12 to classify the information obtained. The data were sorted, with further sub-categories developed. Qualitative data analysis as such would allow for the statements and claims of various interviewees to be corroborated against other interviewees. Methodically, it involved a validity process, which is central to qualitative research [105].

4. Results and Discussion

4.1. Justice (J)

4.1.1. Distributional Justice

Biofuel production can open opportunities for new employment in rural areas [106]. In 2020, oil palm plantations in Indonesia provided 7.1 million direct jobs, or approximately a 30% increase in employment since 2015 [107,108]. Based on FGDs with respondents from GAPKI, 12 million indirect workers are involved in the industry, including those in supporting or downstream industries outside of plantations and CPO factories, e.g., in refineries and other biodiesel-related activities. In total, more than 19 million people depend on this sector, which is approximately equal to 10% of the productive population in Indonesia. According to the interviews with communities and smallholder farmers, approximately 40.79% of smallholder oil palm farmers in Indonesia [107,108], mostly, or approximately 90%, work on their own land. The interviews also confirmed the noticeable presence of migrants from Java Island and Nusa Tenggara Islands to CPO-producing regions, which was induced by higher job opportunities and wages promised by the CPO industry. Approximately 30–50% of those working in privately owned oil palm plantations and the rest of the industrial chains come from outside the regions. These facts show that, to some extent, the palm oil sector helps fulfil the right to employment, which is constitutionally guaranteed by Article 27 Paragraph 2 of the 1945 Constitution (Fourth Amendment) [109] and Article 38 of the country's Human Rights Act [110].

Further, the FGD with TNP2K reveals several vital roles that CPO-based biofuels play in promoting renewable energy in Indonesia. First, they can substitute fossil fuels in diesel-type engines. According to policy documents discussed during the FGD, CPO-based biofuel has blended with traditional diesel fuels up to 30% (B30), replacing 13.61 million kilolitres of pure petroleum-based diesel fuels annually. This substitution effect reduces reliance on imported fossil fuels while utilising domestically produced CPO feedstock for biofuels. Second, reducing fossil fuel imports provides significant savings in foreign exchange reserves. Based on the Bank of Indonesia's balance of payments statistics, substituting CPO-based biodiesels for 13.61 million kilolitres of petroleum-based diesel fuels contributes USD 5.39 billion in savings from reduced fuel import bills. Third, CPO-based biodiesels generate substantial tax revenues for the government. Using CPO production data from the CPO industry and the Ministry of Finance tax data, the FGD found that CPO and CPO-based biodiesels contributed IDR 2.62 trillion in CPO export taxes and biofuel value-added taxes. Fourth, CPO-based biodiesels help mitigate climate change by reducing CO_2 and other GHG emissions. On average, CPO-based biodiesels emit 51% less GHG emissions than petroleum-based diesel fuels. By substituting 13.61 million kilolitres of traditional diesel fuels for CPO-based biodiesel, Indonesia avoided nearly 20.35 million metric tonnes of CO_2 and other GHG emissions.

Developing biofuels in Indonesia is viewed as having helped enhance national energy security while promoting economic growth. Empirical analyses indicate that the biofuel industry accounted for 3.5% of Indonesia's total GDP increase, underscoring its emerging role as a critical driver of macroeconomic progress [111]. At the regional level, biofuel cultivation and production have stimulated the economies of palm oil-producing provinces, creating employment opportunities and revenue streams that have lifted provincial incomes [30]. At the local level, municipalities administering plantations have witnessed microeconomic gains, as biofuel companies made contractual arrangements with smallholder farmers to supply feedstock and provide infrastructural improvements like roads and electricity access to rural communities. However, several significant trade-offs inherent in Indonesia's biofuel model have become evident. First, the massive expansion of oil palm plantations has generated high environmental costs in the form of deforestation, biodiversity loss, GHG emissions, degrading ecosystems, and intensifying climate change [45,112]. Second, the economic benefits of the industry have been unevenly distributed, as a select group of large conglomerates and major producers capture a disproportionate share of the profits, while smallholder farmers remain in a state of vulnerable livelihoods [113,114]. Third, Indonesia's weak governance and

law enforcement have enabled biofuel companies to improperly acquire community lands, restricting local access to vital natural resources and precipitating social conflicts [30,115].

4.1.2. Procedural Justice

Furthermore, the government of Indonesia has implemented extensive regulations to promote the development of various biofuels. Despite opportunities for multiple biofuel sources, only CPO-based biodiesel has reached commercial viability in the past 15 years. As of 2020, new and renewable energy (NRE) accounted for 10.90% of Indonesia's primary energy supply. Of the amount, biodiesel (B30 blend) contributed approximately 34% [116]. The government aims to continue increasing biofuel blending and production into the future to meet renewable energy goals. Regulation no. 12/2015 from the Minister of Energy and Mineral Resources [117] mandated a 30% biodiesel blend target (B30) for 2020, markedly increasing the previous 15% blend requirement (B15). Additionally, the government has set a minimum biofuel production target of 15.6 million kilolitres by 2025, covering deliveries for public consumption and power generation. This includes biodiesel blending targets of 30% (11.6 million kilolitres), bioethanol blending of 20% (3.4 million kilolitres), and bioavtur blending of 5% (0.1 million kilolitres). Procedural support for long-term plans is even more ambitious. According to Presidential Regulation no. 22/2017 [118], the Indonesian government further established biofuel production goals of 54.2 million kilolitres for 2050. However, it remains to be seen whether non-CPO biofuel sources will become commercially viable and contribute to meeting these goals.

The government has taken a proactive role in ensuring the quality and readiness of biofuel through comprehensive studies and periodic monitoring. A government-commissioned study assessed the impacts of various biodiesel blends on engine performance across a range of vehicle types in both laboratory conditions and nationwide real-world driving scenarios. The government, to enable ongoing quality control, mandates that all biodiesel distributors submit to periodic audits. The government has also instituted financial penalties for non-compliance with biodiesel blending mandates. Further, sanctions and fines apply to any biodiesel producers and petroleum companies who fail to meet the stipulated blending ratios. In extreme cases, licences can also be revoked. The government has also taken steps to safeguard consumers by issuing quality standards and guidelines for biodiesel usage. The National Standard of Biodiesel Specification specifies the technical properties and composition required. Additionally, the General Guidelines for Handling and Storage of B100 and B30 have been published to ensure quality retention across the supply chain. In addition, the government also issued the Technical Guidelines for B20 Handling and Storage for Heavy Equipment Applications in Mineral and Coal Mining. Roughly speaking, the rigorous technical assessments, the implementation of oversight mechanisms, and the institutionalised standards and penalties indicate that the government has proactively addressed concerns regarding biodiesel quality and readiness.

However, the governance of the palm oil industry in Indonesia suffers from a lack of coordination and oversight from a centralised advisory body. The absence of a single institution that can reconcile conflicting policies, aggregate industry data, and provide recommendations leads to inconsistencies across different ministries and levels of government. For instance, the Ministry of Industry has set a target to achieve 15.6 million kilolitres of biodiesel production by 2020 through the B30 mandate, requiring approximately 3.5 million hectares of new oil palm plantations. However, Presidential Instruction (*Inpres*) no. 8/2018 [119] concurrently imposed a moratorium on issuing permits for new plantations. At least 11 different Indonesian institutions play some role in governing palm oil [120]. The Ministry of Agriculture, for example, oversees cultivation and harvest practices. Meanwhile, the Ministry of Environment and Forestry attempts to balance palm oil expansion with forest protection and biodiversity conservation. The Ministry of Industry manages refining and biodiesel production from CPO, while the Ministry of Trade regulates international and domestic trading, pricing mechanisms, and stockpiling for food security. Then, the Ministry of Finance administers tax policies and subsidies impacting competitiveness. This siloed approach means that policies from

different ministries may undermine each other, and none possess a complete picture of the palm oil system.

Consequently, data on palm oil plantation areas from different government-affiliated institutions induce confusing inconsistencies. Statistics Indonesia [121] reported in 2018 that 49.81% of oil palm plantations were held by large corporations, 49.81% by individual smallholder farmers, 45.54% by communal plantations, and only 4.65% by state-operated plantations. However, one directorate in the Ministry of Agriculture shared markedly different figures for the same year, stating that 55.09% of plantations were operated by large corporations, 40.62% by communal plantations, and just 4.29% by state-operated ones [107]. These striking discrepancies in the palm oil plantation data underline the critical need for a central regulatory institution to align strategies and unify data collection methodologies across ministries and jurisdictions. A centralised advisory body on palm oil could serve as an authoritative institution for harmonising data and policy analysis from the vast array of governmental bodies regulating the palm oil industry. With systematic data aggregation into a unified framework, an overarching institution could produce coherent, evidence-based recommendations to coordinate strategies across ministries and engage industry stakeholders more effectively. Standardised data collection and consolidated data streams would reduce contradictory statistics from different agencies, providing consistency and transparency essential for productive policymaking and oversight of the palm oil sector in Indonesia.

In general, according to FGDs with government institutions and NGOs, the regulatory frameworks surrounding biofuel development in Indonesia have numerous problematic aspects that hinder further development of the biofuel industry. For example, no regulation provides incentives to encourage developments towards second- and third-generation biofuels. Without supportive policies, companies lack the push to invest in developing novel feedstocks and conversion processes that could enable more sustainable and efficient biofuel production. This regulatory gap indicates a failure to keep pace with advanced technological development in the biofuel sector. On the other hand, colour clarity standards for biodiesel derived from used cooking oil (UCO) pose another barrier for the UCO-based biodiesel sub-sector. As revealed in the FGDs, achieving the specified colour clarity thresholds is technically infeasible with UCO-based biodiesels. The colour of the final product is chemically linked to the waste oil feedstock. Thus, it is unrealistic to conform to colour standards that were intended for first-generation biodiesels made from virgin vegetable oils. Without revisions to account for feedstock-specific characteristics, these standards will continue to hinder the development of UCO-based biodiesel and its associated benefits of waste oil utilisation and improved sustainability. Therefore, in a broader sense, targeted regulatory reforms could help overcome these bottlenecks and catalyse a more innovative domestic biofuel industry.

4.1.3. Restorative Justice

The environmental impacts of palm oil production in Indonesia have faced ongoing criticism, particularly regarding deforestation, forest fires, and biodiversity loss. Government regulations still permit land clearing by burning [122], obscuring the causes of fires that often spread to palm oil concessions. In fact, ambiguous regulations enable deforestation and burning on lands prone to uncontrolled fires. Government agencies repeatedly fail to investigate whether burned land was cleared for planting, ignited naturally, or intentionally set ablaze by humans. For example, in Nagan Raya, Aceh [123], local disaster management authorities claimed forest fires resulted from community land clearing. However, interviews with local communities revealed that the burned areas were not intended for oil palm plantations. Meanwhile, ecological hazards represent another form of environmental concern. Three of the seven communities surveyed attributed specific environmental impacts to nearby plantations. One community in Deli Serdang, North Sumatra, suspected oil palm plantation activities were causing a worsened environmental quality, including recurrent flooding and smog. Local people in Berau, East Kalimantan, also reported flooding issues. Meanwhile, an indigenous Dayak leader in Berau worries

about river pollution from improper wastewater treatment at some CPO mills. Thus, stronger environmental protections and enforcement are necessary to clarify the causes of fires, safeguard forests, uphold community rights, and monitor mill discharges.

Concerning CPO mills, the upstream sector of palm oil production (plantations and mills) has implemented the concept of zero waste. For instance, oil palm fronds and empty fruit bunches (EFBs) are repurposed as mulch and organic fertiliser. Further, fibre and kernel shells serve as raw combustible materials to fuel factory boilers. Palm oil mill effluent (POME), the liquid byproduct of CPO production, can be applied to land as an organic fertiliser or utilised as a feedstock for biogas power plants via anaerobic digestion. Furthermore, the biomass residues of palm oil production represent abundant bioenergy sources with many more potential applications [124,125]. However, according to data from Traction Energy Asia, only 10% of existing CPO mills have installed methane capture technology to reduce GHG emissions from POME [126]. The interviews with industry representatives provide vital insights into the lack of investment in POME treatment facilities. Not all companies, including larger corporations, constructed facilities as such since the treatment facilities demand considerable capital equivalent to building entirely new CPO mills, presenting significant financial barriers. In fact, current regulations do not include mechanisms like carbon taxes or cap-and-trade systems that could incentivise GHG emission reductions through private sector investment. The feed-in tariff for electricity from POME-based biogas also offers limited profit potential.

On the other hand, Indonesia has made notable progress in addressing on-farm sustainability issues in palm oil production. Approximately 51% of the world's oil palm plantations certified by the International Roundtable on Sustainable Palm Oil (RSPO) standard are in Indonesia. It highlights the country's leadership in adopting more sustainable practices. At the national level, the Indonesian government introduced the mandatory Indonesian Sustainable Palm Oil (ISPO) certification system in 2011 [127], which was further strengthened in 2015 [128], to improve the environmental and social impact of palm oil companies operating in the country. According to the Indonesian Oil Palm Estate Fund Agency (*Badan Pengelola Dana Perkebunan Kelapa Sawit*, or BPDP-KS), Indonesia, as of 2021, has granted ISPO certificates for around 45% of the total productive oil palm plantations. The ISPO-certified lands are owned by large corporations (5.45 million ha), government-run plantations (320 thousand ha), and communal plantations (12.7 thousand ha) [129]. The government has made it mandatory for all oil palm plantations to have ISPO certificates by 2025. While work remains to be done, these findings suggest that government and industry efforts to implement sustainability certification on Indonesian oil palm plantations are gaining traction and translating to on-the-ground improvements. Technically, oil palm plantations must adhere to seven principles covered in the ISPO certification:

1. Compliance with laws and regulations;
2. Implementation of good plantation practices;
3. Management of the environment, natural resources, and biodiversity;
4. Employment responsibilities;
5. Social responsibility and economic empowerment public;
6. Implementation of transparency; and
7. Sustainable business improvement.

A further look into the BPDP-KS data reveals minimal participation and engagement of smallholder farmers in obtaining ISPO certification for their plantations. Interviews with smallholder farmers, local communities, and industry representatives further confirm a lack of promotion and outreach regarding the ISPO certification process and requirements. Consequently, numerous palm oil business actors, particularly smallholder planters, still demonstrate inadequate comprehension and awareness of the mandatory ISPO certification protocols. Initially implemented in 2011 through Regulation no. 19/2011 of the Ministry of Agriculture [127], the ISPO certification mandate only applies to large-scale corporate plantations over a specified scale threshold. This gap indicates that exclusively mandating ISPO certification fails to address the barriers to participation experienced by smallholders

with limited resources and expertise. Thus, Presidential Regulation No. 44/2020 [130] and Regulation no. 38/2020 of the Minister of Agriculture [131] have expanded ISPO certification to include smallholder farmers, though their participation remains voluntary. Achieving widespread ISPO compliance, even among smallholders, is critical for increasing international acceptance of Indonesian palm oil products, given the negative environmental stigma surrounding the sector's perceived role in deforestation and biodiversity loss. Extensive outreach and educational campaigns remain necessary to promote ISPO certification among smallholder farmers and demonstrate how compliant plantations can gain credibility and open export opportunities.

Meanwhile, there are promising developments in the downstream palm oil sector in Indonesia. Government agencies, including the Ministry of Industry and the Office of Coordinating Minister for the Economy (*Kemenko Perekonomian*), are preparing another expansion of the ISPO certification system to involve downstream industries such as cooking oil and biodiesel production. This regulatory effort indicates policymakers' recognition that sustainability practices must expand beyond plantations and mills to incorporate the entire supply chain. In addition to top-down government policies, grassroots initiatives from local communities and NGOs are emerging to improve the management of CPO waste. For instance, some groups are exploring the conversion of waste cooking oil into second-generation biofuels. Companies such as PT Adaro Energy and PT Tirta Investama (Aqua Danone) have expressed willingness to purchase the biofuels produced. However, converting waste into biofuel faces limitations without supportive regulations and policies from the government. Looking at these findings, while sustainability efforts in the downstream palm oil sector hold promise, a continued multi-stakeholder collaboration in conjunction with issue-specific policies as non-human actors will be critical to overcoming existing barriers and scaling up innovative solutions. Further efforts should thus continue investigating policy mechanisms and partnership models that could accelerate the development of second and third-generation biofuels in Indonesia.

The FGD with APROBI revealed their commitment to utilising the most advanced technologies for constructing a biodiesel plant based on sustainability principles and environmental friendliness. This aligns with the government's efforts to expand the role of CPO in a just energy transition without necessitating further land clearing. One such initiative is introducing an oil palm rejuvenation programme for smallholder farmers, funded by the BPDP-KS. It aims to enhance productivity among smallholder oil palm growers. As is known, small-scale palm oil plantations only yield 16.80 million metric tons of CPO annually, far short of the 29.39 million metric tons generated by large-scale plantations [107]. To support the rejuvenation program for smallholder farmers initiated by the government, six GAPKI-affiliated companies, the state-owned plantation company PTPN VI, 18 Village Cooperatives (*Koperasi Unit Desa*, or KUD), farmer group associations (*Gabungan Kelompok Tani*, or Gapoktan), and members of the Indonesian Palm Oil Farmers Association (APKASINDO) from South Kalimantan (Kotabaru), North Sumatra (Serdang Bedagai), Jambi (Muaro Jambi and Merangin), and Riau (Kampar and Indragiri Hulu) have agreed to collaborate on revitalising smallholder plantations [132]. This solution for smallholder farmers and the large-scale solution by APROBI members would foster Indonesia's effort to pursue a just transition in the biofuel industry.

Looking at the findings above, the Indonesian government has implemented restorative solutions intended to address past and ongoing injustices by pursuing a just transition for smallholder farmers. However, a substantial loophole in related regulations marginalises independent smallholder farmers that do not join farmer groups. The rejuvenation programme, which provides subsidies and technical assistance for replanting aged and unproductive oil palm trees, is applicable only to certain formally recognised farmer groups. Thus, the programme, designed to address restorative justice concerns, has not been comprehensively applicable to all independent smallholder farmers. Other recent government efforts that, to some extent, apply the principles of restorative justice in pursuing a just transition include the 2018 moratorium about the postponement and

evaluation of the clearing of forest land for oil palm plantations [119], the 2019 moratorium about the termination of licencing permits for new oil palm plantations [133], and the establishment of the Peatland Restoration Agency (*Badan Restorasi Gambut*, or BRG) tasked with restoring degraded peatland areas [134]. While these policies indicate increasing awareness of restorative justice concerns, the government and civil society should remain cautious to ensure a truly equitable and comprehensive application of restorative justice principles for all smallholder farmers across Indonesia.

4.2. Universal Forms of Justice (U)

4.2.1. Recognition

Smallholder farmers manage approximately 40.79% of Indonesia's oil palm plantations, while private and state-owned businesses control a majority share of 54.94% and 4.27%, respectively [107]. However, an in-depth analysis shows that government incentives disproportionately benefit large palm oil corporations rather than smallholder farmers [135]. These incentives do not originate from the government budget itself. Instead, they are funded through an oil palm plantation fund (*Dana Perkebunan Kelapa Sawit*) established under Article 93 of the Plantation Act no. 39/2014 [136]. It accumulates levy payments collected from the export of CPO and its derivatives. The FGDs with SPKS revealed that approximately 89.86% of the fund turns into incentives for corporate entities. Meanwhile, a much smaller portion aids smallholder farmers through programmes like oil palm rejuvenation (8.3%), research and development (0.85%), partnership promotion (0.64%), human resource development (0.42%), and facilities/infrastructure (0.22%). Further, SPKS and two NGOs (i.e., Traction Energy Asia and Coaction Indonesia) are concerned about the marginalisation of smallholder farmers from the CPO supply chain. Their investigations reveal that smallholder farmers are only allowed to sell fresh fruit bunches to CPO companies within a 5-kilometre radius. Beyond this range, they must go through intermediaries and collectors. These situations reveal an urgent need to re-evaluate government incentives, the use of the oil palm fund, and the involvement of small actors in the CPO supply chain to ensure more equitable distribution between smallholder farmers and big companies in Indonesia's palm oil industry.

Furthermore, the interviews across six provinces revealed critical issues regarding the recognition and treatment of female workers in the Indonesian palm oil sector. While female employees are active in administrative roles and plantation maintenance, their contributions often go unrecognised, and many are relegated to informal work collecting fallen fruits, spraying pesticides, or spreading fertiliser. More troublingly, children aged 5–18 living near plantations are frequently expected to assist their parents after school for pocket money, losing the complementary educational opportunities typically received by their peers outside the plantations. This underscores the vital need for programmes supporting children's right to education under the 1945 Constitution. To that end, the Palm Oil Scholarship Programme (*Beasiswa SDM Sawit*) launched by BPDP-KS represents a constructive step, fulfilling the mandate in Article 28C paragraph (1), Article 28E paragraph (1), and Article 31 paragraph (1) to provide educational access [109]. By leveraging funds from the Plantation Fund Raising mechanism outlined in Article 10 paragraph (2) of the Government Regulation (PP) no. 24/2015 on Plantation Fund Raising (*Penghimpunan Dana Perkebunan*) [137], this initiative aims to cultivate human capital by targeting scholarships at children from palm oil farming families. While promising, a programme of this nature and scale should help address the lack of recognition for women's labour and children's education that currently plagues the sector. Sustained support and oversight will be critical to ensuring a meaningful impact of the scholarships, providing equitable access to schooling for vulnerable youth.

4.2.2. Cosmopolitanism

Palm oil has become an international trade commodity, with Indonesia and Malaysia producing up to 85% of global yields. The economic benefits from palm oil exports have

been immense for these countries. However, the industry faces criticism and opposition from global powers, situating it within a complex power struggle between international actors, the Indonesian government, and local civil society. Domestically, Indonesian biofuel policy has promoted increased use of palm oil, with regulations enacted since 2015 [117] targeting 20% blending in transportation and industrial applications. This blending target was further increased to 30% (B30) in 2018, necessitating substantial land clearing and higher palm oil production volumes to meet the 15.6 million kilolitre demand. Interviews with communities in palm oil-producing regions like Deli Serdang and Berau reveal local concerns about the immediate environmental impacts. A prevalent issue is the burning of land to clear space for new plantations, which creates widespread smoke and haze. Many stakeholders believe this smoke spreads into settlements and across national borders, contributing significantly to regional air pollution and global climate change. However, groups like APROBI and ESDM cite the benefits of substituting palm oil for fossil fuels to meet domestic energy needs. However, civil society organisations like SPKS note that more must be done to promote the participation of smallholder farmers in sustainable production through strengthened investments, incentives, and support.

Based on FGD with those from APROBI and the ESDM, the government's plans to conduct a road test of B40 biodiesel, containing 40% palm oil-based fuel, have met with both support and concern from stakeholders. BPDP-KS welcomed the move as their funds come from CPO export levies, so increased domestic biodiesel use would boost the funds. However, the CPO industry objected to the idea that increasing the current B30 mandate (30% blend) to B40 (40% blend) could reduce exports and profitability. One proposed solution is the oil palm rejuvenation programme for smallholder farmers, which, if successfully implemented, would increase CPO productivity to support B40 without reducing export capacity within three years. However, the CPO industry remains sceptical about the timeline and feasibility of rapidly increasing yields through rejuvenation. Alternatively, if the program fails, the government may need to provide subsidies using state budget funds due to the higher production costs of biodiesel than petroleum-based diesel fuel. Clarification is also necessary regarding the recently introduced Presidential Regulation no. 98/2021 on carbon pricing and trading [138]. While the regulation has aimed to incentivise emission reduction efforts, such as biogas capture from POME, its applicability remains limited since the technical mechanisms for carbon trading have not yet been detailed in separate regulations. Therefore, incomplete presidential regulation cannot be fully implemented until the trading scheme details are arranged.

In addition, the government of Indonesia has made concerted efforts to improve the reputation of palm oil and counter-accusations of unsustainability from the EU. A key initiative was the release of Presidential Instruction (*Inpres*) no. 8/2018 [119], which imposed a temporary moratorium on new permits for oil palm plantations in forested areas. This moratorium halted the granting of new licenses and investments for plantations on forested land. It also mandated an evaluation of existing permits and land titles (the Right of Cultivation; *Hak Guna Usaha*, or HGU) that had been issued for oil palm plantations in forest areas. Beyond permitting, the instruction promoted redistributing land cleared from oil palm plantations to local communities. It aimed to increase the productivity and sustainability of plantations through the mandatory ISPO certification, aligned with international benchmarks like RSPO. Agricultural institutions were also lined up to be strengthened under the instructional regulation. Looking at these points, the moratorium, albeit temporarily applicable, was part of broader efforts by Indonesia to demonstrate commitment to sustainable palm oil practices [139]. While well-intentioned, the moratorium expired in September 2021 without renewal, raising concerns from multiple stakeholders. Critics worry this may lead to the widespread clearing of forests for new plantations by corporations. Sustainability advocates argue that the moratorium should be made permanent to ensure the responsible growth of oil palm in Indonesia.

As evidenced by the government's own projections, current policies and measures will not be sufficient to achieve the target of the Indonesian energy mix in 2025 and its Nationally Determined Contributions (NDC; the nearest phase is in 2030). Thus, additional

programmes are necessary to meet these goals and fulfil Indonesia's commitments under the 2015 Paris Agreement. As civil society organisations and sustainable palm oil certification bodies recommended [140–142], Indonesia should extend the moratorium on granting permits for new oil palm plantations. It would allow the country to mitigate climate change while conserving its remaining forests and peatlands. Further, Indonesia should solve the deforestation 'mystery', which witnesses mysteriously occurring land clearing through natural-like causes such as repeated forest burning or illegal clearing by corporate players. Targeted investigations into the underlying causes and responsible parties, followed by actions to increase accountability and transparency, are imperative. Third, Indonesia should intensify the replanting project (rejuvenation program) for smallholder farmers. This enables smallholders to meet growing demand without expanding cultivated area, thus preventing the conversion of forests and peatlands. Finally, Indonesia should seek alternative energy sources that can complement the role of CPO-based biodiesel, such as utilising macroalgae to produce biofuels. Diversifying the renewable fuel mix with algal biofuels can protect against limited palm oil supplies while fostering the development of a new biotechnology sector.

4.3. Space Considerations (S)

Biofuel development has raised concerns regarding their impact on GHG emissions, particularly concerning the land use changes associated with production. Numerous studies have investigated GHG emissions from oil palm plantations in Indonesia [143–146]. In general, deforestation driven by the expansion of large-scale plantations is a major contributor to increased GHG emissions in the country. Clearing carbon-dense tropical forests and peatlands releases large volumes of stored carbon into the atmosphere while also reducing the capability of the natural ecosystems in carbon sequestration. Furthermore, immature oil palm trees cultivated on recently cleared land produce sizeable GHG emissions in their early years before reaching peak production [92]. This is attributed to the rapid biological growth and high nutritional requirements of juvenile palms grown on rich soils, leading to substantial GHG emissions from fertilisers. With oil palm plantations expanding into new areas, emissions from land use change threaten to offset any potential climate benefits of increased biofuel use. This could open possibilities for biofuels to reduce GHG emissions based on spatial considerations. The archipelagic nature of Indonesia means fossil fuel resources are unevenly distributed spatially [147], hence the asymmetric price transmission, delivering an underperformed support to regional population centres, industrial hubs, and transportation infrastructure networks [148], especially outside Java Island. Increased biofuel production from more widely dispersed agricultural feedstocks could help bridge regional energy supply gaps. Diversifying transport fuel sources with locally produced biofuels could also enhance energy security.

Numerous studies have exposed the association between deforestation in Indonesia and the expansionist behaviour of oil palm plantations from the 1990s to the 2000s. Estimates indicate that 52% to 79% of oil palm plantations nationwide were established through clearing forest areas [144,149,150]. This extensive deforestation for oil palm expansion resulted in Indonesia contributing the most to carbon emissions in Southeast Asia from 2001 to 2010 compared to other countries in the region [151]. While oil palm plantations were a predominant driver of deforestation in Indonesia during this period, their proportional contribution, among other drivers, has declined in recent years. In 2011, the Indonesian government enacted a moratorium on issuing new licences for oil palm development in primary forests and peatlands in a concerted effort to curb deforestation [152,153]. However, multiple factors limited the effectiveness of this moratorium, including poor dissemination of information regarding the moratorium to local agencies [154], weak law enforcement to support the moratorium policies, and resistance from those with vested interests tied to oil palm expansion [150,155]. The Indonesian government, to strengthen the initial effort to prevent the spatial expansion of deforestation, released Presidential Instruction no. 5/2019 to strengthen the moratorium on new licences for oil palm plantations [133]. Nevertheless, the government should keep tracking the contributions of oil palm expansion

to deforestation following the moratorium by identifying spatial approaches for balancing economic development and forest conservation.

In addition, the Indonesian government implemented another moratorium policy on new oil palm planting [119], prohibiting companies from applying for permits to do new planting, especially in forested areas. This policy aligns with Indonesia's aim to reduce its high rate of deforestation through concerted efforts across ministries and sectors. The respondents from ESDM and GAPKI have confirmed the multi-sectoral decision-making process leading to the moratorium. Under this policy, independent smallholder farmers are the only ones allowed to plant new trees, as they do not require permits to plant on their own private lands. However, the Ministry of Agriculture continues to closely monitor and record smallholder planting activities through relevant departments under the provincial governments. This enables the central government to maintain oversight and issue Cultivation Registration Certificates (*Surat Tanda Daftar Budidaya*, or STD-B) for smallholder plantations [156]. The moratorium policy indicates Indonesia's commitment to balancing economic development and environmental protection by restricting new planting permits for industrial plantations while still allowing smallholder production. Ongoing monitoring and certification of smallholder activities promotes sustainability and prevents uncontrolled expansion into forests by independent farmers. Scholars and civil society organisations have praised the policy as a step in the right direction, though its impacts remain to be thoroughly evaluated [112,157]. Strict enforcement and coordination across levels of government will be vital to ensuring the moratorium achieves its objectives of supporting smallholder livelihoods while reducing deforestation rates.

4.4. Time (T)

Regarding timing and timelines, Indonesia submitted its updated NDC documents to the UNFCCC in July 2021. It contained no significant changes to the country's climate targets compared to the previous iteration. Evidence from the new NDC plan indicates Indonesia has maintained its commitment to achieving net zero emissions by 2050, as outlined in the Long-Term Strategy for Low Carbon and Climate Resilience (LTS-LCCR) 2050. [158]. The current NDC targets remain unchanged, i.e., achieving a minimum 23% share of new and renewable energy sources (such as solar, wind, hydroelectric, geothermal, biomass, and biofuels) in the national energy mix by 2025, in addition to reducing GHG emissions by 29% compared to the baseline by 2030 or reducing the emissions by 41% by 2040 with international financial and technical support. Data from 2021 show the new and renewable energy share of Indonesia's national energy mix was 10.9%, a 0.3% decrease from the 2020 level [159]. While the updated NDC retains the same targets, continued implementation and monitoring will be vital in assessing Indonesia's progress towards its stated goals. In parallel, periodical assessments would be necessary to examine factors driving changes in RE penetration, as evidenced by the slight decline in 2021, and identify potential challenges, opportunities and policy adjustments needed to accelerate decarbonisation of the energy system in line with both near-term NDC targets and the longer-term vision of net zero emissions articulated under the LTS-LCCR 2050.

Indonesia has set ambitious targets for increasing the NRE share in the national energy mix to 23% by 2025 and reducing GHG emissions from the energy and transportation sectors. However, current estimates suggest the country is falling short on investment and progress needed to meet these goals. The country's ESDM estimated that Indonesia requires a total of USD 36.95 billion in investments to reach the 23% NRE target by 2025 [160]. Nevertheless, from 2014 to 2020, RE investments averaged only USD 2.5 billion annually, far below the projected requirement [161–166]. At the current rates, Indonesia will likely miss its NRE target for 2025. Biofuels, mainly biodiesel, offer an additional acceleration to Indonesia's NRE growth and emission reductions. As of 2020, biofuels accounted for 18.2% of RE production, behind only hydropower (58.5%) and geothermal (20.3%) [167]. With less than three years remaining before 2025, Indonesia must expand NRE's share in the energy mix by an additional 12.1%. Biodiesel provided 22.48 million tons of CO_2-

equivalent reductions in 2020, approximately 59% of the 0.038 gigatonne target for the energy and transportation sectors. Looking ahead to 2030, biodiesel could provide even more significant emission reductions, projected at 6% of Indonesia's revised target. The contribution of the B30 programme to the energy sector's NDC is 7.8% [168]. Ramping up biofuel production and consumption would thus remain crucial for Indonesia to boost NRE, curb GHG emissions, and meet its ambitious energy sustainability goals.

4.5. Comparative Perspectives from Thailand

Thailand is the most recent Southeast Asian country to climb the ladder of the world's top biofuel producers. For years, various studies have learned that biofuel development in the country has had positive socio-economic impacts [169–171]. On the production side, Thailand has progressed rapidly in developing its biofuel solutions from different crops, such as cassava, sugarcane, molasses, and palm. According to Silalertruksa and Gheewala [171], biofuels have contributed to a noticeable increase in the country's GDP, with an added value of approximately USD 150 million. Further, the Thai oil palm industry has significantly improved the country's direct and indirect employment rates—as much as 90%. In the country, most oil palm plantations are owned and operated by smallholder farmers. The Thai government, to the most robust extent possible, put strict measures in place to limit large-scale expansions by forbidding deforestation. Nevertheless, promoting palm oil production remains considerably positive for the country's smallholder farmers, who represent approximately 70% of Thai palm growers.

In 2017, biofuel contributed 11.4% of total renewable energy shares in the country's energy mix. On the consumption side, renewable energy sources in Thailand cover 21.11% of the country's final energy consumption [172]. The Thai government has actively supported the industry to foster domestic consumption of biofuels [93]. Similar to Indonesia, Thailand is committed to increasing the share of renewable energy sources in its national energy mix by imposing biodiesel blending policies for the road transportation sector [94]. In fact, the country also implements blending policies on the production side of its biofuels, which very much rely on the CPO stocks [94]. Therefore, the government requires an effective strategy for securing CPO stocks to support the biodiesel industry while at the same time developing progressive plans to manage the impacts of oil palm cultivation on land use change [94].

In its effort to pursue equilibrium, Thailand has established the National Palm Oil Policy Committee (NPOPC), a specially designated institution with an advisory role for the oil palm industry. Practically, the government of Thailand has continuously attempted to anticipate deforestation activities for oil palm plantations by increasing its efforts to bring more lands under various protected statuses [173]. Still, there have been many intrusions into forests and protected areas, with some adverse environmental impacts due to land clearing for oil palm plantations being actively reported. Significant examples include repeated peat swamp fires in Kuan Kreng, Nakorn Sri Thammarat [174], which reached no less than a staggering record of 705 historic fires during 2006–2017 [175]. Further, other reported environmental impacts include soil erosion and GHG emissions [115,176,177]. Aside from land use change and its immediate derivative impacts, palm oil mills in Thailand produce processable residual solid waste, such as fibres, shells, EFBs, and POME wastewater [176].

The Thai oil palm industry, to minimise environmental impacts from residual waste, has applied technologies to recycle and eventually reduce residual waste from palm oil mills and agriculture cultivation processes [152]. In practice, palm oil mills in the country have taken a step further by recycling some of this waste into non-commercial biofuels to generate electricity for powering the mills. Further, the palm oil industry biologically processes the POME wastewater for agricultural irrigation, which is flown to nearby oil palm plantations [152]. In parallel, biogas facilities also capture methane gas naturally generated from wastewater to generate electricity. This practice contributes to GHG emissions reduction throughout the production processes, allowing the industry to register for the Clean Development Mechanism (CDM) project [173]. Aside from the biofuel-making solution, the industry used residual EFBs to cultivate straw mushrooms in the oil palm

plantations, effectively fertilising the oil palm trees using a nature-based solution. All these solutions would foster circularity within the entire CPO industry in Thailand.

In 2010, Thailand officially began promoting the Good Agricultural Practice standards (Thai GAP) towards the country's oil palm sector on a voluntary basis without legal punishments [173]. The Thai GAP addresses issues like safety in the use of pesticides, water, and fertilisers. In practice, the Thai government monitors the level of compliance of oil palm farmers in implementing standardised good agricultural practices through its Department of Agriculture. In terms of certification, Thailand applies the Roundtable on Sustainable Palm Oil (RSPO), the globally accepted standard for sustainable palm oil, in its effort to increase its competitiveness in the global CPO market. Still, the adoption of RSPO certifications among smallholder farmers and palm oil mills in Thailand remains insignificant [178], which is way lower than 51% of RSPO-certified plantations in Indonesia. Nevertheless, Thailand has successfully begun exporting its palm oil to India since 2010 as palm oil prices from Thailand became competitive against Indonesia and Malaysia in the global market [179].

Unlike Indonesia, in which more than half of oil palm plantations are owned and run by corporations, the significant majority (70%) of plantations in Thailand are owned and operated by smallholder farmers [173]. The Thai government is extremely concerned about its smallholder farmers, so the government restricts any import of biofuels to protect the farmers. Of course, there could be exceptions to the rule to maintain the country's energy security. Still, any exception to the rule requires potential importers to obtain approvals from Thailand's Ministry of Energy (MoE) [93], with which they must have highly reasonable justifications to import biofuels. The Thai government, to foster both production and consumption, provides incentives to increase the supply and demand sides of biofuels [180]. The incentive policies are pretty helpful since its domestic market absorbs most CPO-based biofuels produced in Thailand. The governmental support throughout the industrial chains could be the reason for fewer "issues" around the development of oil palm plantations in Thailand.

Furthermore, Thailand has also set its NDC target as part of the 2015 Paris Agreement. Its CPO industry has applied different technologies to reduce GHG emissions by capturing them when processing biogas to generate electricity. This allows the industry to apply for the CDM since the country manages to reduce emissions under the Kyoto Protocol [115,158]. Prior to the Paris Agreement, the Thai government had already forbidden any deforestation-causing expansion of oil palm plantations [171,181], considering their negative environmental impact on biodiversity and GHG emissions [171,178]. The only land allowed for the conversion is some existing croplands (e.g., cassava, paddy fields, rubber fields). Still, these indirect land-use changes might worsen GHG emissions, except for rubber fields. Nevertheless, the total GHG emissions produced from converting the existing croplands are still lower than those from deforestation [171]. For smallholder farmers, the government provides the land required for their oil palm plantations, further preventing unmonitored and uncontrolled land clearing by non-state actors [21].

Thailand's updated NDC targets remain the same, aiming for a 20% emission reduction by 2030 and a 25% reduction by 2030 with international support. Further, the updated NDC does not amend the RE targets for its national energy mix. The RE share target in its power sector and final energy consumption by 2036 are 20% and 30%, respectively [158]. While Indonesia has its LTS-LCCR 2050, Thailand stipulates its Long-Term Low Greenhouse Gas Emission Development Strategy (LT-EDS) to guide the country towards climate-resilient and low GHG-emission development [158]. In 2019, biofuels contributed 95% of total RE shares, while RE covered 21% of the national energy mix [182]. In 2017, the RE shares in the power sector and the final energy consumption were 9.76% and 21.11%, respectively. According to its NDC, Thailand should increase its RE shares by 10.24% in its power sector and 8.89% in its final energy consumption. It has 15 years to achieve these targets, three times longer than Indonesia has.

5. Conclusions and Recommendations

This research aimed to explore policies and practices in biofuel development in Indonesia, with an in-depth focus on the country's CPO industry. Further, this study provided comparative perspectives from the CPO industry in Thailand as the benchmark. Answering the first research question (RQ1), this study employed the JUST framework covering four key elements, i.e., justice, universal justice, space considerations, and time, to understand the requirements for the CPO-driven biofuel industry in Indonesia to pursue a just energy transition. This study applied qualitative socio-legal analyses to multi-actor data gathered through 22 interviews and 4 FGDs. Based on the results, oil palm plantations in Indonesia and Thailand are crucial for the livelihood of rural people since 40% and 70% of the plantations, respectively, are owned by smallholder farmers. Recognising the significant contributions of the biofuel industry to both Indonesia and Thailand, it is consequently necessary for the governments to provide incentives for the CPO industry, given that it operates under environmentally friendly principles and applies clean technologies throughout its industrial activities. This could drive the industry to be more sustainable, eventually helping the countries achieve their climate goals and fulfil their global commitments, i.e., the 2015 Paris Agreement and JETP.

Furthermore, the biofuel industry plays a significant role in Indonesia's energy transition and economic development. Primarily, it helps maintain the country's gradual process of moving away from fossil fuels. Answering the second research question (RQ2), CPO-based biofuels have fostered the energy transition towards a low-carbon economy in Indonesia by transforming fuel consumption patterns through the policy mandate on biodiesel (the B30 programme). Still, Indonesia should remain cautious regarding the distribution of benefits and impacts of the entire biofuel industry, especially for smallholder farmers who own and run approximately one-third of the country's oil palm plantations. They are indeed vulnerable to fluctuating CPO market prices despite holding a significant share of plantation areas in the country. In addition to various programs targeting corporations or prominent players in the CPO industry, the government must significantly improve the incentive schemes for smallholder farmers. Concerning comprehensive efforts to recognise multi-actor interests, coping with all stakeholders should therefore include thorough considerations for every single individual holding interests within local communities, including the children of the smallholder farmers. Hence, the right to education, which the law has constitutionally guaranteed, should remain a priority and be continuously enhanced in the short and long term.

One striking difference between Indonesian and Thai CPO industries is the use of technologies that, in Thailand, could actively support the pursuit of a sustainable palm oil industry [152,177]. In Indonesia, technologies have not been applied by all business players, implying significant potential for improvements. Furthermore, land-use changes from forests to oil palm plantations remain the main contributor to GHG emissions [181]. This was the case for Indonesia, where more plantations were converted from forests rather than agricultural lands, as in Thailand. Regarding environmental impacts, Thailand has applicable regulations encouraging the biofuel industry to operate under strict ecological principles. Indonesia strengthened its regulations only recently in 2018, which at last forbade deforestation for oil palm plantations. Nevertheless, Thailand should aggressively certify its plantations under RSPO standards since they are still far behind Indonesia. However, Indonesia must also promote ISPO comprehensively to gain more attention from all stakeholders. It would help ensure a just transition in the industry by involving and delivering benefits for all stakeholders (i.e., the government, investors, palm oil companies, and farmers). Regarding NDC targets, Indonesia remains ahead of Thailand, emphasising its critical role internationally in reducing GHG emissions.

Moreover, the biofuel industry in Indonesia has yet to reach a sustainable state. However, the respondents conveyed persistent confidence in a sustainable future for the industrial sector that meets sustainability standards. Still, the interviews, FGDs, and archival analyses concluded that more serious efforts are necessary to support such confidence. The foremost desire is the creation of an integrated institution specially dedicated to strictly

regulating and monitoring the palm oil industry. It is primarily intended to minimise various overlapping regulations between governmental institutions and industrial organisations, including the risk of multiple interpretations of the regulations. Any extreme kind of substantial legal delegation should also be reduced as necessary to ensure that one central legislation is adequate. Ultimately, all the solutions and recommendations above should not be implemented as separate processes. They should be seen as interconnected chains requiring comprehensive implementation to guarantee the expected outcomes. Then, despite being better in NRE growth and RE shares than Thailand, Indonesia should persistently continue moving towards achieving its NDC targets by maintaining and improving its discipline towards the targets. In an optimistic scenario, Indonesia should be able to achieve its targets approximately one-third faster than Thailand.

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Appendix A

Table A1. Indonesia-specific abbreviations and their English translations.

Abbreviation	Name/Term in Indonesian	English Translation
APKASINDO	*Asosiasi Petani Kelapa Sawit Indonesia*	Indonesian Palm Oil Farmers Association
APROBI	*Asosiasi Produsen Biofuel Indonesia*	Indonesia Biofuels Producer Association
B15	*Biodisel 15%*	Biodiesel 15%
B30	*Biodisel 30%*	Biodiesel 30%
B40	*Biodisel 40%*	Biodiesel 40%
BPDP-KS	*Badan Pengelola Dana Perkebunan Kelapa Sawit*	Indonesian Oil Palm Estate Fund Agency
BRG	*Badan Restorasi Gambut*	Peatland Restoration Agency
ESDM	*Kementrian Energi dan Sumber Daya Mineral*	Ministry of Energy and Mineral Resources
GAPKI	*Gabungan Pengusaha Kelapa Sawit Indonesia*	Association of Indonesian Palm Oil Corporations
Gapoktan	*Gabungan Kelompok Tani*	Farmer Group Associations
HGU	*Hak Guna Usaha*	Right of Cultivation
Inpres	*Instruksi Presiden*	Presidential Instruction
KUD	*Koperasi Unit Desa*	Village Cooperative
Perpres	*Peraturan Presiden*	Presidential Regulation
PP	*Peraturan Pemerintah*	Government Regulation
SPKS	*Serikat Petani Kelapa Sawit*	Palm Oil Farmers Union
STD-B	*Surat Tanda Daftar Budidaya*	Cultivation Registration Certificate
TNP2K	*Tim Nasional Percepatan Penanggulangan Kemiskinan*	National Task Force for the Acceleration of Poverty Reduction

Appendix B

Interview Guidelines

Date	Time
Participant Name	**Interviewer**
Signature	**Signature**

Stakeholder Identity

- Name : . . .
- Age : . . .
- Gender : . . .
- Last Education : . . .
- Work : . . .
- Mobile Phone Number : . . .
- Domicile : . . .
- Plantation Location : . . .
- Plantation Area : . . .
- Land Ownership Status : . . .

Distributive Justice

1. Do you agree with the presence of palm oil plantation activities in Indonesia?
2. How many workers can be absorbed in this industry, and how many are local people?
3. What forms of work are provided in this sector?
4. What is the importance of the palm oil sector to the community?
5. Please specify any Corporate Social Responsibility (CSR) programme you know in this industry.

Procedural Justice

1. Presidential Regulation no. 44/2020 concerning the Certification System for Sustainable Palm Oil Plantations requires all plantations to have certification. Are you ready for this regulation? Does the ISPO policy impact the surrounding environment, economy, and society?
2. Do you think that the existing plantations and industries around you are per the spatial plan set by the government?
3. Do you understand the Palm Oil plantation licensing process? Do you know whether your business has a licence?
4. Based on Presidential Instruction no. 8/2018 concerning the Postponement and Evaluation of Palm Oil Plantation Licenses and Increasing Productivity of Palm Oil Plantations, there is a moratorium policy/stopping the granting of new licenses for palm oil plantations. Do you think the moratorium policy is running well or not?
5. Do you think people have access to the Right to Cultivate information? Should it be transparent?

Restorative Justice

1. What are the good and bad impacts of palm oil plantations on life, economy, social and environmental quality?
2. Has all the biomass potential been utilised, i.e., empty bunches, leaves, twigs, trunks, trees, and all parts of the Palm Oil plant?
3. What is the land-clearing method used? Is there any technology used in land clearing other than the burning method?

4. Have you ever experienced air pollution caused by fires caused by Palm Oil plantations? If there is a fire on plantation land, what are the efforts to make the fire immediately extinguished?
5. What is your opinion about palm oil plantations on peatlands?

Recognition

1. Do people know about industrial activities in the surrounding palm oil industry?
2. Are there women and children working in this sector?
3. Is there any conflict in the palm oil sector with the community? How do you convince the community that their land can be handed over? Are there any particular methods used if indigenous peoples own the land?
4. Is there a place/channel for aspirations between plantation owners and policymakers in making a policy made by the Government involving the aspirations of the plantation owner? Do you know that local people have the right to provide input and/or objections to a new Palm Oil plantation business license application?
5. Have you ever received assistance/advocacy from a non-governmental organisation (NGO) in dealing with a problem?

Cosmopolitanism

1. What is your opinion about global warming?
2. What do you think about the farm burning practice that causes a transboundary haze disaster in neighbouring countries, such as Malaysia, Singapore and Brunei Darussalam?
3. What do you think about the B30 biodiesel program?
4. What if palm oil biodiesel is considered unsustainable by the international community? What do you think about this?
5. Has there been any assistance from the government/investors regarding technology for Palm Oil plantations to make it more environmentally friendly and sustainable?

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