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Beyond the Farm Gate: Smallholder-Centred Downstreaming and Inclusive Value-Chain Upgrading in Indonesia's Palm Oil Sector

Loso Judijanto
https://orcid.org/0009-0007-7766-0647
IPOSS Jakarta, Indonesia

ABSTRACT: Indonesia's palm oil downstreaming strategy has expanded domestic processing, product diversification and bioenergy utilization, but its distributional architecture remains incomplete because smallholders continue to participate primarily as suppliers of fresh fruit bunches (FFB). This article develops a smallholder-centred interpretation of downstreaming through a qualitative integrative literature review using narrative and thematic synthesis. The review draws predominantly on peer-reviewed literature published from 2020 to August 2026 and uses recent Indonesian policy documents only to contextualize current policy directions. The synthesis shows that smallholder downstreaming should not be equated with universal farmer ownership of palm oil mills; instead, it is better understood as progressive value-chain upgrading from productive and legal farming to collective marketing, traceability, logistics, processing participation, downstream small and medium enterprises, circular-bioeconomy activities and, where capabilities permit, equity participation in larger industrial ventures. Five interdependent constraints—productivity and replanting, institutional capability, finance, market power, and sustainability compliance—limit this transition. The article proposes an eight-pillar policy architecture that integrates sustainable intensification, land and farm formalization, cooperative professionalization, differentiated finance, equitable partnerships, scale-appropriate processing, circular bioeconomy development and market creation. Its conceptual contribution is to distinguish national downstreaming success from inclusive downstreaming success by emphasizing who acquires capabilities, who bears risks and compliance costs, and who captures value after FFB leaves the farm. The analysis concludes that Indonesia can strengthen industrial competitiveness and rural development simultaneously only if downstream policies transmit resources, economic rights and value-capture opportunities upstream to smallholders.

KEYWORDS: oil palm smallholders; palm oil downstreaming; value-chain upgrading; cooperatives; inclusive industrialization; Indonesia; sustainability; traceability; replanting; rural development
JEL Classification : Q13; Q18; O13; O14; Q56

1. INTRODUCTION

1.1 Indonesia's palm oil economy and the downstreaming imperative

Palm oil occupies an unusually important position at the intersection of agriculture, manufacturing, trade, rural livelihoods, food systems, renewable energy and environmental governance. Oil palm produces substantially more vegetable oil per unit of land than most competing oil crops and provides feedstock for a wide spectrum of products ranging from edible oils and specialty fats to detergents, cosmetics, oleochemicals, biodiesel, biomass-based energy and emerging renewable fuels (Meijaard et al., 2020; Murphy et al., 2021). Its economic significance nevertheless coexists with major environmental and social controversies, making the future competitiveness of the industry inseparable from questions of sustainability, legitimacy, supply-chain governance and equitable value distribution (Qaim et al., 2020; Ayompe et al., 2021; Adwiyah et al., 2023).

Indonesia is the central country in this debate. Preliminary government statistics for 2025 reported approximately 16.83 million hectares of oil palm and around 46.55 million tonnes of crude palm oil (CPO), although different government publications employ somewhat different production definitions and estimates (Directorate General of Plantations, 2026a). More important than any single production estimate is the structural transformation of the sector. Indonesia's policy orientation has increasingly shifted from exporting relatively unprocessed commodities toward processing, domestic value addition, product diversification and energy-related utilization. The Ministry of Industry reported that the number of identified downstream palm-based products expanded from 48 in 2011 to 208 in 2025, while downstream exports account for a large share of the value generated by the industry (Ministry of Industry, 2026).

The energy component of this transformation has become especially important. Indonesia progressively increased mandatory palm-based biodiesel blending and, in July 2026, implemented B50. Government policy discourse now points toward further technological development involving green diesel, sustainable aviation fuel and other advanced palm-

based fuels (Coordinating Ministry for Economic Affairs, 2026). Research also demonstrates that biodiesel policy increasingly connects palm oil prices and energy-market dynamics, implying that downstream energy policy can reshape incentives throughout the upstream supply chain (Hassan et al., 2026).

This industrial transformation is generally described in Indonesia as hilirisasi, or downstreaming. In its narrow sense, downstreaming converts raw or semi-processed commodities into higher-value products, whereas a broader development perspective also emphasizes domestic accumulation of industrial capabilities, technology, employment, investment and learning. Recent research on palm-oil supply chains and industrial integration indicates that competitiveness increasingly depends on coordinating upstream production, processing, sustainability and cross-industry resource use rather than merely adding processing capacity (Adwiyah et al., 2023; Rajakal et al., 2023). This broader interpretation is particularly important for smallholder inclusion because value addition at national level does not automatically determine how value, risk and decision-making power are distributed among actors within the chain.

Against this backdrop, the distributional question is not only how much palm oil Indonesia processes domestically but also who captures the additional value created by downstreaming. Oil palm smallholders occupy a major position in the biological and territorial foundation of the industry, yet their economic participation is concentrated predominantly at the farm-gate interface where FFB is sold to traders or mills. Their livelihoods therefore remain highly sensitive to yields, input costs, FFB prices, access to buyers, intermediary structures and local milling conditions (Mehraban et al., 2021; Hendrawan et al., 2024). This produces what this article terms the smallholder downstreaming paradox: smallholders are indispensable to the material supply base of downstream industries but remain comparatively peripheral to ownership, management and profit streams generated after FFB leaves the farm. Recent reviews similarly conclude that certification-led sustainability upgrading alone has delivered limited gains for many smallholders because persistent problems of low income, low yields, insecure tenure and weak market position extend beyond certification itself (Ogahara et al., 2022). The paradox therefore concerns value capture and economic agency, not only physical participation in production.

Recent developments illustrate that Indonesian policy actors increasingly recognize this problem. In August 2026, PT Agrinas Palma Nusantara announced plans for a cooperative-based plasma partnership pilot, while policy discussions also encouraged cooperatives to participate not only in plantation management but potentially in CPO processing and other downstream activities (ANTARA, 2026a; ANTARA, 2026b). These developments should not be interpreted simply as a mandate that every cooperative build a mill. Rather, they create an opportunity to reconsider how smallholders can participate in value chains beyond individual farm production.

1.2 Why greater smallholder participation matters

Smallholder participation in downstreaming matters for four interrelated reasons. First, it affects rural value retention because FFB-only participation leaves most post-farm processing and marketing margins elsewhere in the value chain. Greater participation in collective aggregation, logistics, processing services, by-product utilization and selected downstream enterprises can retain a larger portion of economic activity in producing regions, although evidence on welfare outcomes shows that institutions and market conditions strongly shape who benefits (Herdiansyah et al., 2020; Sukiyono et al., 2022; Mulyasari et al., 2023). This distributional perspective makes smallholder participation a central development question rather than an ancillary social component of industrial policy.

Second, stronger participation can improve bargaining power and resilience. Indonesian smallholders are heterogeneous, and vulnerability cannot be addressed solely by higher commodity prices because farmers face different combinations of finance, agronomic knowledge, land legality, organizational capacity and livelihood options (Hendrawan et al., 2024). Evidence on long-running oil palm farmer organizations shows that collective action can strengthen replanting and resilience, but its effectiveness depends on institutional continuity and collaboration beyond the farmer organization itself (Jelsma et al., 2024). Research on farmer-led collective trading in Java likewise shows that cooperative ownership does not by itself guarantee favourable terms of inclusion unless organizations can manage working capital, risk, voice and reward in everyday transactions (Untari and Vellema, 2022).

Third, smallholder upgrading is important for industrial competitiveness. Downstream plants require reliable quantities of FFB and CPO with appropriate quality, timing and increasingly verifiable origins. Low productivity, aging trees, poor fertilizer use, weak extension and fragmented supply relations can therefore become downstream industrial constraints rather than merely agricultural problems (de Vos et al., 2021; Petri et al., 2024; de Vos et al., 2026).

Fourth, smallholders have become central to sustainability and market access. Certification, traceability and zero-deforestation requirements increasingly travel downstream through supply chains, while independent farmers often face disproportionate obstacles related to documentation, land legality, organization and compliance costs (Apriani et al., 2020; Watts et al., 2021; Ogahara et al., 2022). The governance of mandatory ISPO has itself involved institutional ambiguity and rescaling challenges, and private zero-deforestation commitments frequently have limited reach among smallholders who most need transitional support (Choiruzzad et al., 2021; Chandra et al., 2024; Chandra et al., 2026). Smallholder inclusion is consequently integral to the

credibility and marketability of increasingly sustainability-sensitive downstream products.

1.3 Research gap and objectives

Contemporary oil palm scholarship provides rich evidence on smallholder productivity, certification, livelihoods, replanting, land-use change and sustainability. Another body of research examines downstream industries, bioenergy and supply-chain sustainability. Yet these literatures are insufficiently integrated around the question of how smallholders can progressively capture value beyond FFB production.

The gap is conceptually important. Policies that increase downstream processing do not necessarily improve smallholder welfare, while policies that improve farm productivity do not necessarily change farmers' structural location in the value chain. Even successful certification may provide market access without substantially changing ownership, bargaining power or functional participation (de Vos et al., 2021; Santika et al., 2021; Ekaputri et al., 2025).

Accordingly, the review is organized around five research questions. The first asks which roles Indonesian oil palm smallholders currently perform and which additional roles they could realistically undertake in the downstream value chain. The second asks which institutional, organizational, financial, technological and market mechanisms could increase their participation and value capture, while the third identifies the structural, agronomic, regulatory, sustainability and governance constraints that impede such upgrading. The fourth examines how cooperatives, farmer corporations, companies, financial institutions and government agencies can be organized within an inclusive downstreaming ecosystem. The fifth asks what comprehensive policy architecture can reconcile smallholder welfare with industrial competitiveness, traceability, sustainability and environmental protection. Together, these questions shift attention from the volume of downstream production to the distribution of capabilities, risks, rights and returns across the value chain.

The article's principal contribution is to conceptualize smallholder-centred downstreaming as progressive value-chain upgrading rather than merely local processing. This framing responds to evidence that sustainability upgrading and market inclusion depend on a bundle of capabilities that extends beyond farm-level certification or yield improvement (Ogahara et al., 2022; Untari and Vellema, 2022). The objective is neither to romanticize cooperative ownership nor to propose that farmers individually enter capital-intensive oleochemical or biofuel manufacturing. Instead, the analysis identifies differentiated entry points through which organized smallholders can acquire progressively greater functions, bargaining capacity, ownership rights and shares of value added while maintaining attention to scale, commercial feasibility and environmental safeguards.

2. LITERATURE REVIEW AND CONCEPTUAL FOUNDATIONS

2.1 The palm oil chain from farm to advanced downstream industry

Palm oil should be understood as an interconnected agro-industrial system rather than a single commodity. At the upstream end, the chain includes land preparation, planting materials, farm establishment, fertilizer management, harvesting, replanting and FFB production. The midstream includes aggregation, transportation, trading, milling and the production of CPO and palm kernel oil. Downstream stages include refining, fractionation, food ingredients, consumer cooking oil, oleochemicals, detergents, personal-care ingredients, pharmaceuticals-related intermediates, biodiesel and other bioenergy applications (Murphy et al., 2021).

A further layer is increasingly important: the circular palm economy. Empty fruit bunches, fibres, shells, palm oil mill effluent, trunks, fronds and other residues can be transformed into energy, fertilizer, feedstock, biochar, fuels and other biomaterials, thereby creating additional value from existing production rather than from land expansion (Nabila et al., 2023; Rajakal et al., 2023; Goh et al., 2025). From a smallholder perspective, this matters because entry into the most capital-intensive downstream industries is difficult, whereas participation in biomass aggregation, composting, logistics, service provision and selected derivative products may offer more feasible pathways. Circular-bioeconomy opportunities should nevertheless be screened for technical, environmental and commercial viability so that waste valorization does not become a rationale for poorly designed subsidized facilities.

The environmental implications of value-chain expansion must nevertheless remain central. Oil palm's high land productivity does not remove risks associated with deforestation, biodiversity loss and greenhouse-gas emissions, particularly where expansion occurs in environmentally sensitive landscapes (Meijaard et al., 2020; Ayompe et al., 2021). Studies in Sumatra demonstrate strong trade-offs between agricultural profitability and ecosystem multifunctionality where forest or diverse systems are replaced by intensive monocultures (Grass et al., 2020), while spatial research identifies both biophysical and socioeconomic drivers of continued expansion (Xin et al., 2021; Rahman et al., 2025). Productivity-enhancing strategies can reduce pressure for expansion but may also generate rebound incentives when higher profitability is not accompanied by land-use safeguards (Dalheimer et al., 2022; Andiappan et al., 2022). Consequently, downstreaming should seek higher value from existing legal production while strengthening spatial governance and conservation safeguards (Xin et al., 2022; Li, 2024).

2.2 Value creation, value capture and functional upgrading

A crucial conceptual distinction exists between value creation and value capture. A smallholder who increases FFB yield creates additional value for the supply chain, but this does not necessarily mean that the farmer captures a proportionally larger share of final downstream margins. Likewise, a country can increase exports of refined or manufactured palm products while distribution within the domestic value chain remains uneven. This distinction is consistent with recent smallholder sustainability research showing that value-chain upgrading needs to be assessed not only through compliance outcomes but also through market position, livelihoods and the terms on which producers are included (Ogahara et al., 2022; Untari and Vellema, 2022).

For the purpose of this review, four forms of upgrading are distinguished. Process upgrading occurs when the same output is produced more efficiently through improved planting material, nutrient management, harvesting, logistics and loss reduction; recent farm-level evidence shows that agronomic management explains substantial yield gaps and that better management can raise both FFB yield and profit (Monzon et al., 2023; Lim et al., 2023; Sugianto et al., 2025). Product upgrading improves quality, sustainability attributes or differentiation, for example through traceable or certified FFB, although its value depends on whether compliance costs are manageable and market benefits reach farmers (Apriani et al., 2020; Pramudya et al., 2022). Functional upgrading occurs when producers or their organizations perform additional functions such as collective marketing, transport, input procurement, certification management, processing or equity ownership. Inter-chain upgrading occurs when capabilities developed around palm oil support entry into related activities such as biomass energy, fertilizers, food businesses, logistics, digital traceability or other rural services. The four forms are analytically distinct but can reinforce one another because process and product upgrading can build the reliability and market credibility needed for more demanding functional roles.

This framework prevents downstreaming from becoming synonymous with the construction of factories. A cooperative that professionally aggregates FFB, manages traceability, operates transport assets, negotiates reliable contracts and holds a minority equity stake in a mill may capture more stable value than an undercapitalized cooperative attempting to operate an inefficient stand-alone plant. Evidence from collective trading and cooperative research reinforces this point by showing that ownership form must be accompanied by working capital, professional management, member voice and viable commercial functions if collective organizations are to improve smallholder terms of inclusion (Fernando et al., 2021; Untari and Vellema, 2022).

Figure 1 conceptualizes downstream participation as a continuum of value-chain functions. The key analytical point is that smallholders are presently concentrated at the production end of the chain, whereas multiple intermediate entry points exist between individual farming and ownership of highly capital-intensive downstream facilities. The figure therefore frames downstreaming as a portfolio of feasible functions rather than a binary distinction between being a farmer and owning a factory.

Figure 1. Indonesian palm oil value chain and potential smallholder entry points

Figure 1 therefore distinguishes industrial participation from factory ownership. Smallholder downstreaming can begin before physical processing through collective procurement, aggregation, quality control, logistics and traceability. These activities generate capabilities and revenue while reducing transaction costs. Only organizations that achieve sufficient scale, governance quality, feedstock security and financial capacity should progress toward direct processing.

2.3 Collective action and cooperative governance

Farm fragmentation makes collective organization central to downstreaming. Individual farmers generally lack the scale to negotiate directly with major processors, finance industrial assets, maintain sophisticated traceability systems or employ specialized technical and financial staff. Cooperatives, farmer corporations and other collective organizations can aggregate production, pool capital and spread fixed organizational costs across many members, thereby creating the scale needed for market access and value-added activities (Fernando et al., 2021; Jelsma et al., 2024).

Recent evidence from Indonesia supports the importance of group-based approaches in certification, replanting and value-chain management. Certification initiatives commonly depend on internal control systems, collective training, farm mapping, group documentation and relationships with certified mills (Apriani et al., 2020; Irawan et al., 2024), while long-term evidence from Ophir shows that organizational resilience is shaped by broader socio-economic and institutional conditions (Jelsma et al., 2024). Studies of collective action in Indonesian agricultural value chains further emphasize leadership, member voice, rule enforcement and early organizational design as determinants of performance (Ahmad et al., 2024). However, collective organization should not be romanticized because registration as a cooperative is not equivalent to commercial capability, and shared ownership alone does not guarantee inclusive terms of trade (Untari and Vellema, 2022). Downstream participation requires transparent accounting, professional management, working capital, enforceable contracts, member discipline, risk management, technical competence and safeguards against elite capture. Institutional upgrading must therefore accompany functional upgrading.

2.4 Sustainable livelihoods and heterogeneous smallholders

The literature strongly cautions against treating "smallholders" as a homogeneous category. Scheme or plasma farmers, former-scheme farmers, organized independents and isolated independent farmers have different histories, legal positions, access to infrastructure and relationships with companies (Petri et al., 2024). Cross-provincial sustainability assessments and emerging work on agroforestry preferences likewise indicate substantial variation in farm resources, sustainability performance and willingness to adopt alternative production arrangements (Suardi et al., 2022; Supriatna et al., 2024; Beaudet et al., 2026). This heterogeneity means that downstream readiness should be diagnosed rather than assumed, consistent with recent conceptual work emphasizing socio-ecological and integrated-landscape approaches to smallholder sustainability (Ayompe et al., 2025).

Hendrawan et al. (2024), using a sustainable livelihoods framework, identify multiple resilience profiles among Indonesian oil palm smallholders. Different combinations of financial, human, social, physical and natural capital produce different capacities to cope with shocks. Reiss-Woolever et al. (2025) likewise show that farmers participating in different management-assistance arrangements differ in socio-demographic characteristics, attitudes and management practices.

Heterogeneity has direct implications for downstream policy. A farmer without secure tenure and with aging palms should not be pushed immediately into sophisticated downstream investment. For that household, "downstream readiness" begins with legality, replanting, income bridging and access to an organized buyer. A mature cooperative with reliable FFB volume, audited accounts and professional staff can reasonably pursue logistics assets or processing equity. Therefore, differentiated pathways are preferable to uniform industrial targets.

2.5 Sustainability governance, certification and traceability

Certification has become one of the principal interfaces between smallholders and formal value chains. Research on RSPO and ISPO consistently finds that smallholder participation is constrained by documentation, land legality, organizational capacity, compliance costs, limited knowledge and uncertain economic rewards (Martens et al., 2020; Dharmawan et al., 2021; Watts et al., 2021; Pramudya et al., 2022). Governance research also shows that the evolution of ISPO involves institutional ambiguity and rescaling, while private standards have progressively ratcheted up zero-deforestation expectations (Choiruzzad et al., 2021; Jespersen et al., 2024). These dynamics make certification a governance and market-access issue rather than merely a technical farm standard.

Evidence on certification outcomes is also nuanced. Santika et al. (2021) show that sustainability certification can generate welfare-related outcomes, but effects vary with context. de Vos et al. (2021) find differences in management practices between certified and non-certified farmers but caution against attributing all differences causally to certification because better-prepared farmers may self-select into certification. Their subsequent study shows that many farmers able to meet pre-certification conditions already possess relatively favourable institutional and legal characteristics (de Vos et al., 2023). A broader review reaches

a compatible conclusion, finding only limited evidence that certification by itself resolves persistent smallholder constraints related to income, yield and tenure (Ogahara et al., 2022).

These findings reveal an important risk: sustainability governance may generate compliance-based exclusion. If downstream companies require traceable, legal and zero-deforestation supplies but provide little support for farmer transition, poorly documented smallholders can be displaced toward less formal markets rather than becoming more sustainable. The risk is particularly important where compliance becomes a prerequisite for market participation before farmers have received the finance, mapping assistance and organizational support needed to meet it (Ogahara et al., 2022; Chandra et al., 2026).

This concern is increasingly salient. Corporate zero-deforestation commitments have expanded, yet their implementation frequently struggles to reach independent smallholders (Chandra et al., 2024; Eggen et al., 2024). Chandra et al. (2026) find that the reach of such commitments remains limited, reinforcing arguments for more inclusive supply-shed approaches. Similarly, research on certified mill markets shows uneven access between different classes of smallholders (Ekaputri et al., 2025).

Traceability must consequently be treated as productive infrastructure rather than merely surveillance. Digital mapping and data systems can reduce information asymmetry, facilitate certification and strengthen market access, but only when smallholders possess access, skills, incentives and appropriate data governance (Wong et al., 2023; Hasmin et al., 2026). Geospatial and sustainability-assessment tools can make farm conditions more visible, yet their development should be linked to commercial services and farmer capability rather than treated as stand-alone technology projects. This interpretation positions traceability as an enabling capability for downstream participation as well as a compliance mechanism.

3. METHOD

3.1 Research design

This study adopts a qualitative integrative literature review using narrative and thematic synthesis. It is explicitly not a Systematic Literature Review (SLR) and therefore does not claim exhaustive database coverage, PRISMA-style screening, meta-analysis or standardized risk-of-bias scoring. The design is instead intended to integrate heterogeneous empirical, conceptual and policy-oriented evidence in order to explain mechanisms, tensions and institutional relationships across the palm-oil value chain.

A qualitative literature review is appropriate because the research problem is multidimensional and interpretive. The objective is not to estimate a single average treatment effect of downstreaming but to integrate evidence concerning agronomy, farmer livelihoods, value chains, organizations, certification, finance, environmental governance and industrial policy. This approach is appropriate for a policy problem in which the relevant evidence uses diverse methods and units of analysis and where the principal task is conceptual synthesis rather than statistical aggregation.

The approach is consistent with the broader need for interdisciplinary oil-palm scholarship identified by Reiss-Woolever et al. (2021), whose mapping of oil-palm research showed persistent gaps in integrated socio-ecological analysis. It also complements recent review evidence showing that a certification-centred research agenda leaves important implementation and knowledge gaps concerning smallholder needs and value-chain upgrading (Ogahara et al., 2022). Conceptual integration is therefore important because downstream industrial development, agronomic upgrading and smallholder inclusion are frequently examined in separate research domains even though they interact in practice.

3.2 Literature identification, selection and verification

The literature base was developed iteratively using academic search engines, publisher platforms, bibliographic repositories and backward and forward citation tracing. Searches emphasized combinations of the terms oil palm, palm oil, Indonesia, smallholder, downstreaming, value chain, cooperative, replanting, certification, ISPO, RSPO, traceability, biodiesel, sustainable supply chain, zero deforestation, productivity, livelihood, value added, circular economy and industrialization. Search terms and citation chaining were refined as thematic gaps emerged, which is consistent with the purposive and concept-driven logic of an integrative qualitative review rather than an exhaustive systematic search. The review therefore prioritizes explanatory relevance and triangulation while being transparent that the resulting corpus is not a census of all publications.

Peer-reviewed articles published from 2020 through 13 August 2026 were prioritized. Earlier studies were consulted during conceptual interpretation where necessary but were deliberately not made central to the reference base in order to maintain the requested emphasis on recent scholarship. The final synthesis draws on 66 peer-reviewed journal articles, complemented by six policy and contextual sources used for time-sensitive institutional developments. Priority was given to empirically or conceptually relevant journal articles with verifiable publisher metadata and DOI records, while conference papers, unverifiable citations, and non-peer-reviewed claims were not used as academic evidence. Verification emphasized consistency among article title, authorship, journal metadata, publication year, and DOI or publisher record.

Recent Indonesian government documents were used selectively to contextualize current downstreaming, biodiesel,

replanting, and certification policies. Materials concerning cooperative-based downstreaming and the Agrinas partnership initiative were treated as sensitising policy inputs rather than peer-reviewed evidence. Interpretive claims were anchored primarily in journal literature, while recent policy and media sources were used only for time-sensitive institutional developments that post-date much of the academic literature.

3.3 Analytical procedure

The synthesis proceeded through three interpretive stages. First, studies were coded around broad categories including smallholder roles, capabilities, productivity, legality, organization, finance, processing, market access, certification, traceability, environmental risk, value creation, value capture and policy intervention. Second, those codes were consolidated into five thematic clusters concerning the strategic importance of smallholders, stages of functional upgrading, capabilities for participation, barriers and risks, and policy architecture. Third, the clusters were interpreted through four complementary lenses—value-chain upgrading, collective action, sustainable livelihoods and sustainability governance—to identify recurring mechanisms and tensions rather than to count the frequency of particular findings. Coding was iterative, so concepts were refined when evidence revealed contradictions or distinctions, such as the difference between formal cooperative ownership and substantively inclusive terms of market participation. This process generated the conceptual figures and policy architecture presented in the Results and Discussion sections. This design intentionally prioritizes mechanisms, contradictions and complementarities rather than frequency counts. For example, evidence that certification improves particular management practices was considered alongside evidence showing selection effects and unequal access to certification. Similarly, productivity improvement was interpreted alongside evidence that efficiency gains can stimulate expansion in the absence of strong land governance (Dalheimer et al., 2022).

3.4 Scope and limitations

The review is primarily concerned with Indonesia and does not claim universal applicability to all palm-producing countries. It also does not estimate the financial feasibility of specific processing technologies or determine the optimal capacity of cooperative mills. Those questions require project-level engineering and investment studies.

Furthermore, because the methodology is qualitative rather than systematic, the corpus should be understood as a theoretically and empirically relevant body of recent evidence rather than an exhaustive census of all publications. The synthesis is therefore vulnerable to interpretive selection and to uneven evidence availability across themes, particularly for direct smallholder participation in advanced downstream activities where empirical studies remain scarce. These limitations are addressed by source triangulation, explicit distinction between peer-reviewed evidence and contextual policy material, and cautious formulation of proposed pathways as policy hypotheses requiring further empirical and financial validation.

4. RESULTS

4.1 Theme 1: Smallholders are strategically central to downstreaming

4.1.1 Smallholders are part of downstream industry's productive foundation

The most fundamental finding is that downstreaming cannot be separated from upstream productivity. Mills, refineries, oleochemical plants and biofuel facilities ultimately depend on a continuous flow of agricultural feedstock. Consequently, low smallholder productivity is not merely a farm-level welfare problem; at sufficient scale it becomes an industrial supply constraint.

Research demonstrates substantial variation in yields and management practices among independent smallholders. Field evidence from nearly one thousand smallholder plots shows that agronomic management explains a large share of yield gaps, with nutrient management, harvest interval, weed control and pruning among the most influential practices (Monzon et al., 2023). Nutrient supply is frequently insufficient or imbalanced, indicating that access to appropriate fertilizer and technical assistance remains a major productivity constraint (Lim et al., 2023; de Vos et al., 2026). More recent on-farm evidence finds that bundles of better management practices can increase both FFB yield and farmer profit without increasing labour requirements per tonne produced, reinforcing the industrial relevance of agronomic upgrading (Sugianto et al., 2025).

Replanting is particularly critical because many smallholder plantations established during earlier expansion phases are aging. Petri et al. (2024) identify finance, temporary income loss, access to planting material, knowledge and institutional heterogeneity as major replanting barriers, while stated and revealed-preference evidence shows that land documentation and socioeconomic conditions materially influence participation in replanting programs (Siregar et al., 2024). Farmers also value non-monetary program attributes, implying that subsidy design should account for heterogeneity in risk, administrative burden and implementation arrangements (Hendrawan and Musshoff, 2024). Zhao et al. (2026) further argue that subsidy arrangements alone remain insufficient for many farmers because replanting requires a wider package of livelihood and institutional support. The first pillar of smallholder downstreaming is therefore paradoxically upstream: a productive, legal and sustainable farm base capable of supporting reliable downstream supply.

4.1.2 Productivity can expand supply without requiring equivalent land expansion—but governance matters

Increasing yields on existing plantations offers a potential means of meeting downstream feedstock requirements while reducing pressure for continued area expansion. Climate-smart intensification and improved agronomy can close part of the yield gap on existing land, thereby aligning farmer profitability with a more land-efficient supply strategy (Monzon et al., 2021; Monzon et al., 2023; Sugianto et al., 2025). However, productivity policies must incorporate land-use safeguards because greater technical efficiency can increase incentives for farmland expansion and thereby create a rebound effect (Dalheimer et al., 2022). Spatial and optimization studies similarly show that future palm-oil demand must be reconciled with conservation constraints rather than assumed to be environmentally neutral (Andiappan et al., 2022; Xin et al., 2022). The appropriate objective is therefore sustainable intensification tied to legality, spatial governance, conservation and livelihood diversification, not maximum production in isolation.

4.1.3 Smallholders are sustainability gatekeepers

As downstream products become subject to stronger sustainability standards, upstream smallholder practices increasingly determine downstream market access. Processors cannot credibly establish sustainable and traceable outputs if substantial portions of their raw material remain poorly mapped, undocumented or disconnected from recognized compliance systems. Smallholders thus become strategic participants in the industry's market legitimacy, and farm registration, geolocation, land legality, sustainability assessment and traceable FFB flows should be treated as components of industrial competitiveness rather than as separate agricultural bureaucracy (Putri et al., 2022; Wong et al., 2023). The governance challenges surrounding ISPO further indicate that credible implementation requires institutional coordination in addition to farm-level compliance (Choiruzzad et al., 2021).

4.1.4 Smallholders are rural development agents

Oil palm has generated important livelihood benefits in many Indonesian rural areas, although effects are heterogeneous. Mehraban et al. (2021) find welfare and risk-related benefits associated with oil palm cultivation, while Sukiyono et al. (2022) emphasize potential contributions to multiple Sustainable Development Goals. Social-life-cycle analysis likewise shows that smallholder production has consequences across employment, household welfare and community dimensions (Mulyasari et al., 2023).

At the same time, livelihood gains should not obscure distributional questions. Snashall and Poulos (2023) highlight concerns over uneven access to human capital and opportunities among smallholders, while Li (2024) argues that securing livelihoods without new deforestation requires attention to both productivity and broader livelihood conditions. Research on investment, expansion and food security also illustrates that aggregate sectoral growth can coexist with regional trade-offs, underscoring the need to assess distributional outcomes rather than infer them from production growth alone (Hasudungan et al., 2024). The development objective should consequently be to increase the proportion of palm-generated value retained by rural households and institutions without reproducing environmentally harmful expansion or excluding less-capitalized producers.

4.2 Theme 2: A smallholder downstreaming ladder

The evidence suggests that smallholder participation is best conceptualized as a sequence of progressively more demanding functions. The sequence is not a universal development ladder because smallholders differ in assets, legality, organization and market access, but it provides a diagnostic framework for matching ambition with capability. It also prevents policy from treating direct ownership of processing plants as the only meaningful indicator of downstream participation.

Call-out to Figure 2

Figure 2 presents a "Smallholder Downstreaming Ladder". The ladder is not intended as a mandatory linear pathway for every farmer organization. Rather, it demonstrates that downstreaming contains multiple levels of participation and that capability requirements increase as organizations move toward more capital-intensive and technologically complex functions.

Figure 2. The Smallholder Downstreaming Ladder

Figure 2 highlights that the most immediate pathway for many smallholders is not Level 6 but movement from Level 1 to Levels 2 and 3. These transitions can already increase bargaining power, reduce transaction costs and improve access to mills. Conversely, investment in Level 4–6 activities without strong Level 1–3 capabilities may expose cooperatives to excessive debt, operational losses or governance failure.

4.2.1 Level 1: Productive and legal FFB producers

The foundation consists of farmers with legal or progressively formalized land status, productive palms, quality planting material, appropriate agronomic practices and access to extension. The replanting literature indicates that this foundation remains incomplete for many Indonesian smallholders because financial, administrative and livelihood constraints delay renewal of aging plantations (Petri et al., 2024; Siregar et al., 2024; Zhao et al., 2026). Level 1 should therefore be interpreted as minimum downstream readiness rather than as a purely agronomic condition.

4.2.2 Level 2: Organized and traceable suppliers

The second level involves collective organization, farm mapping, transaction records, certification systems and collective marketing. Group-based certification studies show that organizational structures can reduce per-farmer compliance costs and improve access to external technical assistance (Apriani et al., 2020; Irawan et al., 2024). Long-term evidence from farmer organizations further suggests that collective structures are most resilient when they can adapt to replanting and other life-cycle challenges rather than merely satisfy administrative requirements (Jelsma et al., 2024).

At this stage, traceability should generate commercial functions. Farmer organizations should know member production volumes, harvest schedules, farm coordinates, legal status and FFB sales. Such information enables stronger negotiations and can make organizations investable counterparts for processors and banks.

4.2.3 Level 3: Aggregators and service providers

An important but frequently overlooked form of downstream participation is ownership of supply-chain services. Cooperatives can operate collection centres, weighing facilities, transport fleets, input procurement, machinery services, nurseries, certification management and extension, thereby capturing margins and information that would otherwise remain with intermediaries. These functions require substantially less capital than refineries and can build managerial experience, transaction histories and working-

capital discipline that improve subsequent access to finance. Evidence from collective trading organizations indicates that the capability to aggregate, pay suppliers reliably and manage risk can be as important for inclusion as formal ownership structure (Untari and Vellema, 2022; Fernando et al., 2021).

4.2.4 Level 4: Participation in primary processing

Palm oil milling is the first major processing gateway because FFB is perishable and must be processed rapidly. Direct ownership may be appropriate where a farmer organization possesses sufficient and predictable feedstock, professional management, infrastructure, financing and technical support, but participation need not imply 100 per cent cooperative ownership. Alternatives include minority equity, joint ventures, guaranteed processing allocations, service contracts and profit-sharing arrangements that can distribute value without placing all operational risk on farmer organizations. The corporate-farming model discussed by Witjaksono et al. (2024) provides useful support for an organizational approach that connects collective farm management with CPO supply-chain functions. Ownership structure should therefore be designed around capability, commercial feasibility and risk allocation rather than political symbolism.

4.2.5 Level 5: Downstream SMEs and circular economy activities

Smallholder organizations and local entrepreneurs can also enter downstream activities with lower technological entry barriers. Potential examples include selected food products, soap, compost, organic fertilizer, biomass aggregation and other applications of palm residues. Such activities can create additional rural revenue without necessarily increasing land demand and can convert waste-management obligations into commercial opportunities. Reviews of Indonesian oil-palm biomass and circular palm-sector configurations demonstrate multiple technically plausible routes for valorizing residues, although local business models still require scale, off-take and life-cycle assessment (Nabila et al., 2023; Rajakal et al., 2023; Goh et al., 2025).

4.2.6 Level 6: Equity participation in advanced industrial assets

Refineries, oleochemical plants and advanced biofuel facilities generally require scale, technological expertise and capital beyond the capacity of ordinary farmer organizations. Smallholder participation at this level should therefore focus on economic rights and risk-adjusted returns rather than unrealistic operational autonomy. Mechanisms can include cooperative equity pools, preferred shares, public-private-cooperative joint ventures, revenue-sharing arrangements or investment vehicles that allocate part of downstream profits to qualifying producer organizations. The crucial design question is whether these arrangements create enforceable rights to information, governance and returns without exposing farmers to liabilities that exceed their capacity to absorb risk.

4.2.7 Level 7: Integrated certified and branded participation

At the most advanced stage, smallholder organizations can participate in differentiated markets through traceability, sustainability claims, branding and direct contractual relationships. Certification alone is insufficient because it must be connected to actual market access, credible buyer relationships and value capture. Reich and Musshoff (2025) reinforce the importance of understanding farmer incentives along the road to certification, while Ekaputri et al. (2025) show that access to certified mill markets remains uneven across smallholder types. If compliance costs are visible but economic benefits remain remote, adoption is unlikely to be sustained.

4.3 Theme 3: Capabilities required for greater participation

4.3.1 Productivity and replanting capability

Smallholder downstreaming begins with resolving the productivity gap. Aging trees produce insufficient FFB to support both household income and investment. Replanting must therefore be treated not simply as an agronomic program but as industrial infrastructure renewal. A more comprehensive replanting architecture should combine grants or concessional finance with certified seedlings, farm mapping, technical assistance, income-bridging instruments and alternative livelihood opportunities during immature years. Fosch et al. (2023) show that targeted replanting of unproductive plantations can contribute to development objectives, while Petri et al. (2024) demonstrate why farmer-specific constraints determine whether replanting is feasible. Evidence on replanting participation also shows that land documentation, farmer experience and socioeconomic characteristics matter, and stated preferences indicate that program design must account for non-monetary attributes as well as subsidy size (Siregar et al., 2024; Hendrawan and Musshoff, 2024). Replanting policy should consequently be designed as a livelihood transition and organizational challenge, not only as a financing transfer. Fertilizer access also requires attention. de Vos et al. (2026) show that agronomic recommendations interact with credit, input markets and socioeconomic constraints. Thus, extension programs should integrate farm economics and finance rather than deliver agronomic recommendations in isolation.

4.3.2 Legal and spatial capability

Land legality is a gateway variable. Farmers lacking appropriate documentation face obstacles to certification, bank finance, formal partnerships and certain government programs, and studies of ISPO readiness identify structural and administrative constraints as persistent barriers (Dharmawan et al., 2021; Putri et al., 2022). Land formalization should therefore precede or accompany ambitious downstream investment programs rather than be treated as a separate compliance exercise. Integrated district-

level services could combine mapping, STDB facilitation, land-document clarification, certification preparation and referral to finance so that formalization produces practical market benefits.

4.3.3 Institutional capability

Farmer organizations must evolve from membership bodies into credible business organizations. Representative governance should be distinguished from professional management so that elected boards supervise strategic decisions while competent managers run daily commercial operations. Minimum institutional readiness for significant downstream investment should include audited accounts, procurement rules, conflict-of-interest policies, member transaction records, business plans, internal controls and transparent surplus-distribution mechanisms. Research on agricultural collective organizations emphasizes that governance, ownership arrangements, leadership and member voice materially affect the ability to gain scale and participate in higher-value activities (Fernando et al., 2021; Ahmad et al., 2024). Institutional aggregation can also reduce fixed certification and service costs by sharing systems across many farmers, suggesting that professionalization has benefits before any direct investment in processing occurs (Irawan et al., 2024).

4.3.4 Financial capability

Finance is arguably the bridge between farmer organization and industrial participation, but the required instruments differ by stage of upgrading. Replanting requires household finance and long grace periods to cover immature years, collective FFB purchasing requires revolving working capital, and transport or collection assets require medium-term investment finance. Processing and equity participation require longer-tenor project finance, risk capital and, in some cases, guarantees or insurance against operational and governance risks. A credible smallholder-downstreaming strategy should therefore combine farmer equity, concessional credit, commercial lending, public guarantees and development funds rather than rely on a single subsidy instrument. This differentiated approach is consistent with evidence that replanting preferences and participation depend on both financial and non-financial program attributes (Hendrawan and Musshoff, 2024; Siregar et al., 2024).

Traditional collateral-based lending is poorly suited to organizations with weak balance sheets and highly variable member supply. A smallholder downstreaming strategy therefore requires blended financial architecture that combines farmer equity, concessional credit, guarantees, development funds and commercial lending while matching tenure and repayment structures to asset life. Pramudya et al. (2022) show that sustainability compliance itself depends on appropriate incentives and financing, so policy cannot reasonably demand simultaneous replanting, certification, traceability and industrial investment while expecting farmers to finance every transition from current FFB income. Financial support should therefore be conditioned on governance quality and commercially credible plans rather than treated as an entitlement to capital-intensive assets.

4.3.5 Technological and human capability

Technology upgrading has at least four dimensions: agronomic technology, processing technology, digital infrastructure and managerial knowledge. Digital traceability can integrate farm-level information with mill and downstream records, while remote-sensing and multi-criteria approaches can support monitoring of sustainability performance (Wong et al., 2023; Hasmin et al., 2026). However, a mapping application without data governance, farmer literacy, connectivity, maintenance and commercial incentives will not produce meaningful inclusion. The central policy principle should therefore be technology plus institutional support, with digital systems designed around concrete services such as market access, certification, credit assessment and supply planning rather than data collection for its own sake.

4.3.6 Market capability

Smallholder organizations need predictable demand and transparent pricing. Collective marketing should be linked to direct or long-term relationships with mills where possible, and uneven access to certified mills illustrates why certification without market connectivity is incomplete (Ekaputri et al., 2025). Contracts should incorporate transparent quality deductions, independent weighing, predictable payment terms and accessible mechanisms for resolving disputes. As organizations mature, contracts can also incorporate sustainability premiums, input financing, replanting commitments, profit sharing or equity participation so that compliance and supply reliability are connected to measurable economic benefits.

4.4 Theme 4: Persistent problems and challenges

4.4.1 Agronomic constraints

Low yields, aging palms, inadequate fertilizer, poor planting materials, and inconsistent agricultural practices reduce the surplus available for downstream investment and weaken feedstock reliability. Detailed field studies show that nutrient deficiencies and suboptimal agronomic management remain widespread among independent smallholders, while better management can materially improve yield and profit (Monzon et al., 2023; Lim et al., 2023; Sugianto et al., 2025). Climate risks add another dimension because climatic variability can affect future production performance, strengthening the case for climate-resilient agronomy and risk management (Go et al., 2024). The agronomic constraint is therefore simultaneously a household-income problem and an industrial supply-chain problem.

4.4.2 Replanting and household cash-flow constraints

Replanting temporarily eliminates income from replanted plots, and small farms with limited savings cannot easily

absorb several immature years. Consequently, farmers may postpone replanting even when old trees are clearly inefficient, especially where land documentation, access to alternative income and administrative capacity are weak (Petri et al., 2024; Siregar et al., 2024). Preference experiments further indicate that farmers evaluate program design as a package rather than responding to subsidy size alone (Hendrawan and Musshoff, 2024). Zhao et al. (2026) therefore argue that subsidy levels should be assessed against full livelihood realities, and the downstream implication is that processing expansion without upstream biological renewal can intensify competition for constrained FFB rather than create sustainable supply growth.

4.4.3 Weak institutions and organizational heterogeneity

Some cooperatives have strong leadership and commercial experience, whereas others exist mainly to satisfy administrative requirements. The difference becomes critical once substantial debt, working capital or industrial assets are involved because weak governance can generate elite capture, non-transparent procurement, member distrust and eventual default. The policy objective should therefore not be more cooperatives in numerical terms but more commercially capable, accountable and member-controlled organizations. Evidence from Indonesian collective-action studies underscores the importance of leadership, member voice and organizational rules, while long-term oil-palm evidence shows that farmer organizations must remain resilient through replanting and changing external conditions (Ahmad et al., 2024; Jelsma et al., 2024). Integrated organizational models can support downstream participation only when professionalization and risk controls evolve alongside the expansion of commercial functions (Witjaksono et al., 2024).

4.4.4 Power asymmetries in the supply chain

FFB perishability places farmers in a structurally weak negotiating position because delayed sales rapidly reduce quality and value. Farmers without transport or access to alternative mills may depend on local traders, and those relationships can provide useful credit and market functions while also reducing price transparency and bargaining options. Collective trading can shorten market chains, but comparative evidence from Java demonstrates that cooperative ownership alone does not guarantee inclusive outcomes when organizations lack sufficient working capital or risk-bearing capacity (Untari and Vellema, 2022). Formal downstreaming could reproduce similar asymmetries if farmer organizations become nominal shareholders without meaningful information or economic rights. Inclusive partnerships therefore require transparent valuation, governance representation where appropriate, auditable profit sharing, clear pricing formulas and accessible dispute-resolution mechanisms.

4.4.5 Certification and traceability costs

Certification studies repeatedly demonstrate that smallholders face fixed costs that are disproportionately high relative to farm size (Apriani et al., 2020; Watts et al., 2021). Group-level and jurisdictional approaches can reduce some of these costs by sharing mapping, documentation and internal-control functions across many producers (Irawan et al., 2024). There is nevertheless a selection problem because farmers entering certification may already possess favourable preconditions, meaning programs can disproportionately reach comparatively prepared producers while leaving more marginalized farmers behind (de Vos et al., 2023). A broader synthesis similarly finds limited evidence that certification alone resolves persistent smallholder constraints, reinforcing the need to connect standards with tenure support, finance, agronomy and market access (Ogahara et al., 2022).

4.4.6 Zero-deforestation compliance and exclusion risks

Zero-deforestation requirements can protect forests while simultaneously producing unintended exclusion if smallholders lack maps, legal documentation and monitoring capacity. Zhunusova et al. (2022) warn that deforestation-free supply-chain regulation can impose substantial adjustment burdens on smallholders and local communities in producer countries, while corporate commitments in Indonesia continue to struggle to reach independent producers (Chandra et al., 2024; Eggen et al., 2024). The progressive ratcheting of private standards increases the importance of credible chain-of-custody and no-deforestation evidence but also raises the organizational threshold for participation (Jespersen et al., 2024). By 2026, the reach of zero-deforestation commitments to Indonesian oil palm smallholders remains limited (Chandra et al., 2026). The appropriate response is therefore not to weaken environmental standards but to finance and institutionalize compliance inclusion through mapping, legal support, technical assistance and supply-shed coordination.

4.4.7 Environmental rebound risks

Smallholder productivity improvement can increase profitability, which may in turn increase incentives for land expansion. Dalheimer et al. (2022) identify this rebound concern empirically, and Grass et al. (2020) show that land-use profitability can trade off sharply against biodiversity and ecosystem functions. Broader spatial studies confirm that both socioeconomic and biophysical drivers shape oil-palm expansion, while recent deforestation research shows continued relevance of commodity-driven land-use change (Xin et al., 2021; Rahman et al., 2025). Yield improvement, downstream demand creation and biofuel expansion must therefore be linked to spatial governance, and intensification without land safeguards can undermine the environmental legitimacy on which long-term market access depends (Andiappan et al., 2022).

4.4.8 Social differentiation

Oil palm communities contain diverse households with different levels of land, education, assets, labour availability, indebtedness and market access. Hendrawan et al. (2024) show substantial variation in resilience, Reiss-Woolever et al. (2025) identify differences among smallholders under alternative support arrangements, and sustainability assessments likewise reveal cross-farm and cross-regional heterogeneity (Suardi et al., 2022; Supriatna et al., 2024). Emerging evidence on smallholder perceptions of agroforestry in peatland landscapes further illustrates that willingness to adopt alternatives is conditioned by context rather than by a single farmer type (Beaudet et al., 2026). A downstream program requiring large farmer equity contributions could therefore unintentionally favour better-capitalized households, so inclusion mechanisms should prevent dilution or exclusion of smaller and more vulnerable members.

5. DISCUSSION

5.1 From downstream industrial capacity to inclusive value capture

The central insight from the synthesis is that Indonesia should distinguish national downstreaming success from inclusive downstreaming success. National performance can be measured through processing capacity, export composition, investment, biodiesel output and the number of derivative products, but those indicators say relatively little about the position of farmers supplying the biological raw material. Inclusive downstreaming additionally asks who owns downstream assets, who receives processing margins, who controls market information and who bears sustainability-compliance costs. It also asks whether smallholders can access finance, exercise meaningful governance rights and move into higher-value functions rather than remaining price-taking suppliers. This distributional lens is consistent with research showing that inclusive collective trading depends on ownership, voice, reward and risk rather than ownership form alone (Untari and Vellema, 2022). The proposed distinction therefore adds a smallholder-centred performance dimension to conventional measures of industrial deepening.

The distinction is particularly important because Indonesia's downstream sector is becoming more sophisticated. Government reports indicate rapid diversification of palm-based products and expansion of sustainability governance into downstream industries (Ministry of Industry, 2026), while biodiesel and emerging renewable fuels reinforce the strategic role of palm oil in national energy policy (Coordinating Ministry for Economic Affairs, 2026; Hassan et al., 2026). If smallholders remain exclusively spot-market suppliers of FFB, greater industrial sophistication may create additional aggregate value without materially changing rural value capture. Inclusive downstreaming therefore requires explicit mechanisms that connect industrial upgrading with the distribution of capabilities and returns.

5.2 The smallholder downstreaming paradox

The smallholder downstreaming paradox has three dimensions. First, material importance does not equal economic power because farmers may control substantial plantation resources while remaining weak in price formation, processing and final-market access. Second, higher downstream demand does not guarantee higher welfare because household outcomes still depend on yields, costs, contract terms, bargaining arrangements and risk exposure. Third, sustainability obligations can flow upstream faster than industrial benefits when farmers are expected to finance mapping, legal compliance and agronomic transition without commensurate support. This asymmetry is visible throughout the certification literature and in recent assessments of zero-deforestation initiatives (Martens et al., 2020; Dharmawan et al., 2021; Pramudya et al., 2022; Ogahara et al., 2022; Reich and Musshoff, 2025; Chandra et al., 2026). A genuinely inclusive strategy must therefore transmit resources, technology, information, finance and economic returns upstream alongside compliance obligations.

5.3 Cooperatives are necessary but not sufficient

Cooperatives and farmer corporations are potentially important organizational bridges between fragmented farms and industrial-scale markets because they can create economies of scale, pool capital, professionalize marketing and coordinate certification. However, cooperative-based downstreaming should not become synonymous with subsidized construction of small mills regardless of commercial feasibility, because milling requires stable feedstock, high utilization, reliable utilities, working capital, engineering capability, environmental management and secure off-takers. Evidence from cooperative and collective-action research shows that ownership structure must be accompanied by capable governance, member voice, working capital and operational competence if collective organizations are to improve farmers' terms of inclusion (Fernando et al., 2021; Untari and Vellema, 2022; Ahmad et al., 2024). The sequencing implied by the literature is therefore to organize and formalize farmers, improve productivity, aggregate supply, establish transparent markets, build commercial capability and only then invest selectively in processing or equity participation. Long-running oil-palm experience reinforces the importance of organizational resilience across plantation life cycles and replanting episodes (Jelsma et al., 2024). Legal form matters less than whether institutions can allocate rights, risks and returns transparently and sustain commercially viable functions.

5.4 Differentiated downstreaming rather than one-size-fits-all policy

Smallholder heterogeneity implies that Indonesia needs differentiated upgrading pathways rather than a single model of downstream participation. For vulnerable independent farmers, priority should remain land legality, replanting, certified planting materials, extension, livelihood protection, access to farmer organizations, traceability and dependable market links because these conditions determine minimum commercial readiness. Moderately organized cooperatives can then expand toward collective purchasing, FFB aggregation, weighing, logistics, certification management, working-capital finance and longer-term mill contracts. Commercially mature cooperatives or farmer corporations can consider processing equity, joint ventures, downstream SMEs, biomass utilization, branded products and participation in industrial clusters, but only where feedstock, governance and finance are adequate. This differentiated logic is consistent with evidence of heterogeneity in certification readiness, resilience, replanting preferences and management-assistance outcomes (de Vos et al., 2023; Hendrawan et al., 2024; Hendrawan and Musshoff, 2024; Reiss-Woolever et al., 2025). A readiness-based approach also reduces the risk that subsidized industrial assets benefit better-capitalized organizations while leaving structurally weaker smallholders further behind.

5.5 Reconciling productivity, downstreaming and environmental sustainability

An integrated policy must avoid three false dichotomies. The first is productivity versus sustainability: better management can raise yields, but intensification should be accompanied by protection of high-conservation-value areas, spatial monitoring and credible restrictions on expansion (Monzon et al., 2021; Dalheimer et al., 2022). Empirical evidence on agronomic yield gaps strengthens the case for producing more efficiently on existing plantations, but this strategy remains environmentally conditional rather than automatically land-sparing (Monzon et al., 2023; Sugianto et al., 2025).

The second is smallholder inclusion versus environmental standards. Lowering standards risks undermining market legitimacy; imposing standards without assistance risks exclusion. The solution is to socialize compliance costs through group systems, public support, company assistance and landscape-scale governance (Irawan et al., 2024; Chandra et al., 2026).

The third is industrial scale versus local participation. Large industrial facilities may be economically efficient, while local ownership is socially desirable. These objectives can be reconciled through joint ventures, equity participation, service contracts and revenue-sharing rather than requiring every cooperative to own a complete industrial complex.

5.6 An integrated smallholder-centred downstreaming ecosystem

Call-out to Figure 3

Figure 3 summarizes the institutional ecosystem required to move smallholders beyond the farm gate. The cooperative or farmer corporation is placed at the centre not because it can perform every function, but because it can become the interface connecting individual farms to technology, finance, processors, government and markets. The hub-and-spoke structure also emphasizes that inclusion depends on coordinated external relationships rather than on the internal capabilities of farmer organizations alone (Ahmad et al., 2024; Jelsma et al., 2024).

Figure 3. Integrated smallholder-centred downstreaming ecosystem

The ecosystem illustrates why no single ministry or program can deliver smallholder downstreaming. Agricultural agencies influence productivity and farmer institutions; land and local authorities influence legality; industrial agencies shape processing conditions; financial institutions determine investability; certification bodies affect market eligibility; companies control key industrial gateways; and cooperatives aggregate farmer participation. These interdependencies create coordination failures when programs pursue replanting, certification, finance and industrial investment on separate timelines. A central coordinating mechanism is therefore needed to align eligibility, sequencing, data systems and incentives across institutions rather than simply add new stand-alone programs.

6. POLICY IMPLICATIONS: AN EIGHT-PILLAR SMALLHOLDER-CENTRED DOWNSTREAMING ARCHITECTURE

The literature synthesis supports an eight-pillar policy architecture. The pillars are deliberately interdependent because productivity, legality, institutional capacity, finance, technology, market access and environmental governance jointly determine whether smallholders can perform higher-value functions. The architecture should therefore be implemented as a sequenced capability-building strategy rather than as eight independent funding programs.

6.1 Pillar 1 — Build a productive and sustainable upstream foundation

Indonesia should explicitly connect the Smallholder Replanting Program (Peremajaan Sawit Rakyat, PSR) to the downstreaming agenda by treating replanting as renewal of the country's agro-industrial feedstock base rather than as an isolated plantation program. Support packages should integrate certified planting materials, technically appropriate replanting, agronomic extension, establishment finance, temporary income support or livelihood diversification, farm-level business planning, and safeguards against compensating expansion into forests. Recent evidence shows that farmers' replanting decisions are influenced by land documentation, socioeconomic circumstances, risk, and program attributes, so a uniform grant is unlikely to resolve the transition problem by itself (Siregar et al., 2024; Hendrawan and Musshoff, 2024; Zhao et al., 2026). Agronomic investments should also incorporate recent evidence on nutrient deficiencies and better management practices so that replanted areas achieve realistic productivity gains (Lim et al., 2023; Sugianto et al., 2025). Government programs in 2026 already emphasize PSR, infrastructure, certification, and farmer capacity, providing an institutional basis for closer integration with downstream planning (Directorate General of Plantations, 2026b).

6.2 Pillar 2 — Accelerate legality, certification and traceability

A farmer unable to prove farm location or legality is increasingly disconnected from premium, regulated and traceable value chains. Legality and mapping services should therefore be treated as basic economic infrastructure, and district-level one-stop services could integrate STDB registration, geospatial mapping, land-document assistance, environmental documentation and certification preparation. Group-based approaches are particularly important because fixed compliance costs fall heavily on individual small farms and can be lowered when mapping, internal-control and documentation functions are shared (Apriani et al., 2020; Irawan et al., 2024). Formalization should also be linked to bankability and market access so that farmers experience concrete benefits from compliance rather than additional administrative burden.

6.3 Pillar 3 — Transform farmer organizations into professional business institutions

Public support should shift from measuring success by the number of cooperatives established toward the number that achieve commercial readiness. A national readiness framework should assess governance, audited finances, membership and transaction records, supply volume, managerial competence, transparency, internal controls, digital capability, contract performance and investment readiness. Such criteria are consistent with evidence that the value of collective organizations arises from their ability to pool resources and govern commercial functions, not from legal status alone (Fernando et al., 2021; Untari and Vellema, 2022). Leadership and member voice should be assessed alongside financial controls because participation and internal legitimacy influence the sustainability of collective action (Ahmad et al., 2024). Major public support for industrial assets should therefore be conditional on progressively stricter governance and commercial thresholds.

6.4 Pillar 4 — Create dedicated smallholder industrial finance

The financial architecture should distinguish different risks and maturities rather than offer a single generic credit product. Replanting finance requires long grace periods and household-income bridging, aggregation requires revolving working capital, and transport or collection infrastructure requires medium-term asset lending. Processing investment requires long-term project finance and equity, while advanced downstream participation may require special-purpose investment vehicles that separate operational liabilities from farmer household assets. Public guarantees can reduce lender risk, but they should be conditional on professional governance, credible feedstock plans, transparent accounts and viable off-take arrangements. Otherwise, subsidized finance can convert weak institutions

into indebted weak institutions rather than create durable downstream capacity. The differentiated preferences found in replanting studies support a broader principle that financial instruments should be designed around the actual risk and cash-flow profile of each upgrading stage (Hendrawan and Musshoff, 2024; Siregar et al., 2024).

6.5 Pillar 5 — Institutionalize equitable industrial partnerships

The emerging Agrinas–cooperative discourse illustrates a potentially important policy direction because partnerships can connect smallholders to land, processing capacity, management systems and markets (ANTARA, 2026a). However, partnership quality should be evaluated through transparent valuation of farmer contributions, enforceable supply and off-take agreements, disclosure of processing costs and pricing formulas, appropriate governance representation, auditable distribution of profits, protection against unilateral contract changes and independent dispute-resolution mechanisms. These safeguards reflect the broader insight that inclusion depends on ownership, voice, reward and risk rather than on partnership labels alone (Untari and Vellema, 2022). Contract design should also clarify how sustainability compliance costs, price risk and operational losses are allocated so that farmers do not acquire nominal equity while bearing disproportionate downside risk. Partnership performance should therefore be assessed by the distribution of rights, risks and returns and by measurable improvements in market access and value capture, not simply by the number of agreements signed.

6.6 Pillar 6 — Promote appropriate and distributed downstreaming

Different products have different efficient scales, so policy should avoid assuming that decentralization is always economically superior. Small-scale or cooperative operations may be feasible for aggregation, transport, biomass handling, selected food products, compost and other local services, whereas CPO milling requires carefully calculated feedstock catchments and higher capital intensity. Refineries, oleochemicals and advanced fuels generally require still larger industrial scale and specialized technological capability. A more appropriate model is distributed participation within clustered industrialization, in which farmer organizations own or operate functions suited to their capabilities while gaining contractual, service-based or equity participation in larger facilities. Research on integrated palm-oil industrial systems similarly shows that circular and cross-industry configurations depend on optimized scale, material flows and shared infrastructure rather than universal replication of stand-alone plants (Rajakal et al., 2023). This scale-sensitive approach makes participation, rather than complete local ownership, the central policy objective.

6.7 Pillar 7 — Develop a smallholder-linked circular palm bioeconomy

Policy discussions on downstreaming often focus on CPO and major derivatives, thereby underestimating the economic potential of by-products and residues. A smallholder-linked circular palm bioeconomy can include compost from empty fruit bunches, biomass aggregation, biogas partnerships involving POME, palm-kernel-cake applications, fibres and shells, pruning and replanting biomass, biochar and other technically validated biomaterials. Reviews focused on Indonesia document substantial opportunities for thermochemical upgrading of oil-palm biomass, while industrial-systems research identifies value from integrating palm-oil residues with other sectors (Nabila et al., 2023; Rajakal et al., 2023). More recent circular-bioeconomy research likewise emphasizes waste-to-energy, material recovery and decarbonization potential across palm-oil waste streams (Goh et al., 2025). These activities may be comparatively accessible entry points for local enterprises because some have lower capital intensity than refining or advanced biofuels, but they still require feedstock aggregation, quality control and reliable buyers. Environmental safeguards and life-cycle evaluation remain essential to ensure that proposed products improve resource efficiency rather than shift environmental burdens or create uneconomic waste-processing capacity.

6.8 Pillar 8 — Create markets for inclusive downstream products

Production capability without market demand creates stranded assets, so government and industry should consider demand-side mechanisms for commercially viable smallholder-linked products. Potential mechanisms include public or institutional procurement, retail partnerships, time-limited off-take support during enterprise incubation, business-to-business platforms, traceability-based marketing and access to certified supply chains. Certification should be tied to market outcomes because the objective is not merely to increase the number of certificates but to increase the number of farmers obtaining better market access, more stable commercial relationships or measurable value from compliance (Ogahara et al., 2022; Reich and Musshoff, 2025). Demand support should nevertheless be transparent and time-bound so that it incubates competitive enterprises rather than permanently shelters non-viable production.

7. INTEGRATING CONSTRAINTS, INTERVENTIONS AND OUTCOMES

CALL-OUT TO FIGURE 4

Figure 4 translates the review findings into an intervention logic. It shows that policy outcomes depend on resolving constraints sequentially and jointly. A processing subsidy alone cannot compensate for weak farmer organizations,

while certification alone cannot solve low productivity or lack of finance.

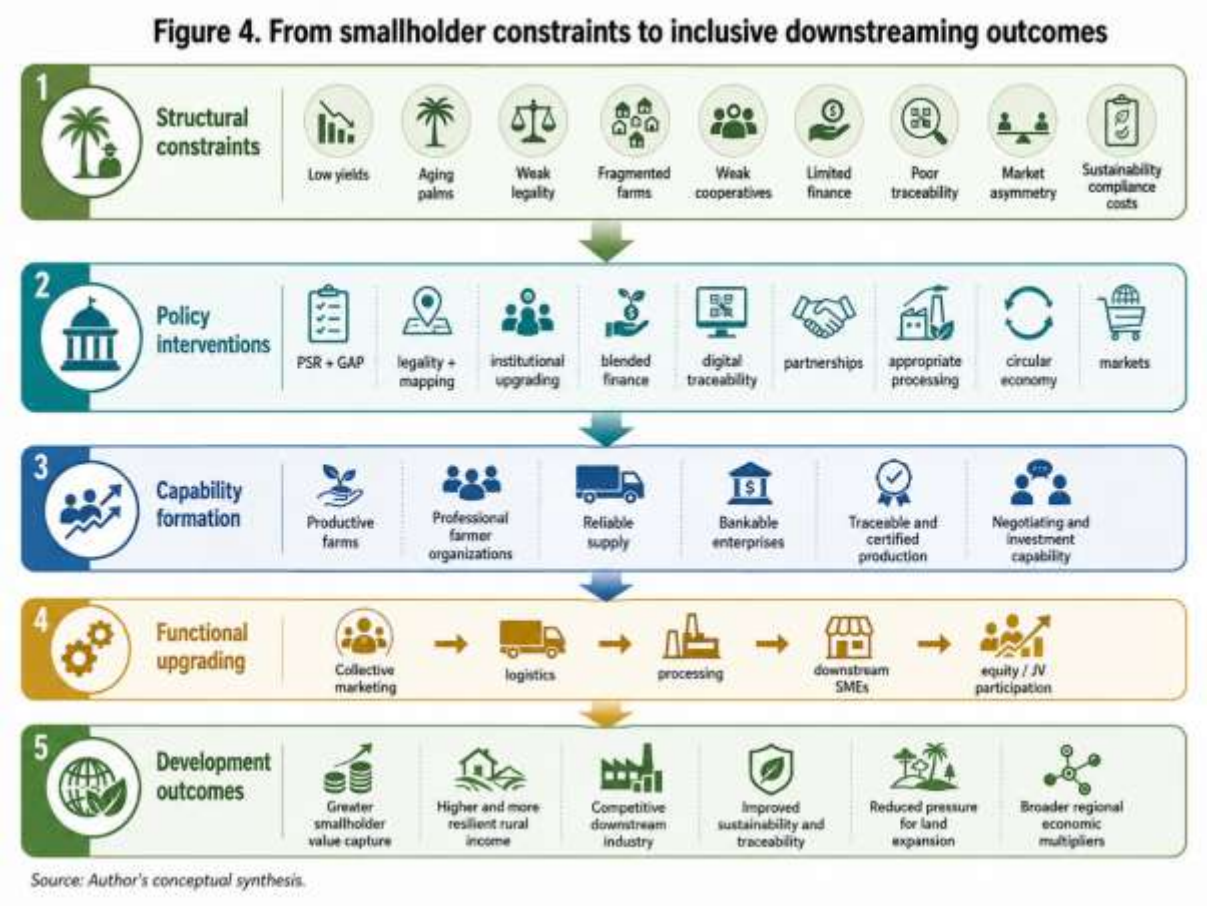

Figure 4. From smallholder constraints to inclusive downstreaming outcomes

Figure 4 emphasizes complementarity across intervention domains. The return on replanting is greater when farmers have reliable market access, and the return on certification is greater when compliant FFB reaches buyers that recognize and reward the associated attributes. Cooperative strengthening becomes more valuable when organizations can obtain appropriately structured finance, while processing investment is safer when sufficient productive and traceable feedstock already exists. The figure therefore depicts inclusion as a cumulative capability process in which isolated subsidies are unlikely to compensate for unresolved bottlenecks elsewhere in the system.

8. THEORETICAL AND ANALYTICAL IMPLICATIONS OF SMALLHOLDER-CENTRED DOWNSTREAMING

8.1 Downstreaming as redistribution of capabilities

The conventional language of downstreaming emphasizes where processing takes place, whereas a smallholder-centred perspective asks where capabilities accumulate and who can deploy them. Inclusive industrial transformation requires farmer organizations to acquire transferable capabilities in financial management, quality assurance, logistics, data management, certification, contractual negotiation, processing knowledge, investment governance and market development. Those capabilities have value beyond a particular processing plant because they allow rural organizations to participate in future industrial opportunities and to negotiate from a stronger informational position. This interpretation links industrial policy with sustainable-livelihoods research, in which human, financial, social and physical capital jointly shape resilience and adaptive capacity (Hendrawan et al., 2024). It also aligns with evidence that durable collective action depends on organizational learning and the ability to adapt through replanting and other structural transitions (Jelsma et al., 2024). Downstream policy can therefore be understood as a mechanism for capability accumulation rather than simply as an instrument for increasing physical processing output.

8.2 Downstreaming as redistribution of economic rights

Capability alone is insufficient if economic rights remain concentrated downstream. Inclusive downstreaming should broaden market rights through direct and transparent buyer relationships, information rights through access to pricing and quality data, income rights through transparent distribution of margins, ownership rights through

appropriately structured equity, and governance rights through meaningful representation in cooperative or joint-venture decisions. These dimensions closely resemble the ownership, voice, reward and risk framework used to assess the substantive inclusion of smallholders in collective trading organizations (Untari and Vellema, 2022). The framework prevents symbolic participation because a farmer organization listed as a partner but unable to verify prices, costs, risks or dividends possesses weak economic rights regardless of formal ownership. It also clarifies why minority equity can still be meaningful when it is coupled with information, governance and enforceable return rights, whereas majority ownership can be harmful if it concentrates unmanageable debt and operational risk on farmers.

8.3 Smallholder participation and national competitiveness are complementary

It may be argued that including smallholders in more stages of the chain raises transaction costs. In the short term, building organizations, maps, traceability systems and professional management is indeed costly. Yet exclusion also creates costs.

Unmapped farms complicate traceability. Aging plantations reduce raw-material efficiency. Weak institutions increase side-selling risks. Poor legality complicates certification. Social exclusion creates political and reputational risks. In this sense, investment in smallholder capability is part of the transaction infrastructure of a competitive downstream industry.

The increasingly stringent sustainability expectations facing downstream industries reinforce this argument. Indonesia's extension of ISPO governance toward downstream industries means that upstream and downstream sustainability can no longer be treated as separate policy domains (Ministry of Industry, 2026). At the same time, research on ISPO governance and private zero-deforestation standards shows that stronger formal requirements must be matched by institutional coherence and realistic inclusion mechanisms if smallholders are not to be relegated to less formal market channels (Choiruzzad et al., 2021; Jespersen et al., 2024; Chandra et al., 2026).

8.4 The role of the state should evolve from subsidy provider to ecosystem architect

Many farmer programs are organized around individual subsidies for seedlings, equipment, replanting or certification, and these instruments can be useful when they address a clearly defined constraint. Downstreaming nevertheless requires coordination across multiple stages, so the state should increasingly act as an ecosystem architect that reduces coordination failures across ministries and levels of government. It should establish shared infrastructure such as farm registries and interoperable traceability standards, de-risk private investment where there is a clear public-good rationale, and protect farmers against exploitative contracts while strengthening safeguards against elite capture. The state should also link access to public finance with transparent performance standards so that subsidy programs reward governance and capability rather than asset acquisition alone. Evidence on collective action indicates that external institutions influence whether farmer organizations remain resilient, while governance research on ISPO demonstrates that policy coherence matters for the credibility of sustainability transitions (Jelsma et al., 2024; Choiruzzad et al., 2021). The appropriate state role is therefore to coordinate rules, infrastructure, incentives and accountability rather than attempt to operate every downstream enterprise directly.

8.5 Measuring what matters

Conventional metrics such as hectares replanted, certificates issued or processing capacity installed remain useful but insufficient because they measure program outputs more readily than distributional outcomes. A smallholder-centred dashboard should therefore track the proportion of smallholder area that is legally documented, geolocated and traceable; changes in yield; and the share of FFB marketed collectively or sold directly to mills. It should also measure cooperative revenue generated beyond simple FFB trading, the value of farmer-owned logistics and processing assets, smallholder equity in processing ventures, and the share of downstream margins returned to producer organizations. Financial and social indicators should include the number of bankable farmer organizations, certification costs per farmer, income resilience during replanting and downstream employment generated in producing regions. Circularity can be monitored through the quantity and value of residues transformed into useful products, while environmental safeguards should track deforestation and land-expansion outcomes within participating supply sheds. Together, these measures would shift evaluation from how much has been processed to how inclusively value has been created and captured and whether higher value capture is compatible with credible sustainability performance.

9. CONCLUSION AND POLICY PRIORITIES

Indonesia's palm oil industry is moving deeper into domestic processing, product diversification and bioenergy, creating opportunities for competitiveness, energy security, technology accumulation and domestic value addition. The qualitative literature reviewed in this article nevertheless reveals a structural tension: smallholders are indispensable to the palm-oil economy, but their economic participation remains concentrated at the farm gate while control over aggregation, processing, finance and marketing lies predominantly elsewhere. The core policy challenge is therefore not simply to expand downstream capacity but to connect that expansion to smallholder capability, bargaining

power and value capture. The article conceptualizes this challenge as the smallholder downstreaming paradox and argues that inclusive downstreaming should be assessed by the distribution of capabilities, rights, risks and returns as well as by national processing indicators.

The central substantive conclusion is that smallholders should be repositioned from residual FFB suppliers into progressively value-capturing actors within the industrial ecosystem, but this does not imply that every farmer organization should own a refinery, biodiesel plant or CPO mill. A more credible pathway is sequential functional upgrading from productive, legal and sustainable farming to organized and traceable supply, aggregation and logistics, selective participation in primary processing, downstream SMEs and circular-bioeconomy activities, and eventually equity or joint-venture participation where capabilities permit. This sequence reflects the empirical importance of agronomy, replanting, and collective organization documented in recent Indonesian research. It also reduces the risk that political enthusiasm for downstreaming produces underutilized or over-indebted cooperative assets before basic farm and organizational constraints have been resolved.

Policy should begin by integrating smallholder replanting, productivity improvement, and downstream industrial planning so that PSR functions as renewal of the national feedstock base as well as a farm-support program. Land legality, registration, mapping, certification and traceability should then be accelerated through integrated services that connect compliance with market access and bankability. Cooperatives and farmer corporations should be professionalized against transparent readiness standards, while a differentiated financing architecture should match replanting, working capital, logistics, processing and equity participation with appropriate maturities and risk-sharing instruments. These first four pillars establish the minimum productive, legal, organizational and financial capabilities on which more ambitious downstream roles depend.

The remaining pillars should institutionalize equitable company–cooperative and state-enterprise–cooperative partnerships, promote scale-appropriate and distributed participation in processing, develop a smallholder-linked circular palm bioeconomy, and create market mechanisms that reward legal, traceable and sustainable production. Partnership evaluation should focus on transparent rights, risks, returns and information rather than on the number of agreements or nominal equity positions. Circular-economy opportunities based on residues can broaden rural value creation, but they should be supported only where life-cycle performance, feedstock supply, technology and off-take are commercially credible. Across all eight pillars, public support should be sequenced and conditional on organizational capability so that downstreaming strengthens rather than destabilizes smallholder institutions.

Evaluation should accordingly move beyond hectares replanted, certificates issued, and processing capacity installed. Relevant indicators include legal and traceable smallholder area, yields, collective marketing, direct mill access, cooperative revenue beyond FFB trading, farmer equity or contractual participation in processing, income resilience during replanting, residue valorization, regional employment and land-use outcomes. These indicators would allow policymakers to distinguish aggregate downstream growth from actual improvement in smallholder terms of participation. Empirical research should now test the proposed ladder and policy architecture through comparative case studies, investment-feasibility analysis and longitudinal measurement of income, governance and value capture across different smallholder types and regions. The future of Indonesian palm oil therefore lies beyond the farm gate: not in abandoning the smallholder plantation as the productive foundation of the industry, but in enabling smallholders to follow the value created from that plantation farther through the chain.

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