ISSN: 2978-5111

Journal on Political Sciences & International Relations

SCIENTIFIC Research and Community

Research Article

Open Access

Beyond the '33-Year Gap': Replanting Indonesia's Smallholder Coconut Economy for Productivity, Resilience, Value Capture, and Global Trade Competitiveness

Loso Judijanto

IPOSS Jakarta, Indonesia

ABSTRACT

Indonesia remains one of the world's most important coconut-producing and exporting countries, yet ageing palms, low smallholder productivity, limited availability of certified planting material, fragmented value chains, climate risks, and uneven downstream value capture increasingly constrain the productive foundation of its coconut economy. Recent proposals to regenerate approximately 500,000 hectares of coconut plantations have therefore generated considerable strategic interest. A frequently cited calculation suggests that, at a reported replanting capacity of approximately 15,000 hectares per year and an implied requirement of 150 seednuts per hectare, supplying 500,000 hectares would take about 33 years if planting-material availability remained unchanged. This qualitative literature review critically evaluates that proposition and develops an integrated framework for Indonesian coconut regeneration. The review finds that the "33-year gap" is better interpreted as a capacity-stress scenario than as an immutable forecast. The more consequential constraints arise from interactions among seed and nursery capacity, biological maturation lags, smallholder transition economics, agronomic performance, climate resilience, farmer organisation, downstream processing, and market coordination. Successful regeneration should therefore be assessed through survival, productivity, farmer income, processing absorption, and value capture rather than hectares replanted alone. Indonesia requires a coordinated strategy combining selective replanting, rehabilitation, sustainable intensification, income bridging, climate-smart germplasm, nursery expansion, farmer-centred finance, traceability, regional processing clusters, and whole-coconut valorisation. Such integration can strengthen both smallholder livelihoods and Indonesia's strategic position in the evolving global coconut economy.

***Corresponding author**
Loso Judijanto, IPOSS Jakarta, Indonesia.

Received: September 01, 2026; **Accepted:** September 07, 2026; **Published:** September 15, 2026

Keywords: Coconut, Cocos Nucifera, Smallholder Replanting, Indonesia, Seed Systems, Sustainable Intensification, Coconut Value Chain, Downstream Industrialisation, Global Coconut Trade, Rural livelihoods

JEL Classification: Q13, Q16, Q17, Q18, O13

Introduction

Coconut (Cocos nucifera L.) occupies an unusual position in tropical agricultural economies because it is simultaneously a food crop, an industrial raw material, an export commodity, a source of rural employment, a component of diversified farming systems, and a supplier of biomass suitable for a growing circular bioeconomy. Its kernel, water, husk, shell, leaves, sap and residual biomass can support multiple commercial pathways, ranging from fresh nuts, copra and conventional coconut oil to virgin coconut oil, coconut milk, cream, beverages, coconut sugar, flour, desiccated coconut, coir, cocopeat, activated carbon, biochar and emerging biomaterials. The crop therefore illustrates why agricultural competitiveness cannot be evaluated only through primary production volume: economic performance depends equally on biological productivity, product differentiation, processing capability, supply-chain coordination and the proportion of total biomass converted into marketable outputs [1-4].

Indonesia possesses several structural advantages in this economy. It has an extensive coconut resource base, considerable genetic diversity, a longtradition of smallholder production, access to major Asian consumer markets, and substantial experience in food processing and plantation-based industries. Recent molecular and genomic studies demonstrate that coconut genetic diversity can be mobilised for breeding, productivity enhancement, and stress resilience [5-8]. At the same time, Indonesian and international evidence identifies ageing stands, limited access to high-quality planting material, biotic and abiotic stresses, and weak uptake of improved technologies as persistent constraints on coconut-sector performance [9-12].

The urgency is particularly important in Indonesia because coconut farming remains predominantly smallholder based. Small family farms face fundamentally different replanting incentives from large estates: removing old palms requires immediate establishment expenditure, sacrifices at least part of current coconut income, creates a multi-year waiting period, and exposes households to climatic, biological, and market risks. Evidence from Indonesian coconut-producing areas also shows that remoteness, market access, infrastructure, institutional capacity, and farm-level sustainability can constrain the performance and resilience of smallholder supply chains [13-15]. Evidence from Indonesian oil-palm replanting further demonstrates that technically justified replacement can proceed slowly when farmers face financing constraints, uncertain land documentation, limited access to certified seedlings, insufficient extension services, and difficulty replacing income during the immature period [16-19].

Against this background, Indonesia's proposed large-scale coconut regeneration has generated a powerful market narrative. An International Coconut Community account of an Indonesian presentation referred to a national ambition involving approximately 500,000 hectares over five years, or roughly 100,000 hectares annually, while contemporary replanting capacity was described as around 15,000 hectares per year and associated with approximately 2.25 million seednuts. Those figures imply approximately 150 seednuts per hectare and a roughly 6.7-fold difference between the stated annual ambition and reported implementation capacity [20].

Taken literally and holding seed availability constant, the arithmetic is dramatic. Five hundred thousand hectares multiplied by 150 seednuts per hectare requires approximately 75 million seednuts. Dividing 75 million by 2.25 million seednuts annually yields approximately 33.3 years. This calculation has been interpreted as evidence of a "33-year gap" between policy ambition and production capability. However, treating this outcome as an unavoidable forecast would be misleading because seed production, nursery investment and planting capacity are themselves variables that policy can change.

Other recent figures reveal a moving rather than a fixed constraint. A later International Coconut Community account estimated approximately 375,039 hectares of old or damaged coconut land requiring about 53.5 million seedlings, while potential certified seed production was placed at around 6 million seeds annually [21]. Because the estimates refer to different operational concepts and points in time, they should not be treated as directly interchangeable. Their divergence instead reinforces the need for an authoritative national database linking plantation age, condition, seed sources, nursery capacity, farmer readiness, and annual planting cohorts.

The biological constraint is harder to compress. Coconut is a perennial palm with a long juvenile phase, and improved agronomic management cannot make a newly planted seedling behave like a mature palm. Conventional propagation remains important because commercial-scale clonal propagation is still constrained by technical limitations, even though advances in somatic embryogenesis, molecular breeding, transcriptomics and tissue-culture research are promising. Tall, dwarf and hybrid material also differ in precocity, yield architecture, market suitability and environmental adaptation, making variety choice a strategic decision whose consequences may last several decades [11,12].

The central research problem is therefore broader than whether Indonesia can plant 500,000 hectares. The more important question is whether Indonesia can convert plantation regeneration into a coordinated transition from ageing, relatively low-productivity smallholder coconut landscapes toward productive, climate-resilient and commercially integrated systems that allow farmers and domestic processors to capture substantially greater value. The distinction matters because planting 500,000 hectares of poorly adapted seedlings without reliable farmer financing, agronomic support, pest surveillance and downstream demand would fulfil an administrative target without necessarily creating competitive production capacity.

This article addresses five questions. First, why has regeneration of Indonesia's smallholder coconut resource become strategically important for the country's future role in the global coconut economy? Second, what biological, institutional, financial, and technological constraints could prevent large-scale replanting from achieving its intended results? Third, what combination of seed-system expansion, transition finance, agronomy, and farmer organisation is needed to make replanting attractive and sustainable? Fourth, how should replanting be connected to downstream industrialisation and international trade? Fifth, should competitiveness continue to be defined primarily in terms of coconut tonnage, or should Indonesia increasingly optimise productivity, processing recovery, and economic value captured per nut? By linking biological supply lags with smallholder transition economics, seed-system capacity, downstream value creation, and trade positioning, the review contributes an integrated policy framework that is largely absent from fragmented discussions of coconut breeding, farm management, and processing.

Figure 1: Summarises the Central Distinction Developed in this Article.

The widely circulated 33-year calculation is useful because it exposes how far current seed and planting capacities would have to expand, but it should not be treated as a prediction that nothing can change for 33 years. The figure therefore separates an arithmetically fixed-capacity scenario from the biologically constrained but policy-responsive pathway that is more appropriate for strategic planning.

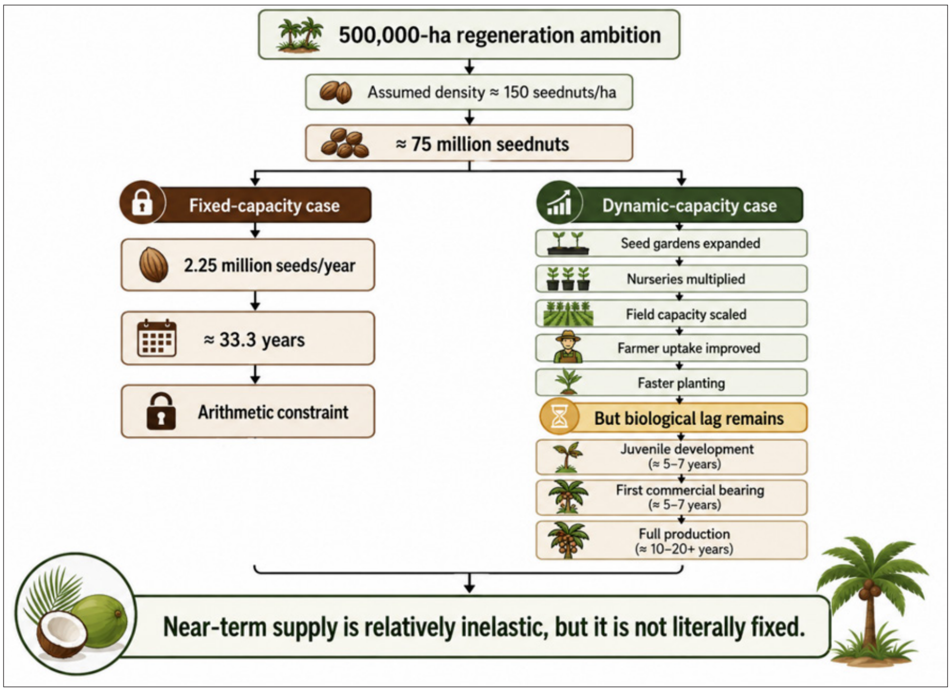

Figure 1: From the "33-Year Gap" to a Dynamic Coconut Supply-Response Framework

Source: Author's synthesis based on the policy figures for this review, ICC evidence, and recent coconut propagation literature.

The figure implies a major strategic distinction. Infrastructure can be expanded by investment, institutions can change, seed gardens can be multiplied, and financing can increase farmer participation; biological maturation cannot be accelerated to the same degree. Indonesia thus needs a two-speed strategy: recover more production and value from existing palms immediately while simultaneously creating the new productive resource that will determine supply in the 2030s and beyond. This interpretation is consistent with research showing both the severity of coconut senility and the continuing technological constraints on mass propagation.

Literature Review

Coconut Production as a Long-Lived Biological and Economic System

Coconut differs fundamentally from annual crops because each planting decision locks farmers and landscapes into a biological asset whose consequences extend over decades. Palm establishment, canopy development, flowering, fruit formation, and yield stabilisation occur sequentially, while genetic characteristics influence height, precocity, product attributes, resistance, and long-term management requirements. Research on coconut fruit biology emphasises that ageing stands and inadequate planting material contribute to declining productivity, while genomic research shows substantial scope for improvement in stress tolerance and economically valuable traits.

The implication is that a national replanting programme cannot treat seedlings as homogeneous units. Indonesia possesses locally valuable germplasm, including tall and dwarf populations and specialised types such as kopyor coconut. Molecular-marker research demonstrates substantial diversity that can support better breeding and geographically differentiated material, while comparative work on kopyor and macapuno illustrates how distinctive traits can underpin higher-value markets. A strategy focused solely on distributing the maximum number of seedlings could therefore narrow genetic diversity or install material poorly matched to local climates, farming systems, and target markets.

Conventional breeding and propagation cannot, however, be transformed overnight. Coconut is heterozygous, perennial and relatively slow to breed. Somatic embryogenesis is scientifically promising because it could eventually permit mass multiplication of selected elite palms, but the technology remains limited by callus induction, embryo conversion, acclimatisation and commercial-scale reproducibility. Research into coconut root development, molecular markers and transcriptomic regulation further expands future possibilities, but such advances should be viewed as complements to not substitutes for immediate investment in conventional mother-palm blocks, seed gardens, certified nurseries and quality assurance.

Sustainable Intensification and the Yield-Recovery Option

Replanting is only one route to greater coconut supply. Where stands remain biologically viable, rehabilitation and agronomic intensification can produce earlier gains than complete replacement. Evidence from coconut-based systems shows that nutrient management, biomass recycling, fertigation, cover crops, intercropping, and soil management can materially increase system productivity and resource-use efficiency [26-30]. More recent field evidence further shows that multi-storied coconut systems combined with soil-test-based nutrient management can improve productivity, profitability, and system resilience for smallholders [31].

This supports a critical policy distinction between replanting and rehabilitation. Old, seriously diseased or structurally unproductive palms may need removal, whereas younger palms with recoverable productivity may respond more quickly to fertilisation, canopy management, water conservation, pest control and harvesting improvements. A programme that mechanically classifies all low-yield stands as replanting candidates risks destroying productive capacity that could otherwise supply processors during the long establishment phase of new plantings.

Rehabilitation is also economically attractive because it helps moderate the supply trough created when mature palms are removed. This consideration becomes especially important when market prices are strong. A simultaneous programme of selective replanting and existing-tree productivity recovery could stabilise national output while allowing nurseries to scale progressively, creating a smoother age structure rather than replacing very large areas in a single cohort.

Smallholder Economics and the Intertemporal Replanting Problem

A recurring lesson from Indonesian perennial-crop research is that replanting is an intertemporal household investment rather than merely an agronomic operation. Smallholders must finance land preparation, seedlings, labour, crop establishment, and several years of maintenance before the replacement crop generates meaningful returns, while household expenditures for food, education, healthcare, and other needs continue. Identify finance, planting material, and knowledge as central barriers in Indonesian oil-palm replanting, show that participation is also influenced by experience, land documentation, and socioeconomic characteristics. These findings are relevant to coconut because its long biological cycle similarly makes household liquidity and risk-bearing capacity integral to adoption.

similarly show that financial incentives can alter replanting preferences, but programme design matters [19]. Demonstrate that collective action can support replanting, yet farmer organisations are not inherently resilient: management quality, physical conditions, financial governance, and member heterogeneity shape outcomes. These lessons are directly relevant to coconut because producers are often geographically dispersed and may operate with limited cash margins, while recent Indonesian coconut supply-chain studies likewise emphasise the importance of institutional capacity and coordinated stakeholder action [14-15].

The literature therefore suggests that a coconut replanting grant alone would be inadequate. Farmers require a transition package incorporating planting cost, maintenance finance, technical assistance and an income bridge. The financing horizon must reflect the crop's biological horizon. Debt repayment that begins before meaningful coconut production is generated would transfer biological risk to households and could encourage premature abandonment of newly established gardens.

Agroforestry as an Income and Resilience Bridge

Coconut architecture creates opportunities for diversified land use. During early establishment, inter-row space can support annual food crops, legumes, horticulture, or fodder, while mature coconut systems may accommodate cocoa, coffee, spices, fruit, livestock, or other compatible enterprises where ecological conditions permit. Indonesian and regional literature shows that diversified agroforestry can contribute to food access, income diversification, climate resilience, ecosystem services, and more efficient land use when crop combinations are appropriately designed [32-35].

This creates an opportunity to design replanting around household cash flow rather than coconut biology alone. Intercrops can generate income while palms mature, improve food access, and create incentives for farmers to maintain young coconut stands. Coconut-based mixed systems can also improve system productivity, carbon stocks, and nutrient cycling; recent evidence from Eastern India further indicates that multi-storied/intercropping systems combined with appropriate nutrient management can increase net income and sustainability indicators [27, 28,31].

However, agroforestry should not be romanticised as automatically profitable. Farmers need market outlets, seed and planting material for intercrops, labour availability and appropriate technical recommendations. Poorly designed combinations may compete for nutrients or water, complicate mechanisation, or fail commercially. Income-bridge packages must therefore be adapted to specific provinces and livelihood systems rather than prescribed through a uniform national intercrop.

Climate Resilience, Pest Management and the Long-Term Nature of Replanting

Planting a perennial tree in the late 2020s is effectively an investment in climatic conditions that may prevail in the 2040s and 2050s [36]. Project important changes in tree-crop suitability across Southeast Asia, including deterioration in suitability in some existing coconut-producing locations under more severe climate scenarios. Their analysis indicates that climatic risks may not simply reduce average productivity; they can alter the geography in which future coconut production remains economically defensible. This long planning horizon makes climate screening a core component of replanting rather than an optional environmental add-on.

Climate-smart replanting consequently requires more than distributing high-yield varieties. Material must be matched to rainfall patterns, drought and waterlogging risk, salinity, wind exposure, soil conditions, elevation and anticipated future climatic conditions. Genomic evidence of coconut salt-tolerance pathways and the genetic diversity identified within international and Indonesian germplasm highlight opportunities for breeding and selection, but genetic uniformity itself can increase vulnerability if future stresses differ from current assumptions [37].

Pests and diseases reinforce the importance of biological diversity and surveillance. Coconut rhinoceros beetle, red palm weevil, stem bleeding, leaf diseases, and phytoplasma-associated diseases can cause major economic losses, while regional movement of pests makes biosecurity increasingly important [38-41]. Recent Indonesian surveys confirm the continuing importance of documenting local pest and disease conditions, while biological-control research shows that native entomopathogenic nematodes can contribute to integrated management of coconut rhinoceros beetle [42-43]. Digital detection tools based on machine vision and deep learning add a potentially scalable surveillance layer, although their effectiveness depends on reliable imagery, connectivity, farmer access, and extension response systems [44-45].

From Coconut Production to the Coconut Value Chain

The literature increasingly treats coconut competitiveness as a value-chain problem. identify technological, socioeconomic, environmental, and institutional constraints across coconut supply chains, shows that participation in international coconut value chains depends on institutional coordination and value-chain upgrading rather than primary production alone. Recent evidence from Riau similarly finds that marketing and institutional capacity are critical weaknesses in remote coconut supply chains, reinforcing the need to analyse farm production together with aggregation, processing, logistics, governance, and market acces.

Processing technology substantially alters the amount and type of value that can be captured from a nut. Research on virgin coconut oil demonstrates that extraction technology affects yield and product quality [46]. Coconut-water research shows that preservation and non-thermal processing are essential because the beverage deteriorates rapidly after opening [47-48]. Coconut-milk studies likewise show that formulation, fat content, and pasteurisation conditions influence product stability and quality while innovation in desiccated-coconut drying can reduce processing time and energy requirements [49-51]. Coconut sugar represents a further differentiated pathway whose quality, nutritional profile, and food applications illustrate the breadth of potential value-added markets [52].

The non-food fractions are equally strategic. Coconut shell and husk can become activated carbon, biochar, energy carriers, adsorbents, and industrial materials, while coir can be processed into growing media or biocomposites [53-57]. Research on coconut-shell-derived graphitic activated carbon further demonstrates the potential to move residues into higher-performance material applications [58]. The broader implication is that "waste" is partly an institutional and technological category: a residue becomes a marketable input when processing capability, standards, logistics, and demand are coordinated.

International Trade and the Meaning of Coconut Leadership

Indonesia remains highly significant in world coconut trade. World Bank WITS/UN Comtrade data for 2024 identify Indonesia as the largest reported exporter in the broad HS 080110 category for fresh or dried coconuts, with exports of approximately US$471.8 million and 1.18 billion kg. Indonesia therefore should not be described as having disappeared from global coconut leadership; instead, its position differs across specific product categories [59].

The pattern changes when coconut oil is considered. Under HS 151311 for crude coconut/copra oil, the Philippines reported exports of approximately US$1.35 billion in 2024 compared with approximately US$412.5 million for Indonesia; under HS 151319 for non-crude coconut oil and fractions, Philippine exports were approximately US$873.1 million and Indonesian exports approximately US$481.0 million. These data demonstrate why "global leadership" must distinguish raw-nut scale, oil-processing capability, and value-added product portfolios rather than rely on a single production ranking [60-61].

Trade studies reach a similar conclusion [62]. Show that even large producing countries do not automatically enjoy competitiveness in every processed coconut category, while value-chain evidence demonstrates that raw-product exports can create trade-offs with domestic processing opportunities [63]. Indonesian research likewise suggests that production, productivity, and international competitiveness must be considered together rather than assuming that extensive planted area automatically creates strong market performance [64]. The strategic objective should therefore be to build a portfolio of comparative and competitive advantages across products of increasing value intensity.

Recent Indonesian evidence makes the trade-upgrading problem more explicit. Studies of coconut-oil competitiveness show that Indonesia retains strong comparative advantages in several markets, but its export structure remains concentrated in crude or less processed forms and competes closely with the Philippines and Malaysia [65-67]. A broader assessment of the Indonesian coconut industry similarly identifies low upstream productivity and insufficient downstream innovation as mutually reinforcing constraints on export performance [68].

International comparison also shows that supply reliability is a competitive asset rather than merely a production statistic. The Philippine supply-chain literature links ageing palms, declining production, fragmented marketing and underutilised processing capacity to difficulty meeting export demand, while empirical export modelling shows that domestic production, destination-market income, population and exchange rates materially influence raw-coconut exports [69-70]. These findings strengthen the case for treating Indonesia's replanting programme as both an agricultural intervention and a long-horizon investment in trade capacity.

Method

This study employs a qualitative literature review (QLR) and explicitly does not constitute a systematic literature review or meta-analysis. The methodological objective is interpretive synthesis: to integrate agronomic, biological, socioeconomic, institutional, technological and international-trade evidence into an explanation of what successful coconut regeneration would require in Indonesia. This approach is particularly suitable because the problem crosses multiple research domains that use very different methods and units of analysis, ranging from plant genomics and propagation experiments to household replanting decisions, value-chain studies and international trade statistics.

Literature selection was purposive and iterative. Priority was given to peer-reviewed publications from 2020 onward that addressed coconut biology, genetic resources, propagation, nutrient management, agroforestry, climate risk, pest and disease management, processing, value chains, smallholder organisation, plantation replanting, and agricultural traceability. Recent Indonesian studies were prioritised where available, while evidence from other coconut-producing countries was used to illuminate mechanisms relevant to Indonesia. Literature on Indonesian oil-palm replanting was included as an analytical analogue because both crops are long-lived perennial commodities with substantial smallholder participation and share problems of income loss, planting-material quality, collective action, and financing during regeneration. Official evidence from the International Coconut Community and World Bank WITS/UN Comtrade was used only for contemporary policy and trade figures that are not adequately captured in journal literature.

The literature was interpreted through nine linked themes that correspond to the Results section: regeneration versus acreage expansion; seed and nursery capacity; capacity scaling and biological lag; smallholder income transition; farmer organisation; climate resilience and biosecurity; value captured per nut; downstream investment sequencing; and traceability. Studies were compared for their explanatory contribution rather than counted mechanically, and greater weight was given to recent peer-reviewed evidence with direct relevance to coconut production, Indonesian smallholders, or comparable perennial-crop transitions. Contradictory evidence and differences among policy figures were retained when they materially changed interpretation; in particular, the 33-year proposition was treated as a scenario derived from stated capacity assumptions rather than as a factual forecast.

No PRISMA flow diagram, exhaustive database-enumeration claim or statistical pooling is presented. This methodological choice is deliberate. The objective is not to answer how many studies report a particular effect, but to explain how mutually dependent constraints can cause a large replanting programme to succeed or fail. The article therefore follows the logic of an integrative, policy-oriented qualitative synthesis rather than a systematic review protocol.

As a qualitative and purposive review, this study is designed for conceptual integration rather than exhaustive coverage or statistical effect estimation. The synthesis therefore does not claim that the included literature represents every coconut study published since 2020, and findings derived from analogous perennial crops are used to illuminate mechanisms rather than to imply one-to-one transferability. Institutional and trade databases are used only for contemporary policy and market statistics, while the analytical claims are anchored primarily in peer-reviewed literature; future empirical work should test the proposed regeneration and trade framework using cohort-level plantation, processing, price, and export data.

Results

Theme 1: Indonesia Faces a Regeneration Problem Rather Than Merely an Acreage Problem

The first thematic finding is that coconut policy framed around additional hectares risks misdiagnosing the problem. Indonesia already possesses a very large coconut resource base, but biological age, low productivity, weak maintenance and uneven access to improved material reduce effective production capacity. Replacing unproductive palms is necessary, but the economic objective is not land occupation; it is the creation of productive biological assets capable of supporting competitive farms and processors for several decades [64].

This distinction changes the programme's success metric. A seedling distributed is not a productive palm. A seedling planted but poorly maintained is not successful replanting. A surviving palm of unsuitable genetic material is not necessarily competitive production. A high-yielding palm without market access may still fail to improve household welfare. Accordingly, national monitoring should progressively distinguish seedlings produced, seedlings certified, hectares actually planted, survival after one and three years, first bearing, mature yield, farmer income and downstream sales.

Theme 2: The Seed and Nursery System Is the Immediate Capacity Constraint

Large-scale replanting begins before the farm. It begins with identified mother palms, seed gardens, controlled seed production, nurseries, certification, screening, transport, and establishment. Coconut seednuts create logistical difficulties because fruits are large, recalcitrant, and not indefinitely storable, while germination can be slow and variable [11].

Mass expansion therefore requires physical nursery infrastructure, quality assurance, logistics, and biological planning rather than merely larger procurement budgets.

The recent Indonesian figures illustrate the scale challenge. At 150 seednuts per hectare, increasing field establishment from 15,000 to 100,000 hectares annually means increasing annual planting material from about 2.25 million to approximately 15 million seednuts before allowance for nursery rejection, field mortality and contingency stocks. The nominal 6.7-fold gap could therefore understate the actual capacity expansion needed if the programme insists on high germination, certified provenance and replacement of failed seedlings.

This also implies that multiplying unknown or inferior material would be a false economy. The scientific literature demonstrates considerable genetic variation in coconut and rapidly improving ability to characterise that variation using genomic and molecular approaches Replanting represents an unusually important opportunity to upgrade the national genetic base. Once poor material is planted, correcting the mistake may require decades.

Figure 2: Depicts Replanting as a quality-assured chain rather than a field-planting event. Failure at any stage can reduce the value of all investments made upstream. A programme capable of producing millions of seedlings but unable to confirm farmer readiness or post-planting maintenance could generate high reported disbursement but low long-term productive capacity.

Figure 2: Integrated Coconut Replanting Success Chain
Source: Author's synthesis.

The figure highlights why annual hectares alone are an inadequate performance indicator. Seed-system investment, extension, field survival and commercial integration are sequentially connected. Monitoring one part of the chain without the others creates incentives for administrative rather than productive success.

Theme 3: The "33-Year Gap" Is a Warning About Elasticity, not a Deterministic Forecast

The 33-year calculation is important precisely because it asks what happens if capacity does not change. Holding 2.25 million seednuts per year constant produces the arithmetic result of approximately 33 years to supply 75 million seednuts. But a national strategy can invest in seed gardens, nurseries, staffing, logistics and certification, making the numerator fixed but the denominator expandable.

The later International Coconut Community figures reinforce this interpretation. Estimates indicating potential certified production of roughly 6 million seeds annually already differ substantially from the 2.25-million figure associated with existing field capacity. That difference does not mean the constraint has disappeared; it means planting-material availability should be represented as a capacity curve that can change through investment and organisation rather than as a fixed constant [21].

The global-supply conclusion therefore also requires qualification. New plantings may contribute relatively little to immediate production, especially where tall material is used, but supply before 2033 can still change through weather, rehabilitation, nutrient management, harvest efficiency, price incentives, area changes in other countries and earlier-bearing varieties. A more academically defensible formulation is that the new-tree supply response is biologically lagged and near-term coconut supply is relatively inelastic, not that global supply is absolutely fixed.

Theme 4: The Farmer Income Gap May Become More Binding Than the Seed Gap
A successful nursery expansion could create millions of seedlings and still fail to generate corresponding replanting if smallholders cannot afford to remove old trees. Evidence from Indonesian oil-palm replanting shows that farmers often delay replacement because old plantations, even at declining productivity, continue generating cash while new plantations initially generate none [16-17]. Replanting consequently involves an implicit opportunity cost in addition to visible establishment expenses.

Coconut may pose an even more complex problem because holdings frequently combine home consumption, informal sales, intercrops and multiple coconut products. Compensation based only on a standard cost per hectare can therefore underestimate household exposure. Policy needs to measure the income valley between removal of old palms and commercial productivity of replacements.

A farmer-centred financing structure should consequently separate establishment finance from household transition support. Establishment finance covers seedlings, labour, land preparation, fertiliser and maintenance. Transition finance supports the household's ability to wait. The second component can include temporary transfers, concessional loans with sufficiently long grace periods, intercrop finance, livelihood diversification and contracts with processors.

Figure 3: illustrates why planting subsidies alone may not unlock farmer participation.
Replanting initially lowers coconut-derived income before new palms contribute significantly. Agroforestry, temporary income support, and appropriately timed finance can reduce the depth of this transition gap.

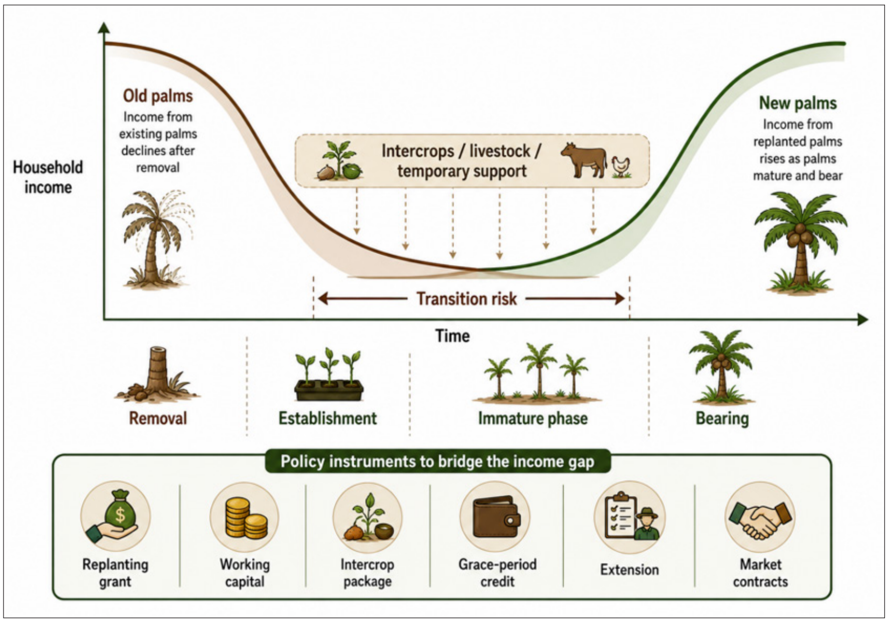

Figure 3: The Smallholder Replanting Income Bridge
Source: Author's synthesis based on Indonesian replanting and agroforestry literature.

The underlying point is institutional rather than graphical. Financing should follow biological cash flow. Repayment schedules that ignore the crop's maturity profile can convert a productivity programme into a household debt problem, whereas income bridging can make technically superior planting material economically adoptable.

Theme 5: Farmer Organisations Are Critical Infrastructure, but They Are Not a Silver Bullet
Scaling a smallholder programme across hundreds of thousands of hectares requires aggregation. Farmer organisations can consolidate seed orders, deliver extension, organise training, support finance applications, coordinate machinery, record traceability information, and aggregate marketable nuts. Evidence from Indonesian commodities shows that collective action can strengthen bargaining and reduce transaction costs, while recent coconut research in Riau specifically identifies collective action and institutional capacity as important for price stability, sustainability, and supply-chain resilience.

Nevertheless, legal formation of cooperatives should not be confused with effective collective action [72]. Demonstrate that collective ownership does not automatically generate inclusive market relationships, show that governance, financial management, farmer heterogeneity, and the wider institutional environment strongly influence organisational resilience [19]. Coconut-sector evidence similarly indicates that institutional strengthening must be linked to the economic and logistical realities of remote production systems rather than treated as an administrative formality [14-15].

The coconut programme should therefore avoid making nominal cooperative membership an end in itself. Organisations need transparent accounts, competent managers, working capital, credible leadership, member participation, extension capability and commercial functions. Where existing farmer groups are weak, external facilitation may be required before significant financial responsibilities are transferred to them.

Theme 6: Replanting Is an Opportunity to Climate-Proof the Next Generation of Plantations

The long productive life of coconut magnifies the cost of incorrect variety-location matching. Replanting allows Indonesia to change the genetic composition of its plantations only periodically; the current regeneration cycle is therefore an opportunity to build resilience before climate stress intensifies [36]. Project changing coconut suitability across Southeast Asia, including risks in parts of insular Southeast Asia, reinforcing the importance of spatial planning and climate-informed planting-material allocation.

Climate screening should consequently become part of seed allocation. Coastal salinity, drought exposure, heavy rainfall, flooding and wind should influence material choice. Genetic diversity is an asset in this context because diverse populations provide a wider portfolio from which breeding programmes can identify stress-tolerant traits.

Replanting should simultaneously install a biosecurity architecture. Nursery inspection, phytosanitary protocols, pest monitoring, and rapid response are generally less costly than controlling a widespread established outbreak. Research on rhinoceros beetle biological control and coconut disease diagnostics demonstrates that integrated approaches can be incorporated into plantation management [38-41]. Digital image classification provides a potentially scalable additional layer of surveillance where extension systems can act on detected problems.

Theme 7: Indonesia Should Maximise Value Per Nut, Not Merely Nuts Per Hectare

The market argument supplied as the starting point for this review makes an important strategic observation: when acreage expansion is slow, competition increasingly concerns how much value can be extracted from existing production. This argument should be broadened rather than rejected. Agricultural productivity conventionally measures output relative to land, labour or inputs. Coconut industrial policy additionally needs an economic extraction ratio measuring the value of saleable products recovered from each nut.

A mature coconut can supply water, kernel, oil, and protein-rich residues; its husk can generate coir and cocopeat; and its shell can become charcoal, activated carbon, biochar, or advanced carbon materials. New processing methods can improve yield or quality of VCO, coconut water, milk, and desiccated coconut, while biomass technologies can transform residues into energy and industrial products [58]. This multiple-output architecture is the technical basis for treating value per nut as a complementary performance metric to yield per hectare.

Figure 4 translates the "extraction rather than tonnage" proposition into an Indonesian whole-coconut value architecture. The strategic objective is not to force every locality to make every product, but to minimise avoidable loss and allocate each biological fraction toward its highest feasible market value.

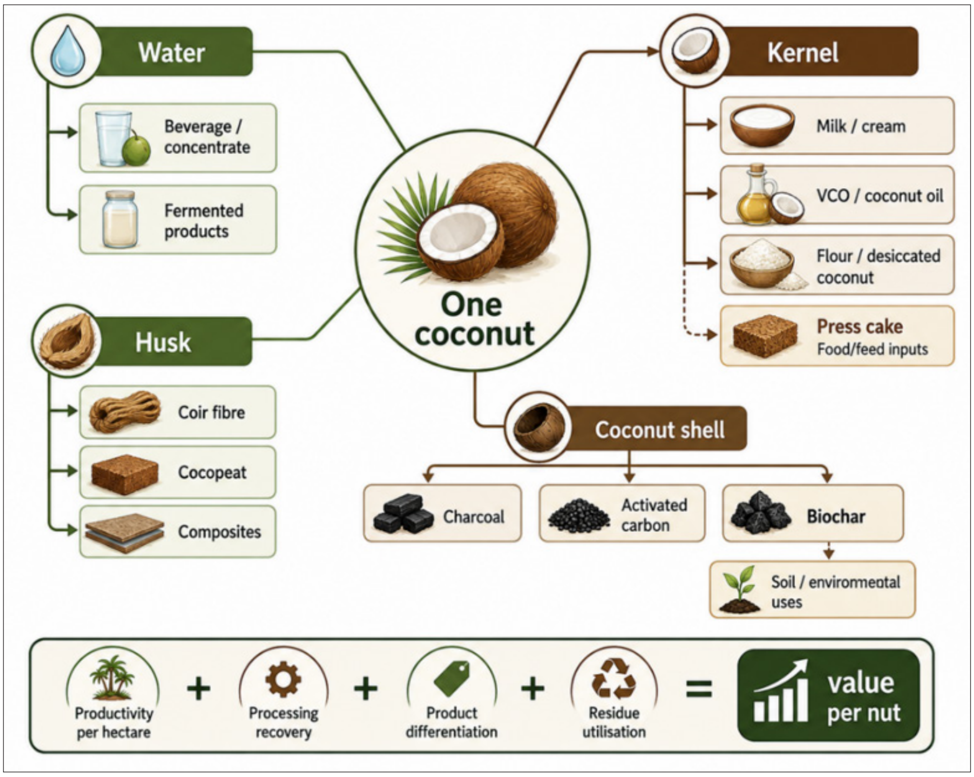

Figure 4: Whole-Coconut Valorisation and the "Value per Nut" Strategy
Source: Author's synthesis from the coconut processing and circular-bioeconomy literature.

This approach has direct implications for replanting. Future varieties should be selected partly in relation to intended markets. A variety optimised for fresh drinking coconut may differ from material preferred for copra, oil or specialised foods. Upstream genetics and downstream investment therefore need stronger communication than conventional commodity policy normally provides.

Theme 8: Downstream Capacity Must Be Developed Before New Plantings Mature

Waiting until regenerated plantations produce commercial volumes before constructing processing systems would reproduce the fragmentation that currently limits value capture. Processing investment should instead be sequenced during the immature phase so that future production enters functioning commercial networks. Recent Indonesian evidence from Riau shows that weaknesses in marketing, infrastructure, and institutional coordination can undermine supply-chain sustainability even when production potential is substantial, underscoring the need to develop downstream capability and market organisation in parallel with farm regeneration [14,15].

Indonesia's geography makes this especially important. Coconut-producing islands may face high transport costs for bulky raw nuts. Where processing is located close to production, water, husk and shell can be transformed locally instead of transporting weight that later becomes waste elsewhere. The optimal industrial structure will vary: fresh-coconut and beverage clusters require quality preservation and cold-chain capability, oil clusters need reliable kernel supply, while coir and charcoal economics depend on residue concentration and logistics.

The policy objective should therefore be a network of regional coconut industrial ecosystems rather than one centralised downstream complex. Each cluster would combine farmer aggregation, primary processing, quality testing, and residue utilisation, with higher-order refining or export functions concentrated where scale economies justify them. Evidence from coconut value chains suggests that such arrangements should be designed to preserve viable local processing opportunities while avoiding the loss of value that can occur when raw or minimally processed products dominate trade flow.

Theme 9: Traceability Should Begin During Replanting, Not Be Retrofitted Later

Large-scale regeneration creates a rare opportunity to build a farm registry from the beginning. Each supported plot can be georeferenced, associated with farmer and organisation records, linked to planting-material provenance, and subsequently updated with survival, production, and sustainability information. High-resolution satellite imagery and machine-learning methods have already demonstrated that individual coconut trees can be detected and mapped at landscape scale, showing the technical feasibility of combining remote sensing with field-based registration for plantation monitoring [73].

Digital traceability research shows considerable potential but also highlights risks [74]. Find that smallholder-oriented digital traceability can impose costs without guaranteed income benefits and that farmer-generated data may be unreliable where incentives and capabilities are weak. Traceability therefore cannot be treated as an application installed after programme design; it requires data governance, verification, interoperability, farmer incentives, and a clear economic rationale.

For Indonesia, the immediate value of traceability is management rather than marketing alone. Geospatial records can reveal where seedlings went, whether farms survived, where pest outbreaks occur, and whether processors have sufficient future supply. Over time, the same system can support sustainability claims, deforestation-risk assessment, quality segregation and market differentiation.

Discussion

Reframe the Programme from "Replanting" to "Coconut Regeneration"

The synthesis indicates that the term replanting programme is too narrow for the transformation required. Indonesia needs a national coconut regeneration mission that simultaneously manages old palms, viable existing plantations and future planting cohorts. Such a programme should optimise production during transition rather than maximise annual removal of old palms.

A three-track structure is particularly appropriate. The first track is Replant, targeting senile, severely diseased, structurally low-performing or inappropriate stands. The second is Rehabilitate, targeting palms that remain biologically productive but suffer from poor nutrition, water management, maintenance or pest control. The third is Intensify and Diversify, targeting healthy stands where agroforestry, processing linkages, residue utilisation and improved market coordination can increase economic returns.

This classification resolves an important conflict embedded in aggressive replanting. Removing too many palms simultaneously can deepen raw-material scarcity before replacement production arrives. Selective rehabilitation can counteract that effect by raising output from remaining productive trees, while staggered replacement progressively restores the age structure.

A Cohort-Based Strategy Is Superior to a Five-Year Aggregate Target

Five hundred thousand hectares over five years sounds precise but conceals implementation complexity. A more useful approach would classify each year's plantings as a separate cohort and track them from seed production to full bearing. Cohort monitoring makes biological lag visible to policymakers and distinguishes planting achievements from actual productive capacity.

For each cohort, government should know the seed source, nursery, province, number of seedlings dispatched, planted area, farmer organisation, one-year and three-year survival, first-bearing year, yield progression, and processor destination. Such data would make it possible to forecast national supply using observed survival and yield rather than administratively reported hectares. Remote-sensing methods capable of detecting individual coconut trees could complement field verification, especially in dispersed or difficult-to-access production landscapes [73].

Cohort planning should also be regional. Riau, North Sulawesi, Maluku, North Maluku, parts of Java, Sulawesi and other producing regions differ in farm structure, climate, markets and product orientation. A single national variety mix or financial package would be unlikely to maximise performance in all regions.

The Seed-System Scale-Up Should Be Treated as National Agricultural Infrastructure

The 6.7-fold capacity gap implied by the 15,000-versus-100,000-hectare figures is not merely a nursery-sector problem. It requires coordinated expansion of mother-palm blocks, certified seed gardens, trained personnel, nursery sites, water, transport, inspection, and farmer demand. The key metric should not be theoretical seed capacity but certified plantable seedlings delivered at the appropriate time and location.

A staged scale-up is preferable to an indiscriminate multiplication campaign. In the first phase, Indonesia should inventory certified seed sources and verify production capability. The second phase should expand regional seed gardens using genetically appropriate and diverse material. The third phase should establish accredited nurseries linked to confirmed planting cohorts. The fourth should add biotechnology-derived material as techniques become commercially reliable.

Private-sector participation is useful where incentives are aligned, but planting-material quality should remain subject to independent standards. Seedling markets suffer from information asymmetry: farmers may not discover that material is inferior until years after purchase. Certification therefore protects both public investment and smallholders from a form of quality failure whose consequences can persist for decades.

Farmer Transition Finance Should Follow the Biology of Coconut

The Indonesian oil-palm experience provides a clear warning against designing replanting primarily around administrative eligibility. Simplifying farmer registration and land verification is important, but an accessible programme can still fail economically if farmers cannot survive the immature period [16-17].

An integrated financing package should contain at least four economic functions even if implementation uses different institutions. First, it should cover part of the non-recoverable public-good component of replanting, particularly certified seedlings and technical support. Second, it should provide working capital for establishment and maintenance. Third, it should finance or facilitate temporary income-generating activities. Fourth, any repayable finance should have grace periods aligned with expected coconut cash flow rather than standard short-term agricultural credit schedules.

Intercropping can materially reduce public financing requirements because it creates productive economic use of plantation space during coconut establishment. Yet intercrop selection should be based on market opportunities, labour availability, and ecological compatibility rather than agronomic possibility alone. Evidence from coconut-based agroforestry and sustainable intensification shows that well-designed multi-species systems can improve income, resilience, and resource-use efficiency, but the benefits depend on appropriate crop combinations and nutrient management. A technically productive intercrop without a reliable buyer can still worsen farmer losses.

Farmer Organisations Need Commercial Functions

Cooperatives and farmer groups should be strengthened around actual economic functions: input procurement, extension, equipment sharing, aggregation, processing, quality assurance or contracting. Organisation for the sole purpose of qualifying for government support creates weak incentives for post-project sustainability.

The collective-action literature suggests that farmer organisations need professional capabilities alongside participatory governance [71-72]. A cooperative handling replanting funds and future product sales needs financial controls, trained managers, transparent reporting, and credible commercial functions. Recent Indonesian coconut studies reinforce this conclusion by identifying institutional capacity and stakeholder coordination as central determinants of supply-chain sustainability in remote producing areas. External audit and technical assistance may therefore be justified during early stages because institutional failure can affect many members simultaneously.

Processors can play a constructive role where contracts are transparent. Long-term purchase relationships can provide farmers with demand certainty, processors with raw-material security, and banks with stronger repayment confidence. The risk is excessive buyer power; cooperative aggregation and transparent price formulas can mitigate that asymmetry.

Replanting and Downstream Industrialisation Should Be One Industrial Policy

Indonesia's trade position shows why downstream industrialisation cannot be separated from agriculture. The country is already a major exporter of fresh or dried coconut and was the second-largest reported exporter of crude coconut/copra oil by value in the 2024 WITS/UN Comtrade data, although the Philippines remained substantially larger in crude coconut-oil exports [59-60]. Replanting policy should therefore consider not only future biological supply but also the domestic processing capabilities through which that supply will be converted into export value.

Replanting should consequently be accompanied by a demand map identifying what future nuts are expected to become. Regions oriented toward young coconuts require varieties, harvest protocols and logistics suited to the beverage market. Oil-processing regions need kernel quality, drying systems and efficient extraction. Areas with concentrated residue streams can support coir, cocopeat, charcoal, activated carbon, biochar or biomaterial industries.

This is where the Vietnam-oriented argument in the supplied infographic is particularly useful. Vietnam does not need to surpass Indonesia in hectares to compete effectively if it extracts more economic value from each nut and organises geographically compact processing chains. Indonesia's answer should not be to reject that logic but to combine it with its own scale advantage. The strategic formula becomes scale × productivity × extraction efficiency × product value × farmer participation.

Competitive Leadership Should Be Measured Through Several Indicators

The concept of "regaining Indonesia's role" requires analytical precision because Indonesia already occupies leading positions in several coconut categories. A future national dashboard should therefore avoid a single global ranking.

One indicator should be farm productivity, expressed in nuts or copra equivalent per hectare. Another should be farmer net income per hectare. A third should measure export value per tonne of coconut-equivalent raw material. A fourth should measure domestic processing share. A fifth could measure whole-nut utilisation, including economically used shell and husk. A sixth should track certified or traceable production. A seventh should track the proportion of young plantation area using recommended genetic material.

This multidimensional approach would prevent an increase in raw nut exports from being automatically interpreted as industrial success. There may be periods when exporting whole nuts generates attractive farm prices, but structurally stronger competitiveness requires Indonesia to possess multiple outlets so that producers are not locked into a single low-value chain.

A 2026–2045 Roadmap

The regeneration challenge requires a horizon substantially longer than five years. The period to 2030 should primarily build capacity and establish cohorts; the early 2030s should see rising first production from those cohorts and faster downstream absorption; the later 2030s and early 2040s should consolidate productivity and value-chain leadership.

Figure 5: Provides a suggested sequencing framework. Its central message is that downstream investment, farmer organisation and market development should not wait for the new palms to mature. These activities should occur during biological establishment so that industrial capacity and market channels are ready when production expands.

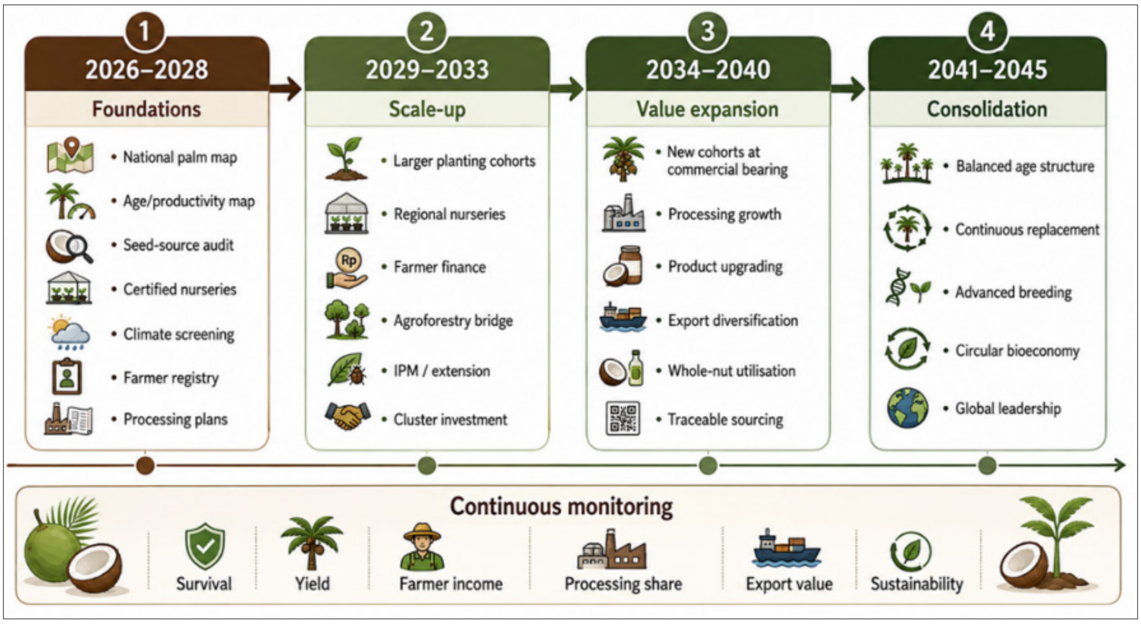

Figure 5: Proposed Indonesian Coconut Regeneration Roadmap, 2026–2045
Source: Author's synthesis.

This roadmap also provides a solution to the alleged 33-year problem. Indonesia does not need to wait three decades for economic improvement. Yield rehabilitation, better processing, waste valorisation and farmer organisation can generate benefits during the 2020s. What does require patience is rebuilding the biological capital represented by millions of productive palms.

Policy Architecture for Successful Implementation

A coherent national programme should begin with reliable data. Contemporary International Coconut Community accounts have reported different operational figures, including a 500,000-hectare five-year ambition and a later estimate of approximately 375,039 hectares of old or damaged coconut land requiring about 53.5 million seedlings. These figures are not directly comparable, but the difference is itself policy-relevant because area definitions, seed demand, nursery construction, budget requirements, and expected future supply all depend on the underlying denominator [20-21].

Indonesia should therefore establish an integrated coconut plantation registry combining remote sensing, local-government verification, and farmer registration. Each plot should be classified by age, variety where known, productive condition, major pest or disease risk, climate exposure, and recommended intervention. High-resolution satellite methods capable of detecting individual coconut crowns indicate that remote sensing can support this type of plantation inventory, although field verification remains necessary for age, variety, ownership, and management attributes [73]. The resulting database would separate genuinely senile plantations from recoverable ones and provide a credible denominator for national planning.

Second, the programme needs a national planting-material strategy rather than annual seed procurement. Genetic diversity must be preserved while high-performing varieties are multiplied. Regional seed gardens should be connected to climate and market objectives, and quality assurance should extend from mother palm to nursery and field. Modern genomics and molecular-marker technologies should increasingly support identity verification and breeding, but conventional seed systems will remain indispensable in the immediate replanting cycle.

Third, smallholder financing should be redesigned around household transition. The policy question is not merely "How much does it cost to plant one hectare?" but "What resources permit a household to maintain that hectare until it is productive?" Evidence from perennial-crop replanting makes clear that this distinction can determine adoption [16-18].

Fourth, replanting should include a mandatory but locally adaptable income strategy. In suitable regions this could involve maize, legumes, horticulture, cocoa, coffee, spices, fodder or livestock. The purpose is neither to prescribe one national agroforestry model nor to turn every coconut farmer into a highly diversified enterprise. It is to ensure that removal of old palms does not create an avoidable livelihood shock.

Fifth, climate and biosecurity screening should occur before public support is approved. A plantation expected to remain productive for decades should not be replanted with material selected exclusively from historical climate conditions. The same principle applies to pest and disease risk. Replanting creates both vulnerability—because many genetically similar young palms may be established at once—and opportunity, because clean planting material and surveillance can be embedded from the outset [36-41].

Sixth, the programme should integrate processors as development partners while preventing excessive market concentration.

Processors have strong incentives to secure future raw material and may contribute nurseries, extension, finance, and purchase agreements, while producer organisations can reduce transaction costs and improve bargaining power. Recent Indonesian coconut studies show that marketing arrangements, institutional coordination, and economic viability are central to supply-chain resilience in remote areas, whereas evidence from other coconut value chains highlights the trade-off between raw-product exports and local value addition. Transparent contracting, farmer aggregation, and competition among buyers are therefore necessary to ensure that productivity gains are transmitted to smallholders.

Seventh, Indonesia should establish provincial or inter-provincial coconut-processing clusters. The appropriate processing mix should reflect production density and market opportunity rather than political pressure for identical factories in every region. Some clusters may specialise in coconut water and young nuts; others in VCO and food ingredients; others in oil, oleochemicals, coir or activated carbon. Residues from one processor can become feedstock for another, allowing industrial ecology to increase whole-nut recovery.

Finally, programme governance requires independent evaluation. Government should publish annual cohort-level outcomes and explain differences between planted, surviving and productive hectares. Transparency would reduce the temptation to declare success when seedlings are distributed and would shift administrative incentives toward sustained productivity.

Implications for Global Coconut Trade

Near-Term Supply Elasticity, Price Formation, and Market Volatility

Successful Indonesian replanting would not translate immediately into a surge of exportable coconut supply. Because new palms require several years before commercial bearing and longer to reach mature productivity, the near-term world market will continue to depend mainly on the performance of existing palms, rehabilitation, weather outcomes and harvesting efficiency. Evidence from the Philippines shows that declining coconut production can constrain the ability of an established exporter to meet external demand, while price research in another major coconut economy documents substantial seasonality and volatility across coconut, copra and coconut-oil markets [69,75]. Indonesia's regeneration programme should therefore be understood as a medium- to long-term supply-stabilisation mechanism rather than as a source of immediate price relief.

This distinction has implications for price expectations. A relatively inelastic near-term supply base means that weather shocks, pest outbreaks, temporary processing disruptions and changes in inventories can generate disproportionate price responses, especially when several producing countries experience constraints at the same time. Diversifying farm output and downstream product portfolios can moderate exposure to any single price cycle, but it cannot eliminate the biological rigidity of the underlying crop. For global buyers, procurement strategies through the early 2030s should therefore place greater weight on supply reliability, contracting, inventory management and multi-origin sourcing rather than assume that announced replanting targets will quickly create abundant new supply.

Trade volumes are also shaped by demand-side and macroeconomic conditions rather than production alone. Empirical modelling of coconut exports from the Philippines finds that domestic production, destination-market income and population, exchange rates and lagged trade performance influence export outcomes [70]. The implication for Indonesia is that additional production will not automatically translate into proportional export growth unless destination demand, relative prices, exchange-rate conditions, quality specifications and logistics are simultaneously favourable. Replanting can expand future supply capacity, but trade performance will remain the product of both biological availability and market absorption.

Product Composition, Domestic Processing, and the Raw-Nut Diversion Effect

The trade effect of regeneration will depend as much on the composition of exports as on their physical volume. Existing competitiveness studies show that Indonesia has strong positions in coconut and coconut-oil trade, yet they also point to a persistent need to move from crude or primary forms toward higher-value processed products [65-68]. This distinction is economically important because the same quantity of harvested nuts can support very different export values depending on whether they leave the country as whole nuts, crude oil or copra, or are transformed into refined oils, food ingredients, beverages, fibre products, activated carbon and other differentiated outputs. Replanting policy should therefore be evaluated partly by how it changes Indonesia's future export basket, not simply by the tonnes of additional coconuts produced.

An expansion of raw-nut exports can nevertheless generate a genuine distributional trade-off. Evidence from Ghana shows that exporters offering higher prices for dehusked coconuts diverted a large share of farmers' output away from local virgin-coconut-oil processors, improving immediate farm sales opportunities while weakening raw-material availability for domestic value addition [63]. Indonesia could face a similar tension if stronger foreign demand for whole nuts raises farm-gate prices faster than domestic processors can improve recovery rates, product quality and purchasing terms. The appropriate response is not a blanket restriction on raw exports, but a competitive domestic processing environment in which processors can pay prices that reflect the additional value they create while farmers retain credible market choice.

This creates a sequencing requirement for industrial policy. Processing plants, quality laboratories, cold-chain facilities, aggregation centres and residue-valorisation businesses should be expanded before the largest replanting cohorts reach commercial bearing, so that new supply encounters multiple domestic buyers rather than a single outlet. Such preparation would reduce the risk that a successful biological regeneration programme merely increases exports of relatively low-value material. It would also allow Indonesia to use future production growth to deepen domestic processing without suppressing farm-gate incentives.

Competitive Positioning Across Coconut Product Segments

Global coconut competition is product-specific. Comparative-advantage analysis indicates that Indonesia competes strongly with other major exporters, including the Philippines, Thailand and other producing economies, but the intensity and direction of competition differ across coconut products [67]. The 2024 trade profile illustrates this segmentation: Indonesia reported the leading export value in the broad fresh/dried coconut category while the Philippines remained substantially larger in crude and non-crude coconut-oil exports [59-61]. Indonesia's position in fresh or dried coconuts therefore does not imply the same position in crude coconut oil, refined fractions, desiccated coconut, coconut water, coir or activated carbon. A national strategy that aggregates these products into a single idea of 'coconut competitiveness' risks concealing where Indonesia is gaining market share, where it is losing it and where processing investment could generate the largest incremental value.

Coconut oil also competes beyond the boundaries of the coconut sector. Indonesian demand analysis finds direct competition between Indonesian and Philippine crude coconut oil in major import markets, while more recent work shows that palm-kernel-oil prices can shift demand for Indonesian coconut oil because both oils serve overlapping lauric-oil markets [76]. This means that the commercial return to replanting is partly influenced by the relative prices and industrial availability of substitute oils, not solely by coconut fundamentals. Trade strategy should consequently monitor cross-commodity price relationships, oleochemical demand and substitution behaviour alongside conventional coconut production and export indicators.

The same product-specific logic should inform breeding and planting-material choices. Regions supplying premium drinking coconuts need traits related to water volume, taste, consistency and harvest timing, whereas oil-oriented clusters place greater value on kernel characteristics and extraction performance, and fibre-oriented systems may value husk properties. Linking replanting cohorts to expected product markets can therefore convert genetic and agronomic decisions into a source of trade differentiation. Without this linkage, Indonesia may expand biological output while producing a product mix that is poorly aligned with the fastest-growing or highest-value market segments.

Market Diversification, Destination Risk, and Trade Resilience

Successful regeneration also creates an opportunity to diversify destination markets. Export modelling demonstrates that coconut trade responds to economic conditions in importing countries and to exchange-rate movements, so dependence on a narrow set of destinations can transmit external shocks directly into producer and processor revenues [70]. This exposure is especially relevant for remote Indonesian production systems, where infrastructure, marketing arrangements, and stakeholder coordination already shape supply-chain resilience [14,15]. A diversified export portfolio can reduce this exposure by combining mature markets for oils and food ingredients with emerging demand for beverages, speciality foods, growing media, carbon products and biobased materials. Diversification should be understood in two dimensions at once: more product categories and a broader set of destination markets.

Product form affects logistical resilience as well. Fresh nuts and coconut water face different storage, handling and quality requirements from shelf-stable oil, desiccated coconut, activated carbon or fibre products, and these differences determine which destinations can be served economically. Processing technologies that improve extraction, preservation and stability therefore have trade consequences because they extend market reach and reduce losses between farm and final buyer [51]. For an archipelagic producer such as Indonesia, reducing domestic logistics costs and locating appropriate first-stage processing near production zones can be as important for competitiveness as lowering farm production costs.

A portfolio approach also improves resilience when individual product prices weaken. Price analysis of coconut, copra and coconut oil shows that volatility differs among products and that diversification can help manage exposure to unstable market conditions [75]. Whole-coconut valorisation therefore has a macro-trade function in addition to its circular-economy benefits: it creates several possible revenue channels from the same biological resource. The ability to redirect material toward alternative products gives producers and processors more options when relative prices change.

Traceability, Quality, and Sustainability as Trade Infrastructure

Future coconut trade will increasingly depend on information quality as well as physical quality. Large buyers in food, cosmetics and industrial markets increasingly require evidence about origin, production practices, product safety, consistency and, in some supply chains, environmental performance, while digital traceability is becoming more prominent in smallholder commodity chains [74]. Indonesia's replanting programme offers a rare opportunity to build these capabilities from the beginning because supported farms can be georeferenced and linked to planting material, farmer organisations, survival records and subsequent production. This would make traceability part of productive infrastructure rather than an expensive compliance layer added after market requirements become binding.

However, traceability can create exclusion if compliance costs are transferred to smallholders without corresponding benefits. Research on digital sustainability tracing shows that data collection can impose new burdens and that farmer-generated information may be unreliable where incentives, verification and governance are weak [74]. Indonesia should therefore treat digital records, quality assurance and sustainability verification as shared value-chain infrastructure supported by processors, cooperatives and public institutions. If designed well, these systems can reduce transaction costs and improve market access; if designed poorly, they can become another barrier separating small farmers from premium export channels.

Strategic Implications for Indonesia and Global Buyers

For global buyers, the central implication is that Indonesia's replanting programme changes expectations about the medium- and long-term supply curve rather than the immediate one. The timing and magnitude of any additional exportable surplus will depend on nursery expansion, planting rates, survival, yield development, rehabilitation of existing palms and the share of production absorbed by Indonesia's own processors. Announced hectares should therefore not be interpreted as equivalent to future tonnes. A more credible assessment of market impact requires cohort-level evidence on planted area, survival, bearing age, realised yields and processing utilisation.

For Indonesia, the appropriate trade objective is neither maximum raw-export volume nor downstream processing at any cost. A strategy that prioritises raw exports can weaken domestic processors and limit value capture, whereas an inflexible downstreaming policy can depress farm-gate competition if processors are inefficient or concentrated. The preferable model is a contestable multi-channel market in which farmers can sell to several types of buyers, processors compete through efficiency and product quality, and public policy invests in the shared infrastructure planting material, extension, logistics, standards, traceability and market intelligence that improves the performance of all channels.

The broader global-trade implication is therefore more nuanced than the claim that coconut supply is simply 'fixed' until 2033. Near-term supply from new trees is biologically constrained, making international markets sensitive to the productivity of existing palms and to shocks in major producing countries, but successful Indonesian regeneration can progressively relax that constraint in the 2030s. If regeneration is coupled with processing and market diversification, Indonesia can influence not only the quantity of coconut entering world markets but also the composition, reliability and value intensity of that trade. The strategic gain would be a more resilient global supply base and a stronger Indonesian position across multiple coconut value chains rather than a one-dimensional return to leadership measured only in tonnes.

Research Agenda

Several research gaps remain particularly important. The first concerns the true age and productivity distribution of Indonesian coconut plantations. National averages conceal substantial regional heterogeneity, and the most economically efficient replanting sequence cannot be determined without plot-level information.

The second concerns the comparative economics of replanting strategies. Indonesian research should quantify farmer cash flows under full replanting, staggered replanting, underplanting where agronomically appropriate, rehabilitation, and different intercropping systems. These studies should measure household consumption and risk, not only farm gross margins.

Third, research is needed to connect variety selection with downstream products. Breeding programmes conventionally prioritise agronomic yield and resistance; industrial users may value water volume, sugar profile, kernel composition, oil recovery, fibre quality or shell characteristics differently. Joint breeding-processing research could therefore create higher total value.

Fourth, coconut agroforestry needs more location-specific economic research. Evidence supports its potential contribution to food security and income, but relatively few studies provide long-horizon financial comparisons of specific coconut-intercrop combinations under Indonesian conditions [32,35].

Fifth, digital agriculture requires evaluation beyond technical accuracy. Deep-learning models can detect plant symptoms, and digital traceability can make supply chains more transparent, but adoption depends on farmer incentives, data governance, connectivity, and extension capability [74]. Technology should be evaluated by whether it reduces farmer risk or transaction costs, not simply by model accuracy.

Finally, the "value per nut" concept deserves formal measurement. Future studies could construct a Coconut Value Capture Index combining farm-gate value, processing recovery, by-product utilisation, employment and export value. Such an indicator would permit meaningful comparison between production regions and countries whose competitive strategies differ substantially.

Conclusion

Indonesia's proposed large-scale coconut replanting programme represents much more than an agricultural rehabilitation exercise. It is a decision about the biological foundation of a strategic rural industry for the next several decades. The frequently cited "33-year gap" is useful because it exposes the magnitude of the difference between reported current capacity and the capacity implied by the stated ambition. It should not, however, be interpreted as an inevitable timetable: seed gardens, nurseries, financing, and field capacity can be expanded through deliberate investment, even though coconut's biological maturation continues to impose a real lag on new-tree supply.

Successful regeneration therefore depends on solving several interconnected problems at the same time. Indonesia needs sufficient quantities of high-quality and genetically appropriate planting material, financially viable smallholder participation, household income protection during the immature period, climate-resilient agronomy, pest and disease surveillance, capable farmer organisations, reliable traceability, and downstream processors able to convert future production into diversified higher-value products. Failure in any major component can weaken the return on investments elsewhere, so implementation should be managed as an integrated system rather than as a seedling-distribution programme.

A national target expressed only as hectares replanted is consequently inadequate. The stronger objective is to establish productive, surviving, climate-resilient, farmer-profitable, and commercially integrated coconut landscapes. Monitoring should move from input indicators such as seedlings distributed and hectares planted toward outcome indicators that include survival, mature yield, farmer income, processing share, residue utilisation, and export value.

Policy should distinguish three complementary interventions: replant stands that are genuinely senile or structurally unproductive; rehabilitate existing palms where productivity can still be recovered; and intensify and diversify healthy plantations. This three-track strategy can reduce the depth of the supply trough while new plantation cohorts mature. It also allows nursery expansion, farmer finance, and downstream investment to be sequenced more realistically across regions with different age structures and market opportunities.

The proposition that the global coconut supply base is "fixed" through 2033 also requires qualification. A more defensible conclusion is that supply from new plantings is biologically lagged and that near-term global coconut supply is relatively inelastic rather than literally fixed. Existing-tree productivity, climatic outcomes, prices, processing efficiency, and production responses in other countries can still change during the period, so market and policy decisions should distinguish biological inertia from absolute supply rigidity.

Indonesia's competitive objective should consequently move beyond a contest over coconut tonnage. Its greater strategic opportunity is to combine scale with productivity, productivity with processing, processing with whole-nut utilisation, and value creation with stronger smallholder income. Water, kernel, oil, cake, husk, coir, cocopeat, shell, and carbon products should be treated as interconnected revenue opportunities within regional value systems rather than as unrelated industries.

If regeneration is implemented as a coordinated agricultural, industrial, and smallholder-development strategy, Indonesia does not need to choose between the "tonnage race" and the "extraction race." It can compete in both, provided biological renewal is matched by institutional and downstream capability. The ultimate measure of success will therefore not be whether 500,000 hectares are administratively recorded as replanted, but whether those hectares become the foundation of a higher-productivity, more resilient, more inclusive, and substantially more valuable Indonesian coconut economy.

References

1. Lin J (2020) Fiji's participation in the global coconut value chain Opportunities and challenges. Journal of Agribusiness in Developing and Emerging Economies 11: 345-365.
2. Ng YJ (2021) A comprehensive review on the techniques for

coconut oil extraction and its application. Bioprocess and Biosystems Engineering 44: 1807-1818.
3. Zainol FA, Arumugam N, Wan Daud WN, Mohd Suhaimi NA, Ishola BD, et al. (2023) Coconut value chain analysis: A systematic review. Agriculture 13: 1379.
4. Ajien A, Idris J, Md Sofwan N, Husen R, Seli H (2023) Coconut shell and husk biochar: A review of production and activation technology, economic, financial aspect and application. Waste Management & Research 41: 37-51.
5. Preethi P, Rahman S, Naganeeswaran S, Sabana AA, Gangaraj KP, et al. (2020) Development of EST-SSR markers for genetic diversity analysis in coconut (Cocos nucifera L.). Molecular Biology Reports 47: 9385-9397.
6. Yang Y, Bocs S, Fan H, Armero A, Baudouin L, et al. (2021) Coconut genome assembly enables evolutionary analysis of palms and highlights signaling pathways involved in salt tolerance. Communications Biology 4: 105.
7. Sudha R, Rajesh MK, Niral V, Samsudeen K, Shil S, et al. (2023) Analysis of genetic diversity and population structure in worldwide coconut germplasm (Cocos nucifera L.) using microsatellite markers. Scientia Horticulturae 309: 111681.
8. Yousefi K, Abdullah SNA, Md Hatta MA, Ling KL (2023) Genomics and transcriptomics reveal genetic contribution to population diversity and specific traits in coconut. Plants 12: 1913.
9. Alouw JC, Wulandari S (2020) Present status and outlook of coconut development in Indonesia. IOP Conference Series Earth and Environmental Science 418: 012035.
10. Kalaipandian S (2021) Cloning coconut via somatic embryogenesis: A review of the current status and future prospects. Plants 10: 2050.
11. Beveridge FC, Kalaipandian S, Yang C, Adkins SW (2022) Fruit biology of coconut Plants 11: 3293.
12. Arumugam T, Md Hatta MA (2022) Improving coconut using modern breeding technologies: Challenges and opportunities. Plants 11: 3414.
13. Rasihen Y, Adhi AK, Suprehatin (2021) Analisis keberlanjutan usahatani perkebunan kelapa rakyat Kabupaten Indragiri Hilir. Jurnal Agribisnis Indonesia 9: 177-187.
14. Nabillah R, Fawzi NI, Awuh HE, Rijanta, Qurani IZ, et al. (2025) Exploring the dynamics of supply chain sustainability and resilience in the coconut agriculture: The case of Indragiri Hilir in Indonesia. Environment, Development and Sustainability advance online publication.
15. Wahyudi A, Ardana IK, Aunillah A, Rianto B, Anggoro UK, et al. (2025) Building sustainable and resilient coconut supply chains in remote areas: A study from Riau Province Indonesia. Sustainable Futures 9: 100709.
16. Petri H, Hendrawan D, Bähr T, Musshoff O, Wollni M, et al. (2024) Replanting challenges among Indonesian oil palm smallholders: A narrative review. Environment, Development and Sustainability 26: 19351-19367.
17. Siregar AA, Halimatussadiah A, Moeis FR, Anky WAK, Nainggolan D (2024) The oil palm replanting imperative: Are smallholder farmers willing to participate? Forest Policy and Economics 169: 103362.
18. Hendrawan D, Musshoff O (2024) Smallholders preferred attributes in a subsidy program for replanting overaged oil palm plantations in Indonesia. Ecological Economics 224: 108278.
19. Jelsma I, Turinah, Gay F, Ollivier J, Rapidel B (2024) Collective action, replanting and resilience: Key lessons from 40 years of smallholder oil palm cultivation in the Ophir plantation, Indonesia. Agricultural Systems 213: 103801.
20. International Coconut Community (2025) Indonesia and India forge path to coconut innovation at ESTCropsCorner 17.
21. International Coconut Community (2025) ICC underlines urgent need for research and technology to save coconut industry.
22. Sabana AA, Rajesh MK, Antony G (2020) Dynamic changes in the expression pattern of miRNAs and associated target genes during coconut somatic embryogenesis. Planta 251: 79.
23. Zhang D, Li Z, Htwe YM, Shi P, et al. (2024) Insights into the developmental trajectories of zygotic embryo, embryogenic callus and somatic embryo in coconut by single-cell transcriptomic analysis. Industrial Crops and Products 212: 118338.
24. Wicaksono A, Raihandhany R, Teixeira da Silva JA (2021) Kopyor versus macapuno coconuts: Are these two edible mutants of Southeast Asia the same? Planta 254: 86.
25. Thuzar M, Sae-Lee Y, Saensuk C, Pitaloka MK (2023) Primary root excision induces ERF071, which mediates the development of lateral roots in Makapuno coconut (Cocos nucifera). Plants 12: 105.
26. Bandyopadhyay A, Ghosh DK, Biswas B, Parameswarappa MH, Timsina J (2020) Fertigation effects on nutrient use efficiency, energy productivity, and economics of coconut (Cocos nucifera L.) cultivation in the Eastern Indo-Gangetic Plains of South Asia. International Journal of Fruit Science 20: 1483-1494.
27. Shinde VV, Maheswarappa HP, Ghavale SL, Sumitha S, Wankhede SM, et al. (2020) Productivity and carbon sequestration potential of coconut-based cropping system as influenced by integrated nutrient management practices. Journal of Plantation Crops 48: 103-110.
28. Dissanayaka DMNS (2022) A sustainable way of increasing productivity of coconut cultivation using cover crops: A review. Circular Agricultural Systems 2: 7.
29. Siddappa R, Sumitha S, Maheswarappa HP, Basavaraju TB (2023) Evaluation of integrated nutrient management of coconut (Cocos nucifera) based cropping system in the central zone of Karnataka. The Indian Journal of Agricultural Sciences 93: 110-112.
30. Andoh-Mensah E, Anthonio CK, Sossah FL, Fianko DA, Yankey EN (2023) Integrated soil fertility management using cocoa bean shells improves soil chemical properties, coconut yield and mitigates environmental pollution. Journal of Cleaner Production 428: 139418.
31. Khopade R, Sawargaonkar G, Kale S (2025) Sustainable intensification in coconut for building system resilience and nutritional security of smallholders in Eastern India. npj Sustainable Agriculture 3: 42.
32. Duffy C, Toth GG, Hagan RPO, McKeown PC, Rahman SA, et al. (2021) Agroforestry contributions to smallholder farmer food security in Indonesia. Agroforestry Systems 95: 1109-1124.
33. Kumar BM, Kunhamu TK (2022) Nature-based solutions in agriculture: A review of the coconut (Cocos nucifera L.)-based farming systems in Kerala, "the Land of Coconut Trees". Nature-Based Solutions 2: 100012.
34. Dissanayaka DMNS, Dissanayake DKRP L, Udumann SS, Nuwarapaksha TD, Atapattu AJ (2023) Agroforestry—a key tool in the climate-smart agriculture context: A review on coconut cultivation in Sri Lanka. Frontiers in Agronomy 5: 1162750.
35. Sudomo A (2023) Can agroforestry contribute to food and livelihood security for Indonesia's smallholders in the climate change era? Agriculture 13: 1896.
36. Appelt JL, Saphangtong T, Malek Z, Verburg PH, van Vliet J (2023) Climate change impacts on tree crop suitability in

Southeast Asia. Regional Environmental Change 23: 117.
37. Muñoz-Pérez JM (2022) Genome-wide diversity analysis to infer population structure and linkage disequilibrium among Colombian coconut germplasm. Scientific Reports 12: 2958.
38. Paudel S (2022) Coconut rhinoceros beetle in Samoa Review of a century-old invasion and prospects for control in a changing future. Insects 13: 487.
39. Tzec-Simá M (2022) Potential of omics to control diseases and pests in the coconut tree. Agronomy 12: 3164.
40. Prastowo S, Soeharto, Addy HS (2022) Virulence of Metarhizium isolated from infected Oryctes rhinoceros larvae around coconut plantations in East Java, Indonesia. Egyptian Journal of Biological Pest Control 32: 146.
41. Yankey EN, Aidoo OF, Sossah FL (2024) A critical review of Cape Saint Paul Wilt Disease: A devastating phytoplasma-associated infection affecting coconut trees in Ghana. Crop Protection 184: 106830.
42. Papona AT, Tondok ET, Istiaji B (2023) Identification of pests and diseases on coconut (Cocos nucifera L.) in Sangihe Island Regency, North Sulawesi Province, Indonesia. Agriprima: Journal of Applied Agricultural Sciences 7.
43. Sujithra M (2022) Biocontrol potential of native entomopathogenic nematodes against coconut rhinoceros beetle. Egyptian Journal of Biological Pest Control 32: 88.
44. Singh P, Verma A, Alex JSR (2021) Disease and pest infection detection in coconut tree through deep learning techniques. Computers and Electronics in Agriculture 182: 105986.
45. Subbaian S, Balasubramanian A, Marimuthu M, Chandrasekaran S, Muthusaravanan G (2024) Detection of coconut leaf diseases using enhanced deep learning techniques. Journal of Intelligent & Fuzzy Systems 46.
46. Negi A, Nimbkar S, Thirukumaran R, Moses JA, Sinija VR (2024) Impact of thermal and nonthermal process intensification techniques on yield and quality of virgin coconut oil. Food Chemistry 434:137415.
47. Naik M, Sunil CK, Rawson A, Venkatachalapathy N (2022) Tender coconut water: A review on recent advances in processing and preservation. Food Reviews International 38: 1215–1236.
48. Rajashri K, Rastogi NK, Negi PS (2022) Non-thermal processing of tender coconut water—A review. Food Reviews International 38: 34-55.
49. Ong LK, Sutikno KH, Jodie KA, Riadi L (2023) Skim coconut milk processing by thermal- and ultrasonic-thermal pasteurization. Jurnal Rekayasa Proses 17.
50. Chen Y, Zhang Z, Chen Y, Li T, Zhang W (2024) The role of fat content in coconut milk: Stability and digestive properties. Food Chemistry 446: 138900.
51. Sahari Y, Anuar MS, Mohd Nor MZ, Abdul Ghani NH (2023) Characterization of single and hybrid mode drying of desiccated coconut. Journal of Food Engineering 357: 111628.
52. Saraiva A (2023) Coconut sugar: Chemical analysis and nutritional profile; health impacts; safety and quality control; food industry applications. International Journal of Environmental Research and Public Health 20: 3671.
53. Astuti MP, Jasemizad T, Padhye LP (2021) Surface modification of coconut shell activated carbon for efficient solid-phase extraction of N-nitrosodimethylamine from water. Journal of Separation Science 44: 618–627.
54. Both AK, Linderman JA, Madireddy G, Helle MA, Cheung CL (2022) Valorization of coco coir into biocomposite materials through water-based chemistry. Industrial Crops and Products 178: 114563.
55. Paul V, Rai N, Agarwal A, Gautam V, Tripathi AD (2023) Valorization of lignocellulosic waste (coconut coir) for bio-vanillin production. Industrial Crops and Products 205: 117502.
56. Saleem J (2024) High-performance activated carbon from coconut shells for dye removal: Study of isotherm and thermodynamics. RSC Advances 14: 33797–33808.
57. Kwon D, Kim Y, Choi D, Jung S, Tsang YF, et al. (2024) Enhanced thermochemical valorization of coconut husk through carbon dioxide integration: A sustainable approach to agricultural residue utilization. Applied Energy 369: 123576.
58. Yanti IF, Wibawa PJ, Mukimin A (2024) Fabrication of coconut shell-derived graphitic activated carbon for carbon-based electrode materials. Jurnal Kimia Sains dan Aplikasi 27: 456–463.
59. World Bank (2024) Coconuts, fresh or dried (HS 080110): exports by country.
60. World Bank (2024) Crude coconut (copra) oil and fractions (HS 151311): exports by country.
61. World Bank (2024) Coconut (copra) oil and fractions, other than crude (HS 151319): exports by country.
62. Narmadha N, Karunakaran KR (2022) A study on trade competitiveness of Indian coconut products. Indian Journal of Economics and Development 18: 868–875.
63. Honlah E, Segbefia AY, Forkuo D, Abass K (2024) The exports of dehusked coconuts from southwestern Ghana: Implications for coconut farmers' role in a rural virgin coconut oil value chain. Social Sciences & Humanities Open 9: 100851.
64. Gunawan I, Trihastuti D, Mulyana IJ, Limbara C (2022) Securing coconut availability in Indonesia. International Journal on Food System Dynamics 13: 294–307.
65. Aulia AN, Chasanah N, Prasetyo AS, Nalawati AN (2020) Competitiveness and export similarity of Indonesia's coconut oil. Jurnal Agribest 4: 123–132.
66. Dewanti RP, Harianto, Nurmalina R (2020) Analisis permintaan dan persaingan minyak kelapa (crude coconut oil) Indonesia di pasar internasional. Jurnal Agribisnis Indonesia 8: 69–82.
67. Suprehatin, Al Naufal H (2021) Daya saing produk kelapa Indonesia dan eksportir kelapa utama lainnya di pasar global. Jurnal Penelitian Pertanian Terapan 21:24–31.
68. Hestina J, Purba HJ, Yusuf ES, Dabukke FBM, Erwidodo, Azhari D, Darwis V (2022) Industri kelapa Indonesia: Kinerja dan perspektif pengembangan menuju peningkatan nilai tambah dan daya saing. Forum Penelitian Agro Ekonomi 40: 55–69.
69. Moreno ML, Kuwornu JKM, Szabo S (2020) Overview and constraints of the coconut supply chain in the Philippines. International Journal of Fruit Science 20: 524-541.
70. Kuwornu JKM, Moreno ML, Martey E (2020) Assessment of the factors influencing the export of coconut from the Philippines. International Journal of Value Chain Management 11: 366–388.
71. Ahmad SR, Shadbolt N, Reid J (2024) Collective action for rice smallholder's value chain: Insight from Yogyakarta, Indonesia. Journal of Co-operative Organization and Management 12: 100236.
72. Untari DW, Vellema S (2022) Are collective trading organisations necessarily inclusive of smallholder farmers? A comparative analysis of farmer-led auctions in the Javanese chilli market. Journal of Agricultural and Environmental Ethics 35: 19.
73. Zheng J, Yuan S, Wu W, Li W, Yu L, et al. (2023) Surveying coconut trees using high-resolution satellite imagery in remote atolls of the Pacific Ocean. Remote Sensing of Environment 287: 113485.
74. Steinke J, Ivanova Y, Jones SK, Minh TT (2024) Digital

sustainability tracing in smallholder context: Ex-ante insights from the Peruvian cocoa supply chain. World Development Sustainability 5: 100185.
75. George GP, Kuruvila A (2023) Price behaviour of coconut and coconut products in markets of Kerala: An economic analysis. Indian Journal of Economics and Development 19: 45-57.
76. Pratama BR, Tooy D, Kim J (2024) Price competition and shifting demand: The relation between palm and coconut oil exports. Sustainability 16: 101.