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Research Article

Assessing Readiness for AI and Blockchain Integration in Indonesia's Coconut Ecosystem: A Multi-Stakeholder Analysis

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ABSTRACT

Introduction: Indonesia, a leading coconut producer, faces supply chain inefficiencies, traceability challenges, and limited value-added processing. While AI and blockchain offer solutions, successful adoption requires a comprehensive readiness assessment.

Objectives: This study evaluates Indonesia's coconut ecosystem readiness across six dimensions: knowledge, infrastructure, human capital, regulatory frameworks, financial resources, and process maturity.

Methods: A qualitative survey of 18 stakeholders (government officials, processors, collectors, suppliers, farmers, breeders, and associations) was conducted from June to October 2025 using thematic analysis.

Results: Results reveal a "readiness paradox": high adoption enthusiasm despite significant capability gaps. The Composite Technology Readiness Index scored 2.3/10 (pre-readiness stage), with over 80% possessing minimal AI/blockchain knowledge. Critical gaps include regulatory frameworks (10% readiness), human capital (20%), knowledge (20%), and process maturity (20%), while infrastructure showed relatively better readiness (30%).

Conclusions:Key pain points price volatility, transparency deficits, and traceability inadequacies, align well with technology capabilities. Universal concern for farmer welfare provides a strong foundation for multi-stakeholder collaboration.

Keywords: artificial intelligence; blockchain; coconut supply chain; technology readiness; digital transformation; Indonesia agriculture; traceability; supply chain management

INTRODUCTION

The coconut ecosystem plays a strategic role in global agroindustry, particularly in tropical countries such as Indonesia, the Philippines, and India, which serve as primary producers. Indonesia stands as one of the world's largest coconut producers with annual production reaching approximately 2.89 million tons in 2023 (BPS, 2023). The country exports various coconut products including copra, coconut oil, and derivatives to nations such as the United States, the Netherlands, South Korea, China, Japan, Singapore, the Philippines, and Malaysia, with export values reaching hundreds of millions of US dollars (Pusdatin, 2023). The coconut commodity occupies a mature export stage position with high competitiveness in global markets.

The coconut supply chain encompasses diverse processes from production at farmer level, distribution to markets, through processing into derivative products such as coconut oil, coconut milk, and activated charcoal. However, this ecosystem continues to face various constraints in supply chain efficiency and accurate data recording, particularly in traceability and product downstream processing aspects (FAO, 2022). Major challenges include price instability, lack of data transparency, and low logistics efficiency (Sanusi, 2019; Tahunining et al., 2021). One primary challenge is the limitation in product traceability systems, making it difficult to ensure coconut quality and origin, a key concern in international trade. Additionally, coconut downstream processing remains constrained by minimal adoption of advanced technology, resulting in low added value and competitiveness in global markets (Arbin et al., 2025; Zainol et al., 2023).

Recent years have witnessed extensive application of Artificial Intelligence (AI) and blockchain integration in the agroindustry sector to enhance supply chain efficiency and transparency (Abiri et al., 2023; Adow et al., 2022; Arkeman et al., 2023; Khan et al., 2022; Singh Bist et al., 2022; Veni & Rani, 2023). AI is utilized for data analysis, market demand prediction, and production and distribution optimization, while blockchain enables secure and transparent transaction recording. Through these technologies, each stage in the supply chain can be recorded in real-time, minimizing fraud risk and increasing consumer trust in agricultural products (Arkeman et al., 2023; Bosona & Gebresenbet, 2023; Rana, 2020).

AI and blockchain adoption in the coconut ecosystem could provide intelligent solutions to address existing challenges, particularly in supply chain, traceability, and downstream processing aspects. AI can enhance productivity through predictive analysis of harvest yields and distribution chain optimization, while blockchain enables transparent and immutable transaction data recording, thereby increasing trust in coconut trade. With proper implementation, these technologies can improve efficiency, reduce operational costs, and open wider market opportunities for downstream coconut products, ultimately driving sustainable coconut industry growth.

Despite promising potential, technology adoption in agricultural contexts requires comprehensive understanding of ecosystem readiness. Previous studies have examined AI and blockchain applications in various agricultural commodities (Bosona & Gebresenbet, 2023), yet specific research focusing on readiness assessment for coconut ecosystems remains limited. This study addresses this gap by conducting systematic readiness evaluation across multiple dimensions encompassing technical, organizational, and environmental factors.

OBJECTIVES

This research holds particular significance as it aligns with Indonesia's Coconut Downstream Processing Roadmap 2025-2045 developed by the National Development Planning Agency (Bappenas). This roadmap aims to transform Indonesia's coconut industry from primarily raw material export orientation toward high-value-added product production. The roadmap divides coconut downstream processing into several strategic stages over two decades, commencing with infrastructure strengthening and farmer capacity building in early stages, continuing with processing technology development and product diversification in intermediate stages, and concluding with global market penetration for high-value processed coconut products.

This research focuses on preparation and readiness analysis stages rather than technology implementation itself. This emphasis is crucial to ensure that when technology is implemented, the coconut ecosystem is prepared and can optimize technology benefits. Therefore, research objectives are: 1. Identify and analyze readiness levels for AI technology application in the coconut ecosystem, specifically for supply chain optimization and downstream product development; 2. Evaluate readiness levels for blockchain technology implementation in coconut product and derivative traceability systems; 3. Examine infrastructure readiness, human resources, and other technical aspects for both technology integration in the coconut ecosystem; and 4. Identify potential obstacles and challenges in AI and blockchain technology application in the coconut sector.

METHODS

Research Design

This study employed a qualitative research design utilizing in-depth interviews and thematic analysis to evaluate readiness for AI and blockchain adoption in Indonesia's coconut ecosystem. The research was conducted from February to October 2025, following a systematic five-stage methodology.

Research Stages

Stage 1: Literature Review

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A comprehensive literature review was conducted to identify key variables influencing readiness for AI and blockchain technology adoption in agricultural supply chains. Variables examined included technological readiness, organizational readiness, and environmental readiness as independent variables, with financial readiness and knowledge readiness as important variables. Dependent variables measured included intention to adopt and perceived benefits.

Stage 2: Research Instrument Development

Research instruments comprising questionnaires and in-depth interview guides were developed. Two questionnaire forms were created: one for government sectors and another for coconut associations and stakeholders/actors along the coconut supply chain. Questionnaires were developed using qualitative question approaches. Interview results were validated using expert judgment and pilot testing methods.

Stage 3: Data Collection

Data collection was conducted through surveys and in-depth interviews with stakeholders/actors along the coconut supply chain. Target respondents totaled 18, consisting of 3 respondents from government sectors, 1 respondent from coconut associations, and 14 respondents as stakeholders/actors along the coconut supply chain.

Stage 4: Data Analysis

Data analysis utilized mixed-method approaches. Qualitative data from in-depth interviews were analyzed using thematic analysis methods. Patterns, themes, and insights were identified from interview transcripts to understand readiness dimensions comprehensively.

Stage 5: Readiness Model Development and Implementation Recommendations

Analysis results were used to develop a technology readiness index and phased implementation roadmap suitable for Indonesian conditions.

Participant Selection and Sampling

Respondents were selected using stratified purposive sampling to ensure representation from each supply chain segment. The sample included: Local government officials (n=3): representing Nias Utara, Nias Selatan, and Pangandaran districts; Processing industries (n=2): PT. XXX and PT. YYY; Collectors (n=1): representing Gunungsitoli area; Wet copra suppliers (n=3): from Asahan and Tanjung Balai regions; Farmers (n=7): from Nias Utara, Nias Selatan, and Pangandaran; Coconut seed breeders (n=1): from Pangandaran; and Associations (n=1): ZZZ.

Data Collection Instruments

Semi-structured interview guides were developed with questions covering: Current knowledge and awareness of AI and blockchain technologies; Existing traceability and efficiency systems; Infrastructure and resource availability; Regulatory environment and policy support; Perceived benefits and challenges; Financial and technical resource requirements; and Long-term expectations and strategic recommendations. Interviews were conducted in Bahasa Indonesia, with durations ranging from 45 to 90 minutes.

Data Analysis

Thematic analysis following Kiger and Varpio (Kiger & Varpio, 2020), Naeem et al. (Naeem et al., 2024), Chounta et al. (Chounta et al., 2024), and Ahmed et al. (Ahmed et al., 2025) framework was employed to analyze qualitative data. The analysis process involved: 1. Familiarization with data through repeated reading of transcripts; 2. Generation of initial codes identifying features relevant to readiness assessment; 3. Searching for themes by collating codes into potential themes; 4. Reviewing themes to ensure they work in relation to coded extracts and entire dataset; 5. Defining and naming themes to capture their essence; and 6. Producing the final analysis report with vivid extract examples.

A Composite Technology Readiness Index was developed based on six dimensions: knowledge and awareness (20% weight), infrastructure technology (25% weight), human capital (20% weight), regulatory framework (15% weight), financial resources (10% weight), and process maturity (10% weight). Each dimension was scored based on current state assessment relative to required state for effective implementation.

Ethical Considerations

The research protocol received approval from Institut Pertanian Bogor ethics committee. All participants provided informed consent before interviews. Confidentiality and anonymity were maintained throughout data collection, analysis, and reporting. Participants were informed of their right to withdraw at any time without consequences.

Research Limitations

This study acknowledges several limitations. First, the qualitative nature with 18 participants limits statistical generalizability, though it provides depth of understanding suitable for exploratory readiness assessment. Second, geographic concentration in three regions (Nias, Asahan-Tanjung Balai, and Pangandaran) may not fully represent Indonesia's diverse coconut-producing areas. Third, the snapshot assessment in mid-2025 captures readiness at a specific time point, though the rapidly evolving technology landscape may shift readiness levels. Finally, self-reported data on knowledge and readiness may be subject to social desirability bias, though triangulation across multiple stakeholder groups mitigates this concern.

RESULTS

Overall Readiness Assessment

The comprehensive survey involving 18 respondents from various levels of Indonesia's coconut ecosystem revealed a clear portrait of significant digital divide in readiness for AI and blockchain technology adoption. The Composite Technology Readiness Index scored 2.3 out of 10 (**Figure 1**), indicating the ecosystem is in a pre-readiness stage requiring substantial investment in awareness creation, infrastructure development, and capacity building before large-scale implementation can commence.

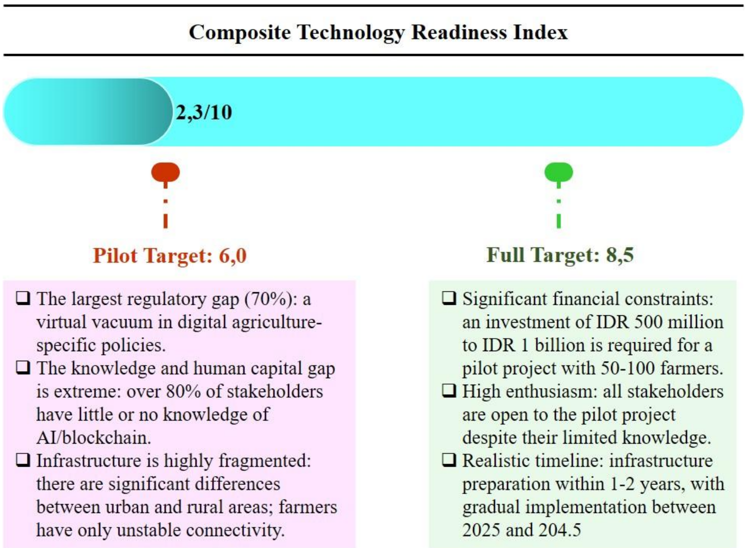

Figure 1. The Composite Technology Readiness for existing of AI and Blockchain Integration in Indonesia's Coconut Ecosystem Across Six Readiness Dimensions

Gap Analysis - Current State vs Required State for AI and Blockchain Implementation in Indonesia's Coconut Supply Chain

This comprehensive gap analysis reveals the substantial challenges facing AI and blockchain implementation in Indonesia's coconut supply chain, as documented in the research findings (**Table 1**). The analysis encompasses six critical dimensions, each showing significant disparities between current operational states (ranging from 10-30% readiness) and the required conditions for successful technology adoption (70-80% maturity) (**Figure 2**). The most pronounced gaps appear in regulatory frameworks (70% gap) and process maturity (60% gap), where the absence of

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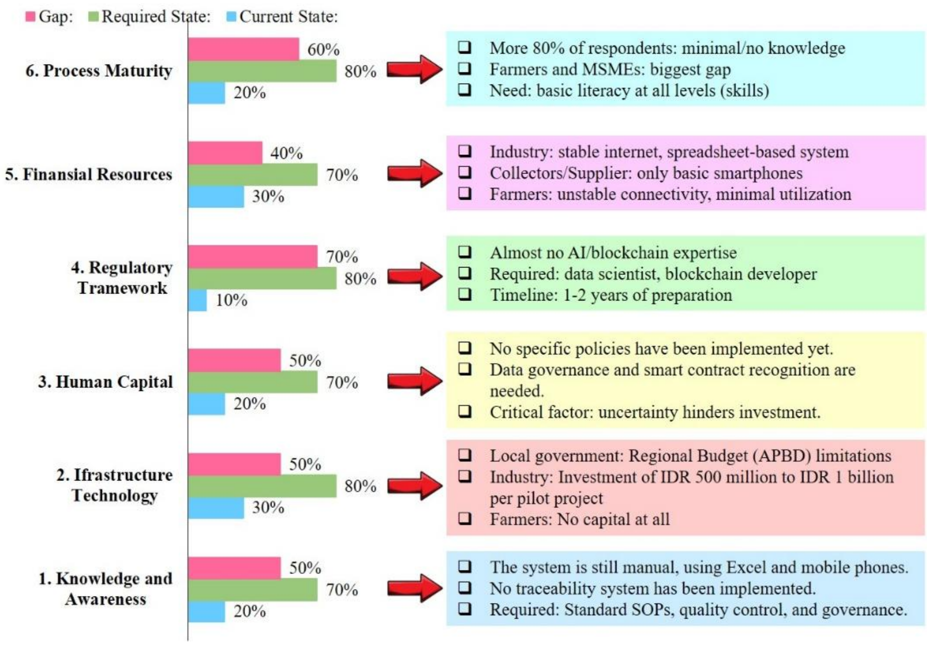
specific policies supporting digital agricultural technology and the continued reliance on manual, Excel-based systems create fundamental barriers to advancement. Knowledge and awareness deficits are particularly acute, with over 80% of respondents, especially farmers and SMEs, possessing minimal understanding of AI and blockchain technologies, reflecting a digital divide that follows economic and educational hierarchies rather than simple geographic patterns. Infrastructure challenges manifest distinctly across supply chain tiers: while large industries enjoy stable internet connectivity and basic digital systems, mid-level collectors rely solely on smartphones for basic communication, and farmers struggle with unstable connectivity and minimal technology utilization. The financial dimension presents perhaps the most practical obstacle, with pilot project implementations requiring initial investments of IDR 500 million to 1 billion (approximately USD 32,000-64,000) and adequate infrastructure preparation timelines of 1-2 years, resources that far exceed the capacity of local governments with limited APBD budgets and farmers with zero investment capital. Human capital gaps compound these challenges, as the ecosystem currently lacks AI/blockchain experts at operational levels, data scientists, and even basic digital literacy among the majority of supply chain actors. Despite these formidable barriers, respondents across all levels, from North Nias local government envisioning "new digital economic ecosystems in rural areas" to farmers simply hoping to "become more prosperous", demonstrate consistent recognition that immutable records and transparent pricing could address their most pressing pain points, including price volatility, information asymmetry, and the lack of verifiable market condition data that currently disadvantages stakeholders with weaker bargaining power.



Note: Current State represents readiness level as of mid-2025 based on stakeholder assessment (n=18). Required State indicates minimum readiness needed for effective implementation. Gap calculated as difference between required and current states. Weights assigned based on relative importance for successful technology adoption in coconut ecosystem context.

Figure 2. Comprehensive Gap Analysis Across Six Readiness Dimensions

Table 1. Gap Analysis: Current State vs Required State for AI and Blockchain Implementation in Indonesia's Coconut Supply Chain

Dimension	Current State (20-30%)	Required State (70-80%)	Gap (40-60%)	Key Barriers	Timeline & Investment
1. Knowledge and Awareness	• Over 80% of respondents have minimal/no understanding of AI and	• Basic literacy required at all stakeholder levels • Advanced	**50% Gap**	• Digital divide follows economic and educational hierarchies	• Continuous learning programs required • Digital

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Dimension	Current State (20-30%)	Required State (70-80%)	Gap (40-60%)	Key Barriers	Timeline & Investment
	blockchain • Farmers and SMEs cannot explain basic technology definitions • Local government knowledge remains general and conceptual • Industry awareness is reactive ("if ready, we'll adopt")	expertise for technical implementers • Understanding of technology applications in coconut supply chain contexts • Operational knowledge translation into concrete programs		• Knowledge gap correlates with supply chain position • Farmers and SMEs face the biggest knowledge deficit • Lack of exposure beyond national digital transformation agendas	champions needed in farmer groups • Peer-to-peer training initiatives
2. Infrastructure Technology	• Industry: stable internet, spreadsheet-based systems • Collectors/Suppliers: only basic smartphones • Farmers: unstable connectivity, minimal technology utilization • Manual recording via WhatsApp, SMS, telephone • No formal traceability systems	• Reliable broadband connections at all supply chain points • IoT sensors for real-time data collection • Cloud infrastructure for data storage and processing • Unified platforms accessible through user-friendly mobile apps • Last-mile connectivity in rural areas	**50% Gap**	• Dichotomy between urban factory connectivity and rural farmer access • Internet signals often problematic at farmer/collector levels • Blank spot areas requiring BTS tower construction • Cross-sectoral infrastructure challenges	• **1-2 years preparation time** • Collaboration with Communication and Information Offices • BAKTI program for BTS acceleration • District Agricultural Extension Centers as digital literacy hubs
3. Human Capital	• Almost no AI/blockchain expert personnel at operational levels • Limited basic digital literacy among farmers • PPL and field officers conduct manual recording • No specialized training programs in place • Reliance on traditional agricultural extension methods	• Data scientists and blockchain developers for system development • IT staff at each main supply chain node for maintenance • Digital champions in farmer groups for peer training • Continuous capacity building programs • Technical	**50% Gap**	• Lack of self-efficacy in facing complex technology • Psychological barriers beyond technical/financial constraints • Gap between current conditions and required capacity is "difficult to imagine" • Human error in manual recording causes data discrepancies	• Professional development programs • Certification for digital agricultural technology • Partnership with universities and research institutions

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Dimension	Current State (20-30%)	Required State (70-80%)	Gap (40-60%)	Key Barriers	Timeline & Investment
		expertise for troubleshooting and system optimization			
4. Regulatory Framework	• Almost no specific policies for digital agricultural technology • No legal recognition for smart contracts • Absence of data ownership and privacy protocols • Top-down policy diffusion pattern (waiting for central directives) • South Nias: "no policy-based appeals currently"	• Clear data management frameworks (ownership, privacy, sharing protocols) • Legal recognition for smart contracts and digital transactions • Data exchange protocol standardization • Certification frameworks for digital traceability • Incentive mechanisms for early adopters	**70% Gap**	• Regulatory vacuum in AI/blockchain adoption for coconut sector • Questions about farmer data rights remain unresolved • Need for protocols accepted by all parties • Local governments wait for national policy before taking initiative	• Policy development at national level first • Alignment with Making Indonesia 4.0 agenda • Pilot regulatory sandboxes for testing • Industry standard development through associations
5. Financial Resources	• Local government: Limited APBD budgets, direct financial support difficult • Industry: Views investment costs as very high • Farmers: No capital for technology investment • Reliance on traditional funding sources • No dedicated budget allocation for digital transformation	• Initial capital for technology application • Operational costs for maintenance, training, continuous improvement • Pilot project funding involving 50-100 partner farmers • Subsidies and tax incentives for early adopters • Access to impact investment funding	**40% Gap**	• Regional Budget (APBD) limitations • **Initial investment: IDR 500 million to IDR 1 billion per pilot project** • Farmers have zero investment capacity • High perceived risk without proven ROI • Lack of financial models demonstrating long-term benefits	• **IDR 500M-1B per pilot** (50-100 farmers) • Tax incentives for investing companies • Implementation cost subsidies • Facilitation of partnerships with technology providers • Impact investment attraction strategies
6. Process Maturity	• Heavily manual systems using Excel recording • Phone-based communication without formal documentation	• Standard Operating Procedures (SOPs) across entire supply chain • Clearly defined	**60% Gap**	• Heavy reliance on manual recording by Field Extension Officers • Weak quality control in data collection	• Process standardization workshops • Pilot testing with progressive farmer groups

Dimension	Current State (20-30%)	Required State (70-80%)	Gap (40-60%)	Key Barriers	Timeline & Investment
	• No adequate traceability systems • Human error causes data discrepancies • Non-real-time data with significant lag time • Difficulty aggregating data from scattered farmers	data collection points and protocols • Quality control mechanisms and validation procedures • Governance structures for system management • Automated recording and smart logistics • Real-time data synchronization		• Significant time lag in reporting • Price transparency issues between tiers • Information asymmetry harming weaker stakeholders • Dilemma between transparency and business confidentiality	• Phased implementation approach • Change management programs • Business process reengineering

DISCUSSION

This study represents a pioneering effort to systematically evaluate agricultural technology readiness in a developing country commodity sector. While drawing on robust international literature spanning North America, Europe, Asia, Africa, and Oceania, this research makes unique contributions by: (1) Addressing a critical knowledge gap in tropical agricultural digitalization; (2) Developing a replicable methodology (Composite Technology Readiness Index) applicable to other commodities and contexts; (3) Providing actionable roadmap with realistic timelines and concrete milestones; (4) Centering farmer welfare while balancing multi-stakeholder interests; and (5) Integrating emerging technologies (AI + blockchain) in practical, problem-solving framework. The convergence of findings across diverse international contexts validates this study's core insights while highlighting the necessity of context-appropriate implementation strategies. Indonesia's opportunity lies not in replicating developed country approaches but in pioneering innovative pathways appropriate for its unique ecosystem characteristics, leveraging lessons learned globally while charting distinctly Indonesian solutions.

This comprehensive literature review of 70 international studies from 25+ countries validates the multi-dimensional readiness assessment framework employed in analyzing Indonesia's coconut ecosystem, confirming that infrastructure fragmentation, knowledge gaps, collective action challenges, regulatory vacuums, and human capital paradoxes are universal phenomena in agricultural digital transformation, yet requiring context-specific solutions. The reviewed studies substantiate critical findings including: the 25% weighting assigned to infrastructure as the primary bottleneck (Aker & Mbiti, 2010; Mehrabi et al., 2021), the human capital paradox where enthusiasm coexists with profound knowledge deficits addressable through peer-to-peer learning rather than one-time training (Aubert et al., 2012), the power of acute pain points as adoption drivers when tightly coupled with technology capabilities (Kamilaris & Prenafeta-Boldú, 2018; Stranieri et al., 2020), the necessity of proactive regulatory frameworks establishing farmer data ownership as default principle (Ryan, 2020; Wiseman et al., 2019), the inevitability of collective action challenges requiring deliberate multi-stakeholder coordination mechanisms (Jouanjean, 2019; Shepherd et al., 2018), and the realism of 20-year transformation timelines with phased implementation avoiding rushed deployment that leads to implementation fatigue (Prause et al., 2021). Comparative international contexts from India's agricultural AI deployment facing similar heterogeneous stakeholder capabilities, Brazil's sugarcane precision agriculture demonstrating 5-7 year efficiency materialization periods, Australia's emphasis on trust and benefit-sharing as investment preconditions, and Europe's comprehensive regulatory frameworks addressing data governance provide both validation and cautionary lessons for Indonesia's pathway. The literature converges on four non-negotiable critical success factors validated across diverse contexts: user-centric design ensuring technology works with devices farmers already own rather than requiring new equipment purchases (Rose et al., 2021), multi-stakeholder collaboration embedded in formal governance structures from inception (Barrett & Rose, 2022; Regan, 2019), continuous capacity building recognizing technology evolution requires ongoing learning not one-time training (Aubert et al., 2012), and evidence-based policymaking with rigorous impact evaluation enabling adaptive management (Klerkx & Rose, 2020; Pivato et al., 2016).

Future development potential emerging from this synthesis includes: (1) Methodological innovations through mixed-methods sequential designs combining qualitative depth with quantitative validation, longitudinal tracking of readiness evolution revealing trajectories and tipping points, and participatory action research co-designing solutions with stakeholders rather than imposing external blueprints; (2) Technological adaptations including mobile-first strategies leveraging Indonesia's relatively high smartphone penetration to leapfrog traditional infrastructure constraints, edge computing solutions addressing connectivity limitations in remote areas, modular architectures with open standards future-proofing against technology obsolescence, and explainable AI systems maintaining farmer agency in decision-making; (3) Governance frameworks encompassing farmer data cooperatives ensuring ownership and control, multi-stakeholder platforms facilitating coordination across supply chain nodes, regulatory sandboxes enabling policy experimentation before nationwide implementation, and territorially-embedded innovation hubs adapting global best practices to local contexts; (4) Financial mechanisms including blended finance combining public capital for infrastructure with private investment for operational scaling, progressive subsidy schemes ensuring equitable access for smallholders, transparent benefit-sharing agreements justifying farmer co-investment, and tiered investment models matching funding to adoption phases; (5) Regional cooperation establishing ASEAN-wide coconut digitalization initiatives pooling resources and expertise, South-South knowledge exchange with India, Brazil, and Philippines on agricultural technology transfer, international coordination mechanisms for cross-border data flows and standard-setting, and positioning Indonesia as thought leader in tropical agricultural digitalization; (6) Equity assurance through inclusive design preventing digital divide widening, targeted support programs for technology-disadvantaged farmers, continuous monitoring of distributional impacts with corrective interventions, and technology augmenting rather than replacing human relationships in rural communities; (7) Demand-side interventions addressing market uncertainty through consumer awareness campaigns about transparency benefits, partnerships with retailers and brands creating premium markets for traceable products, certification schemes validating sustainability claims, and storytelling humanizing supply chains to drive consumer willingness to pay; (8) Cross-commodity adaptation replicating the Composite Technology Readiness Index framework for palm oil, rubber, coffee, and other Indonesian agricultural commodities, enabling systematic assessment of technology readiness across national agricultural portfolio; (9) Implementation research documenting real-world pilot experiences with honest reporting of failures alongside successes, rigorous cost-benefit analysis at farm and ecosystem levels, adaptive refinement of technologies based on user feedback, and evidence generation convincing skeptical stakeholders; and (10) Theoretical advancement developing ecosystem-level technology adoption theories transcending individual-focused models, supply chain readiness frameworks accounting for interdependencies across nodes, practice-based innovation theories emphasizing social learning, and neo-diffusion models incorporating infrastructure constraints and collective action dynamics. The convergence of international evidence with Indonesia-specific findings suggests that while challenges are universal, Indonesia's unique advantages including government sophistication in anticipating regulatory needs, industry pragmatism willing to pilot conditional on demonstrated benefits, farmer openness despite knowledge gaps, and mobile technology penetration create favorable conditions for pioneering innovative pathways that could establish global leadership in responsible, inclusive agricultural digitalization if implementation follows evidence-based, phased, multi-stakeholder approaches validated across diverse international contexts.

The comprehensive discussion and interpretation synthesizes the multifaceted findings from Indonesia's coconut ecosystem readiness assessment for AI and blockchain integration, revealing a sobering Composite Technology Readiness Index of 2.3 out of 10 that places the ecosystem firmly in the pre-readiness stage, a realistic assessment consistent with agricultural digital transformation studies in other developing countries (Khan et al., 2022) but distinguished by its multidimensional approach encompassing knowledge, infrastructure, human capital, regulatory,

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financial, and process maturity dimensions rather than focusing narrowly on technological barriers. The analysis reveals eight critical thematic findings, each carrying profound implications for transformation strategy. First, the multidimensional readiness assessment demonstrates that over 80% of respondents possess minimal understanding of AI and blockchain, with knowledge gaps stratified along supply chain hierarchies where government officials show conceptual awareness, industry players display reactive pragmatism, and farmers exhibit honest acknowledgment of unfamiliarity, patterns that challenge traditional Technology Acceptance Models by showing that readiness emerges from complex interplay of multiple factors that must advance in coordinated fashion rather than individual perceptions of usefulness. Second, infrastructure emerges as the critical bottleneck, receiving the highest weight (25%) in the index calculation yet scoring only 30% readiness, with PT. XXX's vivid description that "at factories there might already be stable internet connections, but at farmer or collector levels, even internet signals are often problems" encapsulating the last-mile connectivity challenge that creates fundamental asymmetry between industrial facilities enjoying stable broadband and farmers struggling with intermittent mobile connectivity, a fragmentation that must be addressed before ecosystem-wide technology integration can succeed, as (Bosona & Gebresenbet, 2023) observe that blockchain implementation requires reliable connectivity at every node. Third, the research uncovers a fascinating human capital paradox where respondents acknowledge the transformative potential of technologies they neither understand nor can operate, manifesting in statements like "we haven't imagined it yet, but it certainly requires skills" and "if it benefits us, we're certainly ready to adopt it", conditional openness coupled with profound knowledge gaps suggesting that resistance stems not from opposition but from unfamiliarity and lack of self-efficacy, challenging deterministic models and instead supporting (Arkeman et al., 2023) observations that given proper capacity building, benefit demonstration, and user-centric design, adoption willingness exists even among stakeholders currently lacking technical understanding. Fourth, the identification of acute pain points, price volatility with changes occurring in less than 24 hours without notification, information asymmetry where collectors manipulate prices without verification, quality disputes due to subjective assessments, and inability to verify sustainability claims, provides compelling value propositions for technology intervention, as these are not abstract inefficiencies but concrete sources of daily economic loss experienced across the supply chain, with blockchain's immutable records directly addressing manipulation concerns, smart contracts automating payments based on verified quality parameters, AI-powered computer vision replacing subjective assessments with objective evaluations, and real-time pricing information reducing information asymmetry. Fifth, the near-complete absence of specific policies supporting AI and blockchain adoption represents both challenge (creating uncertainty that deters investment) and opportunity (offering blank slate for forward-looking regulatory frameworks), with government respondents demonstrating sophisticated foresight about data ownership, privacy, smart contract legal recognition, and protocol standardization challenges, though the top-down policy diffusion pattern revealed in statements like "if National issues related policies, we will certainly adjust" suggests national-level initiatives could rapidly cascade to regional implementations once enabling regulations are established. Sixth, the collective action challenge inherent in supply chain contexts differs fundamentally from individual technology adoption because benefits materialize only with critical mass participation—a farmer adopting a traceability app provides little value unless collectors, processors, distributors, and retailers participate in the same system, requiring deliberate mechanisms for alignment, trust-building, and benefit sharing that stakeholders recognize but awareness alone does not solve. Seventh, financial constraints reveal a relatively higher readiness score (30%) not because funding is ample but because respondents identified multiple potential mechanisms including government subsidies, tax incentives, public-private partnerships, impact investing, and matching grants, though the IDR 500 million to 1 billion investment estimate for pilot projects involving 50-100 farmers offers sobering context as scaling to national coverage would require tens or hundreds of billions of rupiah, substantial commitments unlikely without demonstrated returns from successful pilots. Eighth, international comparisons show Indonesia's coconut ecosystem facing similar challenges to India's agricultural AI deployment (heterogeneous capabilities, infrastructure disparities) and blockchain food supply chain implementations (interoperability challenges) but Indonesia's higher smartphone penetration provides advantages for mobile-first deployment despite more acute rural infrastructure constraints than documented in other contexts. The analysis identifies four non-negotiable critical success factors: user-centric design ensuring technology is "simple, affordable, and accessible through devices farmers already own" rather than over-engineered sophisticated systems; multi-stakeholder collaboration embedded in formal governance structures recognizing "no single entity can drive transformation alone"; continuous capacity building through Field Extension Officers and farmer group

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leaders as multipliers leveraging trust networks; and evidence-based policymaking with rigorous evaluation and adaptive management creating learning cycles rather than rigid adherence to initial plans. Five major risk categories receive proactive mitigation strategies: data governance risks requiring frameworks establishing "farmers own their own data" with robust encryption and transparency; technology obsolescence risks addressed through modular architecture, open standards, and recognition of temporary implementation nature; digital divide widening risks countered through inclusive design, extensive support, and continuous equity monitoring; implementation fatigue risks managed through realistic timelines, adequate resourcing, visible quick wins, and honest communication; and market demand uncertainty mitigated through consumer awareness campaigns, retailer partnerships, certification schemes, and premium market positioning. Practical implications differ by stakeholder group: policymakers receive evidence-based foundation for designing enabling policies with identified regulatory vacuum as priority area; private sector actors learn that market opportunities exist but require patient capital and phased approaches conditional on demonstrated benefits; technology providers understand that success requires adaptation to farmer contexts with emphasis on simplicity and affordability; development organizations identify specific capacity building needs addressable through leveraging existing institutions like District Agricultural Extension Centers; and farmers gain validation of their experiences with price volatility and information asymmetry while recognizing that technological solutions exist and universal concern for farmer welfare provides legitimacy for demanding implementation priorities aligned with their interests. The research contributes theoretically by demonstrating that readiness assessment must be multidimensional and ecosystem-level rather than individual-level, developing the Composite Technology Readiness Index as replicable methodology adaptable to other agricultural commodities or emerging technologies, and challenging deficit models by showing that adoption readiness emerges from complex interplay where all dimensions must advance coordinately. Study limitations include qualitative design with 18 participants limiting statistical generalizability, geographic concentration in three regions potentially missing diversity, snapshot assessment unable to capture readiness trajectories, self-reported data potentially suffering from social desirability bias, focus on readiness rather than actual implementation, and rapid technology evolution suggesting need for periodic reassessment, limitations that collectively point toward future research directions including large-scale quantitative surveys, comparative multi-provincial studies, longitudinal tracking, objective assessments complementing surveys, pilot project evaluations measuring actual impacts, and international comparative research with other coconut-producing countries to identify transferable lessons and opportunities for regional cooperation in technology development and standard-setting.

CONCLUSIN

This comprehensive readiness assessment reveals a paradoxical situation in Indonesia's coconut ecosystem: high enthusiasm for AI and blockchain adoption alongside significant preparedness gaps. The Composite Technology Readiness Index of 2.3 out of 10 indicates a pre-readiness stage, with critical deficiencies in knowledge and awareness (20% readiness), human capital (20%), process maturity (20%), and regulatory frameworks (10%). Over 80% of respondents possess minimal understanding of these technologies, yet demonstrate an intuitive grasp of their value propositions when explained, particularly regarding immutable records and price transparency. Critical pain points price volatility, information asymmetry, quality disputes, and inability to verify sustainability claims, create compelling business cases for intervention. A five-phase implementation roadmap (2025-2045) is proposed, progressing from foundation building through pilot implementation, ecosystem scaling, optimization, to global leadership, aligned with Indonesia's Coconut Downstream Processing Roadmap and requiring phased approaches with realistic timelines.

Success requires four non-negotiable factors: user-centric design ensuring simplicity and accessibility, multi-stakeholder collaboration embedded in formal governance structures, continuous capacity building leveraging field extension officers and farmer leaders, and evidence-based policymaking with adaptive management. While the journey from current readiness (2.3) to full deployment maturity (8.5) will be challenging, requiring sustained commitment and coordinated action over two decades, these gaps are not insurmountable but systematic challenges addressable through proper capacity building and infrastructure investment. The universal stakeholder concern for farmer welfare provides a moral compass, ensuring technological sophistication serves human development. Success will ultimately be measured not in technical metrics but in human outcomes: farmers earning dignified livelihoods, communities thriving, Indonesian coconut products commanding premium prices, and next generations viewing coconut agriculture as a worthy, technology-supported profession rather than a subsistence struggle.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest. The funders had no role in study design, data collection and analysis, decision to publish, or manuscript preparation.

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