

SUSTAINABLE SUPPLY CHAIN MANAGEMENT IN ORGANIC COCONUT SUGAR PRODUCTION: FOCUSING ON SMALLHOLDER FARMERS IN INDONESIA

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ABSTRACT - This research addresses the paradox between global organic market growth and structural smallholder vulnerabilities in Indonesian organic coconut sugar supply chains. The objective is to analyze supply chain dynamics, evaluate sustainability practices, and formulate an integrated management model. Employing a qualitative dual-case study design, data were collected through 23 semi-structured interviews, 32 participatory observation days, and 3 focus group discussions across Cilacap District. Thematic cross-case analysis revealed a non-sequential, six-layer supply chain where smallholders capture only 28–32% of export value due to seasonal liquidity shortages and informal tenure constraints. However, digitalized cooperative governance reduced internal disputes by 85% and increased price premiums. Synthesizing these findings yields the Local Ecological Knowledge and Agrarian Institutional-based SSCM (SSCM-LKAI) model, which formalizes traditional ecological knowledge and positions inclusive cooperatives as critical mediating bridges. Future research should quantitatively validate this model across diverse agricultural commodities.

ABSTRAK - Penelitian ini menjawab paradoks antara pertumbuhan pasar organik global dan kerentanan struktural petani kecil pada rantai pasok gula kelapa organik di Indonesia. Tujuannya adalah menganalisis dinamika rantai pasok, mengevaluasi praktik keberlanjutan, dan merumuskan model pengelolaan terintegrasi. Menggunakan desain studi kasus ganda kualitatif, data dikumpulkan melalui 23 wawancara terstruktur, 32 hari observasi partisipatif, dan 3 diskusi kelompok terarah di Kabupaten Cilacap. Analisis tematik lintas kasus mengungkapkan rantai pasok non-sekuensial enam lapis di mana petani kecil hanya menangkap 28–32% nilai ekspor akibat kekurangan likuiditas musiman dan kendala penguasaan lahan informal. Namun, tata kelola koperasi berbasis digital berhasil mengurangi sengketa internal sebesar 85% dan meningkatkan premium harga. Mensintesis temuan ini menghasilkan model SSCM berbasis Pengetahuan Ekologis Lokal dan Lembaga Agraria (SSCM-LKAI) yang memformalkan pengetahuan ekologis tradisional dan menempatkan koperasi inklusif sebagai jembatan mediasi krusial. Penelitian mendatang hendaknya memvalidasi model ini secara kuantitatif pada berbagai komoditas pertanian.

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INTRODUCTION

The global organic product market exceeded USD 130 billion in 2022 and is projected to grow 12.2% annually through 2030 (Willer et al., 2023). Organic coconut sugar, processed from coconut palm nectar (*Cocos nucifera*), holds a strategic position in this trend as a leading Indonesian export commodity to the United States, European Union, Australia, and Japan. Its appeal lies in its profile as a low-glycemic-index sweetener (GI 35–54), a characteristic increasingly sought by health-conscious middle-class global consumers concerned with metabolic health and product sustainability footprints (Nainggolan et al., 2021). Notably, this commodity is rarely cultivated specifically; coconut palms typically exist as multigenerational plantings in Javanese rural households' mixed gardens, making organic coconut sugar production essentially an economic activity leveraging landscapes far older than the export industry itself. In Central Java, the Banyumas, Cilacap, Kebumen, and Purbalingga clusters are estimated to account for 60–65% of national organic coconut sugar export volumes (BPS, 2023). However, this aggregate figure masks household-level vulnerabilities: production relies almost entirely on smallholders with average holdings below 200 trees who face working capital constraints, price information asymmetries, and weak bargaining positions relative to downstream supply chain actors. Some lack secure land tenure, a condition determining access to formal credit and trapping others in high-interest informal financing schemes. The paradox between global market growth and producer-level structural fragility drives this research.

Sustainable Supply Chain Management (SSCM) has become the dominant paradigm for understanding global agricultural supply chain sustainability, integrating economic, environmental, and social pillars in unified management frameworks (Seuring & Muller, 2008; Carter & Rogers, 2008). Yet critical reading reveals this field fragments into several non-communicating streams. The first, quantitatively dominant stream adopts compliance-driven perspectives viewing sustainability primarily as multinational reputation risk management in manufacturing supply chains (Beske & Seuring, 2014). The second emphasizes global value chain governance and upgrading mechanisms (Gereffi et al., 2005; Humphrey & Schmitz, 2002), usefully mapping actor positioning yet tending to overlook cognitive and cultural dimensions of local production knowledge. The third, relatively younger stream begins attending to agrarian institutions and developing-country local ecological knowledge (Agyemang et al., 2019; Koberg & Longoni, 2023), yet generally remains descriptive-exploratory without explicit analytical model integration. This inter-stream tension creates the methodological and conceptual gap this research addresses: not merely adding another case study, but bridging these streams in high-value export commodities produced entirely by smallholders.

Beyond theoretical tensions, specific methodological and substantive gaps exist. SSCM mainstream quantitative approaches limit capturing relational nuances, actor subjective meaning, and informal institutional logics determining intervention success or failure in the field (Merriam & Tisdell, 2016). Smallholder perspectives themselves, as the most vulnerable yet ecologically determining production actors, often appear merely as policy objects rather than theory sources (Jouzi et al., 2017; Govindan et al., 2023). Recent studies begin responding: research on smallholder capability strengthening through local knowledge for food security (Munyoro, 2025), systematic reviews of multi-tier agri-food sustainability challenges in developing economies (Khan et al., 2024), and intermediary roles managing compliance sustainability in rice supply chains (Khan et al., 2025). Yet these studies typically treat local knowledge, cooperative institutions, and formal SSCM frameworks as separate topics rather than mutually-locking components. Comparatively



closer geographically, Peruvian smallholder research proposes hybrid models integrating ancestral agricultural knowledge with modern supply chain innovation (Vásquez Neyra et al., 2025), though this model doesn't explicitly position integration within formal SSCM structures or cooperative institutions. This comparative gap, to our knowledge, remains unfilled for high-value export commodities like organic coconut sugar.

This research integrates four complementary theoretical perspectives. The triple bottom line SSCM framework (Seuring & Muller, 2008; Carter & Rogers, 2008) serves as primary analytical structure organizing economic, environmental, social, and governance dimension findings. Global Value Chain theory (Gereffi et al., 2005) aids understanding value governance patterns and upgrading mechanisms available to smallholders. Institutional theory (DiMaggio & Powell, 1983) helps analyze regulatory, normative, and mimetic pressures shaping cooperative and supply chain actor behavior. Meanwhile, local ecological knowledge approaches are employed not as romantic complement but as recognizing traditional ecological knowledge as legitimate cognitive asset requiring formal integration into modern sustainable agriculture management. This combination allows reading field data not merely as descriptive conditions but as material for testing and extending SSCM theory boundaries themselves.

Research novelty lies in SSCM-LKAI model development, explicitly formalizing local ecological knowledge as strategic asset and cooperative institutions as critical mediation variables within unified SSCM framework, moving beyond prior studies discussing these elements separately or descriptively. This research also situates within broader debate on how high-value developing-country export commodities benefit primary producers rather than just downstream chain actors, relevant to global sustainable development agenda addressing responsible production-consumption and rural poverty alleviation. Organic coconut sugar as fast-growing yet smallholder-dependent niche commodity provides instructive case testing whether global organic market growth truly translates to producer-level welfare or merely reproduces conventional commodity inequalities. Thus this research contributes beyond SSCM literature to broader discussions of justice in developing-country agricultural value chain commodities.

Based on these gaps and theoretical foundations, this research aims: (1) mapping organic coconut sugar supply chain structure and dynamics from smallholder perspectives; (2) exploring SSCM implementation challenges and opportunities at each supply chain node; (3) analyzing cooperative institutions' roles in supporting or hindering chain sustainability; and (4) developing context-appropriate SSCM models for Indonesian agrarian realities. This article is organized as follows: introduction establishing background and research aims; methods explaining research approach; results and discussion; conclusion; and references.

RESEARCH METHOD

This research adopts an interpretivist paradigm with a qualitative dual-case study design (Yin, 2018), selected for capturing supply chain actor relational complexity and subjective meaning within natural contexts, which are difficult to obtain through structured surveys (Creswell & Poth, 2018; Merriam & Tisdell, 2016). Two internationally certified organic coconut sugar farmer cooperatives in Cilacap District were selected through maximum variation sampling, considering organizational age differences, membership scale differences, and certification type variations to enrich rather than obscure governance variation

possibilities. We acknowledge that two cases limit statistical generalization claims; however, as Yin (2018) emphasizes, dual-case study replication logic requires not large case numbers but deep comparison enabling analytical rather than statistical theory generalization. Research was conducted in three Cilacap District sub-districts (Cipari, Wanareja, and Majenang) over eight months (January–August 2025) spanning three different production seasons harvest peak, transition, and lean season to capture seasonal dynamics rather than single-moment portraits.

The research subjects and key informants were selected through purposive sampling combined with snowball sampling. Inclusion criteria required a minimum of five years of direct supply chain involvement, voluntary participation willingness, and the ability to provide rich reflective information rather than merely normative answers. Theoretical saturation (Guest et al., 2020) was reached by the tenth interview, when new themes ceased emerging and patterns repeated in subsequent sessions. The study involved 10 key informants across six distinct supply chain actor layers, whose complete profiles are detailed in Table 1.

Code	Supply Chain Role	Location	Experience
INF-01	Coconut farmer (landowner)	Cipari	22 years
INF-02	Coconut farmer (tenant farmer)	Wanareja	28 years
INF-03	Village-level collector	Majenang	15 years
INF-04	District-level intermediary trader	Sidareja	18 years
INF-05	Organic coconut sugar exporter	Sukoharjo	12 years
INF-06	Certified farmer cooperative manager	Cilacap	10 years
INF-07	Organic agriculture extension agent	Cipari	8 years
INF-08	Organic certifier (LSO)	Jakarta	14 years
INF-09	District Agriculture Office Head	Cilacap	20 years
INF-10	Agribusiness academic/researcher	Majenang	7 years

Table 1. Key Informant Research Profiles

Data collection employed three complementary techniques executed across three distinct stages. The first stage involved a preliminary study and stakeholder mapping, including village office and cooperative introductory visits to build initial trust. The second stage focused on primary data collection through semi-structured in-depth interviews, participatory observation, and Focus Group Discussions (FGDs). Specifically, 23 semi-structured interview sessions (90–120 minutes each, yielding over 420 pages of verbatim transcript) were conducted with the 10 informants. Interviews occurred in Javanese Ngoko, Krama, or Indonesian per informant preference. Participatory observation spanned 32 field days distributed throughout the research period, encompassing early morning nectar tapping processes, traditional kitchen sugar processing, regular cooperative meetings, export grading and packaging activities, and field extension sessions. Additionally, three FGD sessions (6–8 participants, 2–3 hours each) were conducted with varied group compositions: a smallholder farmer group, a collector-exporter-cooperative manager group, and an extension agent-academic-agriculture ministry official group. The third stage encompassed finding verification and member checking, where initial theme summaries were revisited with informants for correction or sharpening.

Instrument development was structured to ensure rigorous data collection, validity, and methodological transparency. Semi-structured interview guides and FGD protocols were developed around four core supply chain dimensions: economic, environmental, social, and governance. Research validity was maintained through four criteria established by Lincoln and Guba (1985): credibility through source, method, and theory triangulation alongside member checking; transferability through thick local context descriptions; dependability through a complete audit trail documenting data collection through analysis processes; and confirmability through researcher reflective journals written throughout the field process to monitor positionality and potential interpretation biases. To ensure coding reliability, an independent coding check was conducted on a randomly selected 20% of transcripts by two research team members, achieving an initial agreement percentage above 80% before discussing interpretation differences to full consensus. Ethical protocols were strictly observed: written informed consent was obtained from all informants, identities were protected via coding systems (INF-01 through INF-10), data was stored in encrypted formats, and ethics committee approval was secured prior to field collection.

Data was analyzed using a six-phase thematic analysis approach (Braun & Clarke, 2006) integrated with cross-case analysis (Miles et al., 2020). The process began with data familiarization through repeated transcript and field note reading, followed by initial open coding using NVivo 12, which generated over 350 unique codes. Subsequent axial coding grouped these codes into abstract categories, leading to candidate theme formation, main theme definition, and analytic report production. Cross-case analysis systematically compared Cooperative A and Cooperative B using structured comparison theme-by-case matrices to identify convergent patterns (similarities across cooperatives) and divergent patterns (governance differences with direct member welfare implications). Methodological limitations were acknowledged, including the eight-month observation timeframe, potential meaning nuance loss during Javanese-to-Indonesian translation, and the researcher's outsider academic positionality.

RESULTS AND DISCUSSION

1. Supply Chain Structure and Dynamics

Field mapping identified a non-sequential, six-layer actor structure comprising organic input suppliers, smallholder farmers, aggregators (farmer groups/cooperatives), collectors and intermediary traders, exporters/processors, and international buyers. Rather than a single linear chain, three parallel distribution routes operate simultaneously. Route 1 flows directly through cooperatives to exporters, offering optimal farm-gate prices (Rp 15,000–15,500/kg) but requiring strict quality standards and delivery volumes. Route 2 follows traditional pathways through village collectors, yielding 20–35% lower prices (Rp 11,000–11,500/kg) yet providing immediate cash liquidity on site. Route 3 a hybrid mechanism most frequently utilized by smallholders allocates premium-grade sugar to cooperatives while redirecting surplus or standard-grade output to collectors to satisfy immediate household cash demands. Figure 1 illustrates this multi-layered network and the interplay among actor nodes.

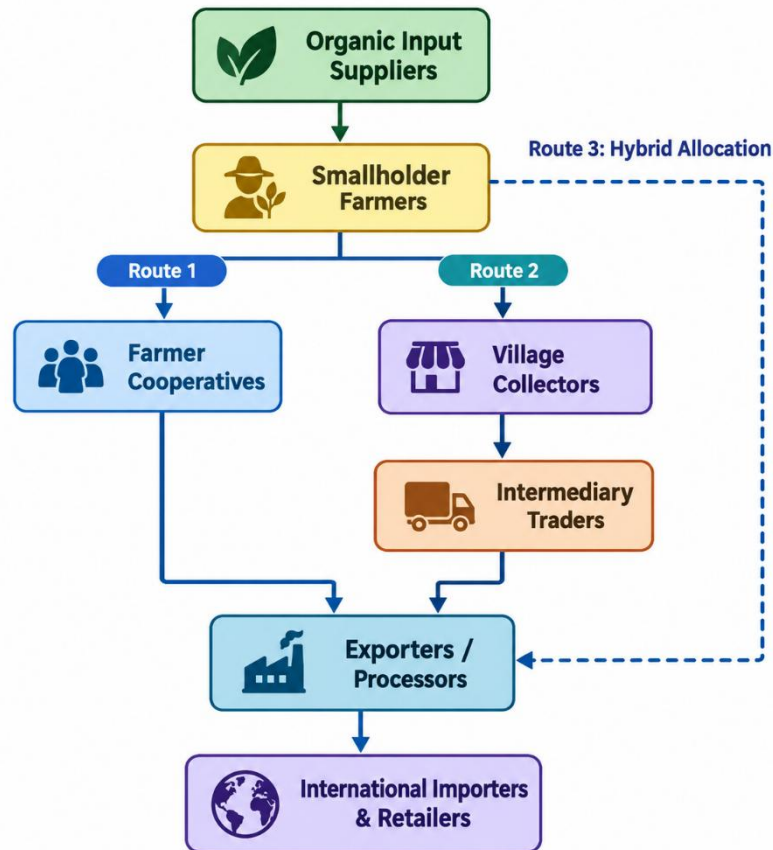


Figure 1. Organic Coconut Sugar Supply Chain Configuration and Parallel Distribution Routes

Figure 1 maps the multi-tier operational flow within the study area, highlighting how smallholders navigate formal cooperative channels alongside informal collector pathways. Farmer distribution decisions are driven primarily by short-term household liquidity constraints rather than long-term economic margin calculations alone. Furthermore, transactional relationships between farmers and village collectors are deeply embedded in socio-cultural kinship networks ("*pakdhe*", "*mas*"), where collectors act as informal credit providers during lean production months. These findings validate Granovetter's (1985) social embeddedness thesis while extending it to show that social capital functions dually providing emergency livelihood safety nets while simultaneously binding smallholders to lower value-add channels. Comparing governance patterns between cases reveals that Cooperative A builds relational governance with fixed annual export contracts, whereas Cooperative B operates under modular, per-harvest-season agreements. Aligning with Gereffi et al. (2005), this demonstrates that relational value chain governance, rather than certification ownership alone, determines long-term price stability and upgrading trajectories for primary producers.

2. Economic Dimension: Value Distribution, Price Volatility, and Financing Constraints

Data triangulation reveals systematic structural inequalities in value-add distribution across the supply chain, as summarized in Table 2.

Actor	Price Received (Rp/kg)	Selling Price (Rp/kg)	Margin (Rp/kg)	Value Share (%)
Smallholders (via coop)	15,000	15,500	500	28–32%
Smallholders (via collector)	11,000	11,500	500	20–22%
Village-level collector	11,500	13,500	2,000	4–6%
Coop/aggregator	15,500	20,000	4,500	8–12%
Exporter	20,000	55,000	35,000	48–55%

Table 2. Estimated Value-Add Distribution in Supply Chain (per kg)

Source: Primary data analysis 2025, cross-validating interviews and informant transaction documents. Estimated average 2024–2025 FOB prices after deducting international logistics, certification, insurance, and marketing costs.

Table 2 outlines the captured value share at each supply chain node, demonstrating that smallholders receive only 28–32% of the final export price when selling through cooperatives and 20–22% through collectors, while exporters capture a 48–55% share. Although exporters absorb substantial international compliance, currency fluctuation, and logistics risks, the magnitude of this margin gap underscores an unequal distribution relative to upstream production hazards. Upstream vulnerability is further exacerbated by 30–40% farm-gate price fluctuations between peak and lean seasons. Moreover, formal credit access is severely constrained because many smallholders hold unregistered land or informal inheritance titles, forcing reliance on informal lenders charging 5–10% monthly interest. Intra-household observations reveal that lean-season financial shocks fall disproportionately on women, who undertake secondary informal labor to stabilize family consumption. These findings align with Reardon et al. (2021) on structural power asymmetries in developing-country value chains and expand on Jouzi et al. (2017) by showing that economic vulnerabilities stem from a triad of price information gaps, seasonal liquidity shortages, and informal tenure realities.

3. Environmental Dimension: 'De Facto Organic' Practices and Certification Barriers

A key empirical insight is the phenomenon of '*de facto organic grounded in local ecological knowledge*'. Smallholders have historically maintained polyculture agroforestry, avoided synthetic inputs, and practiced sustainable nectar tapping for generations prior to the introduction of third-party organic certification standards. As extension agents noted, these practices stem from ancestral worldviews treating coconut palms as living family heritage.

This empirical pattern supports and extends Mutersbaugh's (2022) epistemic justice framework by showing that conventional audit-based organic certification systems often ignore traditional ecological knowledge while imposing heavy administrative compliance and three-year conversion burdens on resource-constrained farmers. Similar observations among smallholders in Peru (Vásquez Neyra et al., 2025) and global organic land reports (Willer et al., 2023) confirm that *de facto* organic management is a widespread structural reality in Southern agriculture rather than a localized anomaly. Consequently, adopting



Participatory Guarantee Systems (PGS) that formally validate local ecological knowledge could alleviate administrative hurdles without compromising ecological integrity.

4. Social Dimension: Cooperative Heterogeneity, Gender, and Capacity Gaps

Comparative evaluation of the two study cooperatives highlights institutional heterogeneity in mediating member welfare, as detailed in Table 3.

Aspect	Cooperative A	Cooperative B
Year established	2006 (18 years)	2015 (9 years)
Member count	247 farmers	132 farmers
Active certification	USDA Organic & EU Bio	USDA Organic
GVC governance model	Relational	Modular
Export contract	Annual fixed	Per harvest season
Organic premium	22–28% above conventional	15–20%
Information system	Digital – mobile app	Semi-digital – spreadsheet
Female participation	32% of active members	18% of active members

Table 3. Case Research Cooperative Comparison Profile

Table 3 compares the operational profiles of Cooperative A and Cooperative B, showing that Cooperative A delivers higher organic price premiums (22–28%) and wider female membership (32%) by leveraging digital mobile applications and long-term relational contracts. Digitalization reduced internal transaction disputes by 85% and increased member assembly attendance from 60% to 89%. However, gender and generational disparities remain. Women perform critical nectar boiling and quality assurance roles yet remain underrepresented in formal cooperative governance. Additionally, older, highly experienced farmers often struggle with written record-keeping requirements. These findings validate Iliopoulos and Cook (2022) by demonstrating that agricultural cooperatives act as conditional social-ecological mediating variables whose developmental impact depends directly on internal transparency, institutional age, and inclusive governance.

5. Governance Dimension: Information Asymmetries and Regulatory Fragmentation

Information asymmetries regarding international market prices persist throughout the supply chain. Furthermore, multi-ministerial regulatory fragmentation across the Ministry of Agriculture, Ministry of Trade, and Ministry of Cooperatives and SMEs creates overlapping policy mandates and administrative roundabouts that hinder long-term cooperative investment. Conversely, market-driven governance innovations are emerging, such as Cooperative A's mobile app and buyer demands for blockchain-based traceability. These observations align with Govindan et al. (2023) regarding policy-induced transaction costs in emerging economies and reflect DiMaggio and Powell's (1983) institutional theory, indicating that global market-driven normative and mimetic pressures currently exert a stronger influence on supply chain restructuring than domestic regulatory frameworks.



6. Theoretical Synthesis: The SSCM-LKAI Model

Synthesizing the four dimensions demonstrates that supply chain sustainability in Southern smallholder contexts is not driven by isolated factors, but by dynamic interactions between local ecological knowledge, cooperative governance, and institutional incentive structures. To bridge the gaps in conventional SSCM frameworks, this study formulates the Local Ecological Knowledge and Agrarian Institutional-based SSCM (SSCM-LKAI) model. The model integrates five core pillars:

1. Local Ecological Knowledge-Based Ecological Foundation: Recognizing traditional knowledge as a legitimate cognitive asset requiring formal validation rather than replacement.
2. Inclusive Collective Institutions: Positioning cooperatives as transparent, gender-inclusive, and democratic mediating nexuses between smallholders and global markets.
3. Equitable Information Systems: Ensuring symmetrical price and market data access as a prerequisite for fair value distribution.
4. Integrated Multidimensional Policy: Harmonizing cross-ministerial regulations, certification policies, and agricultural extension services.
5. Ethical Market Partnerships: Fostering long-term value chain relationships characterized by equitable risk-sharing and fair-trade principles.

The SSCM-LKAI model advances Southern SSCM literature (Touboulis & Walker, 2015) and aligns with recent findings by Li et al. (2025), Khan et al. (2024), Khan et al. (2025), Agyabeng-Mensah et al. (2025), Munyoro (2025), and Agyemang et al. (2019) by demonstrating that supply chain practice effectiveness depends on context-sensitive institutional structures rather than rigid corporate compliance templates.

7. Practical and Policy Implications

The findings yield five actionable policy implications for agricultural supply chain transformation:

- Participatory Certification Subsidies: Directing state organic certification subsidies toward smallholder cooperatives through Participatory Guarantee Systems (PGS) to reduce administrative burdens.
- Contextualized Green Microfinance: Developing credit schemes anchored in cooperative trust networks and group guarantees to accommodate farmers lacking formal land titles.
- Cross-Ministerial Policy Harmonization: Establishing unified service desks combining Agriculture, Trade, and Cooperative ministries to streamline regulatory requirements.
- Inter-Cooperative Peer Learning: Facilitating peer-to-peer knowledge exchange between mature cooperatives (e.g., Cooperative A) and emerging cooperatives (e.g., Cooperative B).
- Village-Level Market Transparency Platforms: Deploying accessible digital price-monitoring platforms at the village level to eliminate price information asymmetries.

8. Limitations and Suggestions for Future Research

This study has methodological limitations. The qualitative dual-case design in a single district limits statistical generalizability to all Indonesian smallholder organic sectors, while the eight-month timeframe precludes multi-year longitudinal price observation. Future research should: (1) execute large-scale quantitative surveys to empirically test and validate the SSCM-LKAI model across diverse agricultural commodities; (2) conduct multi-year longitudinal studies to observe cooperative governance dynamics over extended economic cycles; and (3) perform comparative cross-country analyses in other developing nations to evaluate the boundary conditions and generalizability of the SSCM-LKAI framework.

CONCLUSION

This research leads to four primary findings aligned with the study's analytical objectives. First, mapping the organic coconut sugar supply chain in Cilacap District reveals a non-sequential, six-layer network where smallholders navigate three parallel distribution channels, balancing formal cooperative pathways against informal collector routes driven primarily by short-term household liquidity constraints and socio-cultural kinship ties. Second, analyzing sustainability practices across nodes highlights a severe structural margin gap where smallholders capture only 28–32% of the final export value compared to 48–55% absorbed by downstream exporters further compounded by 30–40% seasonal price fluctuations, informal land tenure barriers, and administrative audit burdens that overlook *de facto* organic practices grounded in local ecological knowledge. Third, evaluating cooperative institutions demonstrates their critical role as social-ecological mediating variables, where digitalized, transparent governance and long-term relational contracts substantially reduce internal transaction disputes by 85% and deliver higher price premiums (22–28%) to primary producers. Fourth, synthesizing these empirical realities yields the Local Ecological Knowledge and Agrarian Institutional-based SSCM (SSCM-LKAI) model, which advances sustainable supply chain theory by formalizing traditional ecological knowledge as a legitimate cognitive asset and positioning inclusive cooperative institutions as essential bridges connecting smallholder livelihoods with global export markets.

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