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Agricultural Downstreaming in Lampung, Indonesia: An Integrated Strategy for Regional Value Addition and Inclusive Agroindustrial Development

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ABSTRACT

Agricultural downstreaming is a central development issue in Lampung because the province combines a large and diverse primary-production base with persistent challenges in retaining value within local value chains. This study analyzes the regional potential for downstream agricultural development, identifies cross-cutting constraints to value creation, and develops an integrated strategy for inclusive and sustainable agroindustrial upgrading. A qualitative document-based design was used, combining official statistics and regional policy documents with peer-reviewed literature on agrifood value chains, agroindustry, smallholder inclusion, post-harvest systems, finance, digitalization, and sustainability. The evidence was organized through content analysis and thematic synthesis. Lampung's downstreaming opportunities are concentrated in commodity-linked pathways such as cassava processing, maize-feed-livestock integration, quality-based coffee upgrading, and local processing of cocoa, coconut, and horticultural products. Across commodities, however, the same enabling conditions recur: reliable raw-material quality, post-harvest infrastructure, fair farmer-industry relationships, accessible finance, certification, logistics, digital market access, and environmental performance. The study proposes a regional downstreaming framework that treats processing capacity as one component of a wider governance system. Downstreaming is therefore most likely to increase regional value added when industrial expansion is accompanied by stronger farmer institutions, transparent value-chain coordination, rural enterprise upgrading, and measurable sustainability outcomes.

IMPACT STATEMENT

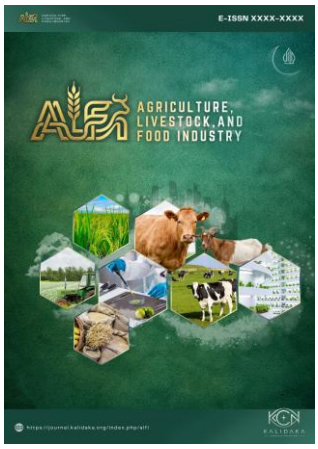
The study reframes agricultural downstreaming in Lampung from a factory-centered policy into a regional value-creation system. It identifies how production, post-harvest capability, farmer institutions, finance, standards, markets, and sustainability must operate together if more value is to remain in producing areas. The framework can support provincial and district planning by linking commodity priorities to infrastructure, partnership design, MSME upgrading, and monitoring indicators. It also provides a practical basis for assessing whether downstreaming improves farmer bargaining power, rural employment, local enterprise capability, resilience, and environmental performance rather than measuring success only through processing volume or the number of new plants.

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1. Introduction

Agricultural downstreaming is often described as the movement from primary production toward processing, product differentiation, logistics, and higher-value market functions. In practice, however, the development problem is broader than adding a processing stage. Food processing creates value only when raw materials, standards, skills, logistics, information, and market relationships are coordinated across the chain [1]. Food-systems research similarly shows that production, markets, institutions, consumption, and environmental outcomes are interdependent [2]. Innovations in one segment can create gains elsewhere, but they can also shift costs or risks to farmers, workers, consumers, or natural resources [3]. For this reason, downstreaming should be evaluated as a regional transformation process rather than as an isolated industrial investment.

A regional approach is especially relevant in areas where smallholders supply multiple commodities to processors and traders. Food-system transformation requires a balance among efficient production, inclusive livelihoods, affordable and safe products, and environmental sustainability [4]. Inclusive agribusiness research further emphasizes that participation in commercial chains does not automatically ensure equitable benefit sharing [5]. Farmers may remain price takers when they face limited market information, weak organizations, high transaction costs, quality constraints, or few buyers. Evidence on farmer-market linkages identifies infrastructure, finance, standards, collective organization, and information as recurring barriers to participation in higher-value markets [6]. Thus, the central policy question is not only how to process more agricultural output, but how to organize downstream activities so that a meaningful share of the additional value remains within producing regions.

Lampung provides a strong setting for this question. The province has long been shaped by agriculture and agroindustry, and regional modeling highlights the importance of agricultural linkages to the wider economy [7]. Spatial research also identifies substantial agricultural potential across Lampung and the need to connect production zones with regional development strategies [8]. The resource base is diverse rather than dependent on a single commodity. According to the 2023 Agricultural Census, food crops, livestock, and plantations are the three dominant agricultural subsectors in Lampung, while cassava, wetland rice, goats, native chickens, cattle, coffee, rubber, hybrid rice, hybrid maize, and coconut are among the most widely cultivated commodities by individual agricultural enterprises [9]. This diversity creates opportunities for several downstream clusters, but it also means that one uniform industrial model is unlikely to fit all commodities.

Recent production data reinforce the scale of the raw-material base. BPS-Statistics Lampung Province reported a paddy harvested area of 596.02 thousand hectares in 2025 and production of 3.25 million tons of dry unhusked rice [10]. These figures are used here only to establish agricultural scale, not as evidence that downstreaming has already improved farmer welfare or regional value capture. The distinction is important because production volume and regional benefit are different outcomes. A province can produce large quantities while value is captured downstream through processing, branding, trading, finance, or distribution outside the producing area.

1.1. Research problem and gap

The policy relevance of this gap is already recognized in Lampung. The Regional Development Planning Agency convened a thematic discussion on technology-based agricultural productivity and downstreaming for the 2025-2029 period, explicitly linking agricultural development with farmer welfare and stronger regional economic growth [11]. Yet academic evidence on Lampung remains fragmented. Commodity studies provide detailed insights into cassava partnerships, competitiveness, risks, rural processing, and farmer income [12]-[19], while coffee studies address value-chain upgrading, certification, and livelihood outcomes [20], [21]. These contributions are valuable, but they do not by themselves provide an integrated regional framework for deciding how infrastructure, institutions, finance, markets, and sustainability should be coordinated across multiple commodities.

1.2. Research objectives

This study therefore examines agricultural downstreaming as a regional value-creation system. It has three objectives: to identify Lampung's principal downstreaming pathways, to synthesize the structural constraints that limit local value capture, and to formulate an integrated strategy for inclusive and sustainable agroindustrial development. The contribution is conceptual and policy-oriented. Rather than claiming causal effects of downstreaming on income or regional growth, the analysis identifies mechanisms and enabling conditions that should be examined when designing and evaluating downstream policies. This distinction keeps the conclusions aligned with the document-based evidence available in the study.

2. Literature Review

2.1. Agricultural downstreaming and regional value addition

Value addition arises when agricultural commodities acquire new economic attributes through processing, preservation, quality differentiation, packaging, certification, services, or improved market access [1]. In developing-country value chains, however, transformation is multi-level: smallholder capacity, chain governance, firm capability, and the surrounding institutional environment all shape whether upgrading is feasible [22]. Downstreaming can therefore increase the value of output without necessarily increasing the share retained by farmers or local enterprises. Relationship structure matters because stable upstream and downstream ties can reduce uncertainty, while excessive concentration may create dependency or bargaining asymmetry [23]. This makes regional value retention a more useful analytical concept than processing volume alone.

For Lampung, the cassava literature illustrates this distinction clearly. Studies describe a large processing base, but also recurring issues in price formation, quality, transaction relationships, institutional coordination, and competitiveness [12]-[16]. Rural cassava processing can create local employment and added value [17], and Mocaf processing provides an example of product upgrading at smaller enterprise scale [18]. Cassava also has a broad industrial application base, including starch, flour, food, feed, bioethanol, and other bio-based products [24], [25]. The regional policy implication is that downstreaming choices should reflect market demand and technical capability rather than assuming that every commodity requires large-scale factory investment.

2.2. Value-chain governance, farmer institutions, and inclusion

The distribution of benefits depends strongly on governance. Inclusive agribusiness requires mechanisms that allow smaller producers to participate on workable terms, rather than simply connecting them to buyers [5]. Collective organization can reduce transaction costs, aggregate volume, support quality control, improve information flows, and strengthen bargaining power. Systematic evidence on collective marketing shows that farmer participation is influenced by institutional, market, infrastructure, and organizational conditions [26]. Agricultural cooperatives can also help coordinate standards and address failures that individual farmers may find costly to manage independently [27].

Lampung-specific studies reinforce this point. Cassava partnerships have been proposed as a way to coordinate farmers, traders, processors, and supporting institutions, but partnership sustainability depends on enforceable rules, quality standards, timely transactions, and balanced incentives [12], [15]. Risk analysis in Central Lampung identifies weather, capital limitations, standards, price volatility, and payment delays among sources of value-chain risk [14]. Competitiveness research similarly points to weak institutions and farmer-facing policy constraints [13]. These findings suggest that downstreaming policy should treat contract design, dispute resolution, transparent quality assessment, and farmer representation as core industrial infrastructure, not as peripheral social programs.

2.3. Post-harvest infrastructure, quality, and market access

Downstreaming begins before processing. Raw-material quality is determined by cultivation, harvest timing, sorting, drying, storage, transportation, and handling. Post-harvest innovation can preserve quality and reduce avoidable losses, but technologies are effective only when they fit commodity characteristics, local energy and logistics conditions, and operator capabilities [28]. Grain-storage research shows that moisture control, storage technology, pests, and management practices strongly affect post-harvest performance [29]. Evidence from horticultural supply chains likewise demonstrates that handling, packaging, temperature management, and transport influence both quantity and quality [30].

Market access is therefore inseparable from infrastructure and standards. Farmers and local processors must meet buyer requirements for moisture, cleanliness, food safety, consistency, traceability, or certification if they are to enter higher-value channels [6], [22]. In Lampung, coffee upgrading depends on post-harvest quality, product and process upgrading, and market positioning [20], [21]. Cassava is similarly sensitive to starch content, cleanliness, price deductions, and processing specifications [12]-[14]. For maize and horticulture, drying, warehousing, cold-chain systems, and packing facilities can be more important to value retention than the immediate construction of a new processing plant.

2.4. Finance, digitalization, and enterprise upgrading

Access to finance is a recurring bottleneck because downstream activities require working capital, equipment, storage, certification, packaging, and market development. Agricultural value-chain finance can

use buyer relationships, contracts, and transaction information to reduce financing frictions [31]. Indonesian experience also shows that smallholders may struggle to access conventional credit products when eligibility conditions do not match agricultural cash flows [32]. Fintech and Islamic finance have been proposed as complementary instruments for agricultural value chains, particularly where transaction data and contractual relationships can improve risk assessment [33]. The key analytical point is that financing should be linked to viable chain functions and repayment capacity rather than treated as a stand-alone subsidy.

Digitalization can improve information sharing, inventory visibility, market access, traceability, and decision support. Agrifood SMEs can benefit from digital decision-support tools when technology is aligned with business processes [34]. A value-chain-based digitalization framework likewise emphasizes network participation and the need to avoid exclusion of less-connected actors [35]. More advanced traceability systems may strengthen transparency and trust, but digital solutions do not substitute for accurate input data, credible standards, and institutional accountability [36]. For Lampung, digital market integration is most useful when it supports concrete functions such as buyer discovery, price information, certification records, product traceability, logistics coordination, and regional branding.

2.5. Sustainability, diversification, and regional resilience

A downstream strategy that raises output while increasing waste, water stress, energy intensity, or unequal risk transfer can weaken long-term regional welfare. Circular-economy research shows that agrifood residues can become inputs for new products, energy, feed, or soil amendments when technically and economically feasible [37]. Sustainable production research similarly highlights resource efficiency and cleaner technologies as part of competitiveness rather than an external environmental add-on [38]. In Lampung, cassava-livestock integration illustrates one possible pathway for using crop residues and nutrient cycling [39], while research on coffee agroforestry and certification connects production systems with environmental governance and farmer livelihoods [20].

Diversification also has a resilience function. Firms with more diversified activities can be better positioned to absorb market shocks than highly specialized firms [40], and broader food-supply reviews emphasize redundancy, flexibility, coordination, and adaptation as resilience mechanisms [41]. Shorter or more regionally embedded food chains can strengthen responsiveness in some settings, although sustainability benefits remain context dependent [42]. Lampung's commodity diversity therefore provides an opportunity to develop several linked clusters rather than concentrating downstream policy on one crop. This does not eliminate risk, but it can reduce dependence on a single commodity cycle when infrastructure and institutions can serve multiple value chains.

2.6. Analytical gap and framework

The literature points to six recurring dimensions: raw-material capability, post-harvest and processing capacity, farmer institutions and governance, finance, market and digital capability, and environmental sustainability. Existing Lampung studies usually examine one commodity or one dimension in depth, while regional policy requires decisions across commodities and agencies. The analytical gap is therefore integrative rather than evidentiary: substantial evidence exists on individual mechanisms, but it is dispersed across agribusiness, value-chain, finance, post-harvest, digitalization, and sustainability research. The framework used in this study treats regional value added as an outcome of interaction among these dimensions and evaluates downstreaming by asking who participates, where value is retained, what risks are created, and whether the system remains resilient over time [4], [22], [43].

3. Methods

3.1. Research design

A qualitative document-based research design was employed to examine agricultural downstreaming as a regional value-creation system in Lampung Province. The design integrates descriptive interpretation of official regional statistics and policy documents with thematic synthesis of peer-reviewed research. It is appropriate to the study because the research questions concern value-chain mechanisms, institutional coordination, and policy design rather than the causal effect of a single intervention. The analytical setting was Lampung Province, and the evidence base included sources relevant to regional agricultural conditions and policy through 2026.

3.2. Data universe and source selection

The data universe comprised publicly available official statistics, regional policy documents, and peer-reviewed studies directly relevant to agricultural downstreaming in Lampung or to mechanisms transferable to the Lampung context. The unit of analysis was the regional agricultural downstreaming system, defined as the relationships linking primary production, post-harvest handling, processing, farmer organizations, MSMEs, finance, logistics, standards, markets, and regional policy. Sources were included when they provided verifiable evidence on regional agricultural structure, downstreaming policy, commodity value chains, farmer-market relations, post-harvest systems, finance, digitalization, or sustainability. Sources that were duplicative, only tangentially related, or insufficiently documented for verification were not used as substantive evidence.

Two evidence groups were used. Official BPS-Statistics Lampung Province releases supplied regional production and Agricultural Census information, while Regional Development Planning Agency documents established the provincial downstreaming policy context [9]-[11]. Peer-reviewed studies were selected for their direct relevance to value addition, agrifood value-chain transformation, Lampung commodity systems, farmer-market relationships, post-harvest infrastructure, finance, digitalization, and sustainability. Preference was given to sources with traceable publication records and DOI identifiers, and to studies that either addressed Lampung directly or provided mechanisms that could be evaluated against the regional context.

3.3. Operational definitions / Analytical dimensions

Agricultural downstreaming was operationalized as the movement of agricultural commodities and services into higher-value functions, including post-harvest preservation, processing, quality differentiation, certification, logistics, branding, and market access. Regional value retention referred to the extent to which these functions create income, employment, enterprise capability, or service activity within Lampung rather than merely increasing processed volume. Inclusive downstreaming referred to arrangements in which farmers and local enterprises can participate under transparent quality, pricing, payment, and market conditions. Seven analytical dimensions were used: raw-material scale and consistency; post-harvest and processing capability; farmer institutions and governance; finance and investment access; standards, logistics, and market access; digital information and traceability; and environmental sustainability and resilience.

3.4. Data collection

Data collection consisted of structured documentary extraction. Regional facts and policy statements were recorded separately from conceptual and empirical claims in the journal literature. Commodity evidence was then organized by value-chain stage: production, post-harvest, processing, coordination, market access, and end use. For each source, the extraction focused on opportunities, constraints, enabling conditions, policy implications, and any directly reported regional statistics. No numerical value was recalculated, extrapolated, or imputed when the original source did not provide the necessary information. Table 1 summarizes the evidence domains and their analytical use.

3.5. Data analysis

The analysis used qualitative thematic synthesis and cross-commodity comparison. First, evidence was coded against the seven analytical dimensions. Second, commodity-specific downstreaming pathways were compared to identify recurring bottlenecks and enabling conditions. Third, the recurring mechanisms were integrated into a regional framework linking agricultural resources, post-harvest and processing capability, farmer institutions, finance, standards, market access, digitalization, and sustainability. The analysis distinguished observed regional conditions from proposed policy options so that recommendations were not presented as measured outcomes.

3.6. Validity, reliability, and trustworthiness

Trustworthiness was strengthened through claim-source matching, source triangulation, and explicit separation of regional evidence from broader transferable literature. Numerical statements about Lampung were traced to official BPS sources [9], [10], and the regional policy context was checked against Bappeda documentation [11]. Commodity interpretations were compared across multiple peer-reviewed sources where available, especially for cassava and coffee. DOI and bibliographic details were checked for the scholarly references used in the synthesis. The analysis also avoided generalizing a finding from one commodity to another unless the mechanism was supported by cross-cutting value-chain evidence.

3.7. Ethical considerations

The study used only publicly available secondary statistics, policy documents, and published scholarly literature. It did not involve human participants, personal identifiers, interventions, or private records. Institutional ethics approval and informed consent were therefore not required for the documentary analysis.

Table 1. Evidence base and analytical dimensions used in the regional synthesis.

Evidence domain	Principal sources	Analytical focus	Use in synthesis
Regional production and structure	BPS Lampung; ST2023	Scale, commodity diversity, enterprise structure	Establishes resource base without inferring welfare effects
Regional policy	Bappeda Lampung	Downstreaming priorities and coordination needs	Defines current planning relevance
Lampung commodity studies	Cassava, coffee, agroindustry studies	Partnerships, competitiveness, risks, local processing	Identifies commodity-specific mechanisms and constraints
Cross-cutting value-chain literature	Peer-reviewed international and Indonesian studies	Inclusion, markets, finance, post-harvest, digitalization, sustainability	Supports transferable mechanisms and enabling conditions

4. Results and Discussion

4.1. Results

4.1.1. Agricultural resource base and downstreaming rationale

The first result is that Lampung has sufficient commodity diversity to justify a portfolio approach to downstreaming. The 2023 Agricultural Census places cassava, rice, livestock, coffee, rubber, maize, and coconut among the province's major individual-farm commodities [9], while the 2025 paddy data demonstrate substantial food-crop scale [10]. The evidence does not imply that all commodities should be processed locally to the same degree. Rather, it indicates that the province has several raw-material systems from which different forms of value addition can be developed. Some require industrial processing, others depend more on post-harvest quality, logistics, certification, or coordinated market access.

The regional evidence also suggests that production strength alone is insufficient. Lampung's agricultural economy is highly connected to other sectors [7], but regional development potential depends on how production zones connect to processing, markets, infrastructure, and service functions [8]. The policy challenge is therefore to convert production advantage into value-chain capability. This shifts the emphasis from a single downstream factory toward a sequence of functions: consistent raw materials, quality preservation, processing where economically justified, standards, finance, logistics, marketing, and governance.

4.1.2. Commodity-specific downstreaming pathways

Cassava offers the clearest industrial pathway. Lampung research documents established links among farmers, traders, tapioca processors, and other actors, but also persistent issues in partnership design, quality, price formation, and competitiveness [12]-[16]. Rural processing and Mocaf production demonstrate that value addition can also occur through smaller enterprises rather than only through large starch factories [17], [18]. Cassava's technical versatility supports food, starch, feed, bio-based, and energy applications [24], [25]. The strategic implication is to differentiate large-scale industrial uses from local enterprise opportunities and to improve the rules that connect both to farmers.

Maize has a different logic. Its downstream value is closely linked with drying, storage, feed formulation, and livestock production. The most immediate bottlenecks are therefore likely to be moisture management, storage, quality preservation, and coordination with feed and livestock markets rather than consumer-food processing alone. The Lampung evidence on cassava-livestock integration also illustrates how agricultural residues and livestock can be connected within a more circular regional system [39]. This supports a broader principle: downstreaming should search for inter-commodity linkages, not only linear transformation of one raw material into one final product.

Coffee downstreaming is more quality- and market-sensitive. Lampung coffee can capture additional value through selective harvesting, post-harvest control, grading, roasting, packaging, certification, branding, and access to differentiated markets. Evidence from Sumatra-Lampung links coffee certification with livelihood and environmental considerations [20], while robusta value-chain research shows the importance of product, process, functional, and channel upgrading [21]. The regional opportunity is

therefore not simply to roast more coffee locally, but to build quality assurance and market identity that allow producers and local firms to enter higher-value segments.

Cocoa, coconut, horticulture, rice, and livestock-related products offer additional pathways, but the evidence base is less uniform. For these commodities, the framework emphasizes functions rather than unverified production targets: fermentation and quality management for cocoa, small-scale processing and product differentiation for coconut, cold-chain and packing capability for horticulture, quality milling and branded products for rice, and feed-processing or integrated value chains for livestock. These options should be treated as candidates for feasibility assessment rather than as predetermined investment decisions.

Table 2. Illustrative downstreaming pathways for selected Lampung agricultural commodities.

Commodity	Potential value-adding pathway	Critical enabling conditions	Main risk	Policy direction
Cassava	Tapioca, Mocaf, foods, feed and bio-based products	Starch/quality standards, transparent pricing, reliable supply	Buyer concentration; price and quality disputes	Differentiate industrial and MSME pathways; strengthen contracts and farmer organizations
Maize	Drying, storage, feed and livestock integration	Moisture control, warehouses, feed-market coordination	Seasonal price and quality losses	Prioritize post-harvest infrastructure and feed-livestock linkages
Coffee	Quality green beans, roasting, packaging and differentiated markets	Post-harvest quality, certification, branding, buyer links	Inconsistent quality; weak access to premium channels	Build quality protocols, traceability and regional market identity
Cocoa / coconut	Fermented or processed ingredients and local consumer products	Quality improvement, equipment, packaging and market testing	Small scale; inconsistent supply or quality	Develop cluster-based MSME processing after feasibility assessment
Horticulture	Sorting, packing, puree/frozen products and cold-chain services	Cold chain, packing houses, food safety and logistics	Perishability and market volatility	Locate handling/processing near production and market corridors
Rice / livestock links	Quality milling, branded rice, feed and integrated processing	Quality control, storage, food safety and stable market demand	Thin margins; overcapacity if investment is supply-driven	Use demand and feasibility tests before major processing investment

4.1.3. Cross-cutting constraints to regional value capture

Across commodities, seven constraints recur. First is raw-material consistency: processors and higher-value buyers require predictable volume and quality. Second is post-harvest capability, including drying, storage, cold chain, packing, and testing [28]-[30]. Third is farmer-industry governance. When quality assessment, pricing, or payment terms are opaque, downstreaming can expand processing without improving producer bargaining conditions [12]-[16]. Fourth is finance: both farmers and enterprises need working capital and investment products suited to agricultural cycles [31]-[33]. Fifth is compliance capability, including food safety, certification, and traceability [27]. Sixth is market intelligence and digital access [34], [35]. Seventh is environmental and resilience performance [37], [38], [40]-[42].

These constraints interact. A new processing line cannot operate efficiently if raw-material quality is inconsistent; quality improvements may not be rewarded if contracts do not specify premiums; finance may not be repayable if market access is weak; digital platforms do not resolve weak logistics; certification may become a cost burden if it does not open a market; and industrial growth can create long-term costs when residue, water, or energy management is ignored. The central result is therefore systemic: regional value capture depends on the weakest links between production, coordination, infrastructure, capability, and market demand.

4.1.4. Integrated regional downstreaming framework

The synthesis is summarized in Figure 1. The framework begins with Lampung's agricultural resource base but does not assume that raw-material abundance leads automatically to local value added. Value creation occurs through five operational pathways: raw-material upgrading; post-harvest and processing capability; farmer institutions and fair partnerships; finance, standards, and market access; and circularity and resilience. These pathways are connected by cross-cutting conditions such as regional coordination, logistics, skills, transparent contracts, traceability, and market intelligence. The intended outcomes are

higher regional value retention, stronger farmer bargaining power, rural employment and MSME upgrading, and a more resilient regional economy.

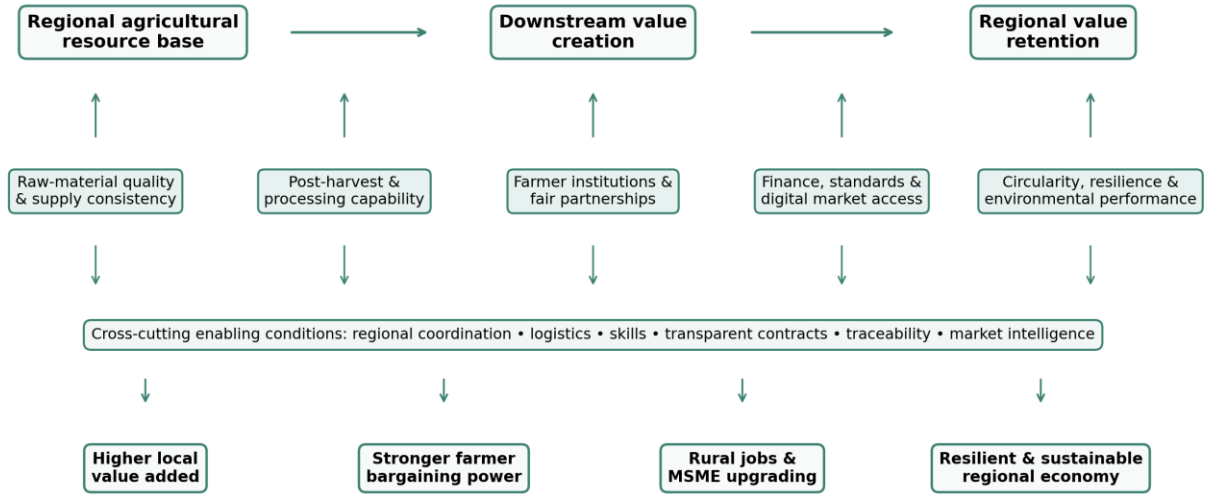


Figure 1. Integrated regional agricultural downstreaming framework for Lampung.

The framework should be read as a policy logic model, not a causal model estimated from field data. Its purpose is to identify the complementary conditions that should be tested in commodity-specific investment and implementation studies. It also prevents a narrow interpretation of downstreaming in which success is measured only by factories, installed capacity, or processed tonnage.

4.2. Discussion

4.2.1 From production advantage to regional value capture

The main implication is that production advantage and value capture are related but not equivalent. Lampung's diverse production base provides a strong starting point [9], [10], yet value can leave the region when commodities are traded in raw form, processing services are located elsewhere, or local actors lack access to differentiated markets. The literature on value-chain transformation supports a multi-level view in which upgrading requires changes at farm, chain, and institutional levels [22]. This explains why a downstream policy centered only on industrial capacity can underperform: value addition depends on the coordination of technical and institutional functions before and after processing.

The same reasoning cautions against maximizing local processing for its own sake. Some activities may be economically efficient at larger interregional scales, while others can be localized because freshness, transport costs, quality differentiation, or regional identity create an advantage. Feasibility therefore requires evidence on raw-material radius, utilization rates, energy, logistics, market demand, by-product use, and competing capacity. The framework proposed here does not replace those calculations. Instead, it identifies the conditions that should be included so that investment decisions account for farmers and regional value retention as well as plant economics.

4.2.2. Farmer-industry governance and smallholder inclusion

Lampung's cassava evidence makes governance especially visible. Research on partnerships, value-chain risk, competitiveness, and policy divergence repeatedly identifies institutional relationships as a source of both opportunity and vulnerability [12]-[16]. This means that farmer inclusion should be designed into downstreaming arrangements. Contracts should specify quality criteria, measurement procedures, price determination, deductions, payment schedules, volume commitments, and dispute mechanisms. Farmer organizations need enough commercial capability to aggregate supply, verify quality, negotiate, and manage information. Without these functions, downstream expansion can increase dependence on a limited number of buyers rather than strengthen farmer agency.

Collective marketing and cooperative research provides support for this institutional emphasis [26], [27]. The objective is not to prescribe one organizational form for every commodity. Cooperatives, farmer corporations, associations, or contract groups may work differently across local settings. What matters is

whether the organization reduces transaction costs, improves information, provides credible quality control, and increases bargaining capacity. For coffee and horticulture, producer organizations may also coordinate certification, collective branding, post-harvest equipment, or shared logistics.

4.2.3. Infrastructure, finance, and market capability

Post-harvest infrastructure should be treated as productive downstream capital. Dryers, warehouses, packing houses, cold rooms, refrigerated transport, quality laboratories, and shared processing facilities can preserve value that would otherwise be lost before industrial conversion [28]-[30]. Location matters: infrastructure should be matched to production density, perishability, transport corridors, energy availability, and buyer demand. Shared facilities can lower entry barriers for MSMEs, but they require viable management, maintenance, utilization, and fee models. Building infrastructure without an operating institution or market link risks creating underused assets.

Finance should follow the same value-chain logic. Research on agricultural value-chain finance indicates that transaction relationships can support credit assessment and reduce some lending frictions [31], while Indonesian evidence shows the need to adapt financing to agricultural cycles and actor constraints [32], [33]. For downstreaming, investment finance should be complemented by working capital, because processors may fail even with equipment if they cannot purchase raw materials, maintain inventory, or wait for buyer payment. Public support is therefore more effective when tied to credible business plans, buyer relationships, cash-flow analysis, and capability building rather than equipment grants alone.

Digitalization can strengthen these functions when it reduces information costs. Price information, buyer matching, inventory records, certification databases, traceability, digital payments, and logistics coordination can improve transparency and responsiveness [34]-[36]. However, digital systems should not be treated as evidence of transformation by themselves. Their value depends on adoption, data quality, interoperability, and whether smaller farmers and enterprises can use them. A regional digital platform should therefore solve a defined transaction problem rather than duplicate existing applications.

4.2.4. Sustainability and regional policy coordination

Environmental performance should be integrated at the design stage because downstreaming changes material and energy flows. Cassava, coffee, rice, maize, livestock, and horticulture generate different residues and wastewater profiles. Circular-economy approaches can create additional value from some residues, but technical feasibility, food/feed safety, collection costs, and markets must be verified [37]. Cleaner technologies, water and energy efficiency, and waste reduction can improve long-term competitiveness [38]. Lampung's cassava sustainability research also reinforces the need to evaluate economic, social, and environmental dimensions together [44].

Regional coordination is necessary because the relevant policy instruments are distributed across agriculture, industry, trade, cooperatives and MSMEs, food safety, environment, infrastructure, vocational education, finance, and local government. Bappeda's downstreaming agenda provides an appropriate planning entry point [11], but implementation needs commodity-specific roadmaps that identify responsible actors, sequence investments, and specify measurable outcomes. A coordinated roadmap can also reduce the risk that several agencies fund disconnected pieces of the same value chain without addressing the binding constraint.

4.2.5. Policy roadmap and monitoring indicators

A practical roadmap can be organized in three stages. The first is readiness diagnosis: map production, seasonality, existing processors, post-harvest gaps, buyer requirements, farmer organizations, and environmental constraints. The second is capability building: prioritize the infrastructure, finance, standards, skills, and governance arrangements that address the binding constraints. The third is market scaling: connect certified and consistent products with domestic or export buyers, while monitoring whether value and risk are distributed in line with regional development objectives. This sequencing allows the province to avoid premature investment in processing capacity before supply and market conditions are ready.

Monitoring should extend beyond output. Food-system scholarship argues for multidimensional monitoring because transformation produces interacting economic, social, and environmental outcomes [43]. For Lampung, indicators can include the share of local raw materials processed under transparent agreements, farm-gate price stability, farmer or MSME participation in higher-value channels, post-harvest loss reduction, utilization of shared infrastructure, certified product numbers, local employment, working-

capital access, waste valorization, water and energy efficiency, and recovery from supply disruptions. These indicators are illustrative rather than newly measured results; they identify what future implementation should track.

Table 3. Regional downstreaming policy roadmap and illustrative monitoring indicators.

Priority	Core intervention	Implementation question	Illustrative indicator
Raw materials	Quality protocols, extension, aggregation and supply planning	Can processors obtain consistent volume and quality without shifting unreasonable risk to farmers?	Share meeting agreed quality; delivery reliability; transparent rejection/deduction records
Post-harvest & processing	Dryers, storage, cold chain, packing, shared processing and testing	Is infrastructure located and managed where it solves a verified bottleneck?	Utilization rate; quality retention; post-harvest loss; service cost
Institutions & partnerships	Producer organizations, contract standards and dispute mechanisms	Do smaller producers have information and bargaining capacity?	Farmer participation; payment timeliness; contract compliance; dispute resolution
Finance & enterprise upgrading	Working capital, investment finance, business development and certification	Does finance match cash flow, markets and management capability?	Finance access; repayment; MSME upgrading; certification/market entry
Markets & digital systems	Buyer linkage, branding, traceability, market intelligence and logistics data	Does digitalization reduce a real transaction cost or information gap?	Active users; verified transactions; buyer diversity; traceable lots
Sustainability & resilience	Waste valorization, resource efficiency, diversification and contingency planning	Are current gains achieved without creating future environmental or concentration risks?	Waste use; water/energy intensity; supplier diversification; recovery time

4.2.6. Limitations

Four limitations define the scope of the conclusions. First, the study is based on documents and secondary evidence; it does not measure current margins, costs, employment, or bargaining outcomes at firm and farm level. Second, the evidence is uneven across commodities. Cassava is relatively well represented in the Lampung literature, whereas other commodity pathways rely more heavily on broader agrifood evidence and therefore require local verification. Third, the framework is qualitative and does not rank investments by net present value, internal rate of return, multiplier effect, or distributional impact. Fourth, policy and market conditions can change, so feasibility assessments should use current commodity, infrastructure, regulatory, and buyer data at the time of implementation. Future research should combine value-chain mapping, farmer and enterprise surveys, processing feasibility analysis, spatial cluster assessment, and longitudinal monitoring of value distribution.

5. Conclusion

Lampung's agricultural downstreaming opportunity lies not only in the volume of primary commodities but in the province's ability to coordinate multiple value-adding functions around them. The evidence supports a portfolio of commodity pathways: cassava offers established industrial and MSME processing opportunities; maize can be linked more closely with feed and livestock systems; coffee can capture value through quality, certification, roasting, branding, and differentiated markets; while cocoa, coconut, horticulture, rice, and livestock products require targeted feasibility assessment based on their own technical and market conditions. Across these pathways, the same conditions determine whether value is retained locally: raw-material quality, post-harvest capability, farmer institutions, fair partnerships, finance, standards, logistics, market access, digital information, and environmental performance.

The study's main contribution is an integrated regional framework that separates processing capacity from the wider governance system needed to make downstreaming inclusive. It also shifts evaluation from factory-centered indicators toward regional value retention, farmer bargaining conditions, MSME upgrading, employment, resilience, and sustainability. The framework does not establish causal income effects and should not be used as a substitute for commodity-level investment analysis. Its value is to provide a disciplined structure for deciding what evidence, institutions, and complementary investments are required before downstreaming projects are scaled. For Lampung, this approach offers a more defensible route from agricultural production advantage to inclusive and sustainable agroindustrial development.

Author contribution statement

Evi Ekawati: Conceptualization, Methodology, Investigation, Formal analysis, Writing - original draft, Visualization. Diah Mukminatul Hasyimi: Methodology, Investigation, Validation, Writing - review & editing, Supervision. Both authors reviewed and approved the final manuscript and agree to be accountable for the integrity of the work.

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Disclosure statement

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AI-assisted technologies disclosure

AI-assisted language tools were used only for proofreading and language refinement. The authors reviewed the final manuscript and remain fully responsible for its accuracy, originality, and integrity.

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Data availability statement

All data and documents analyzed in this study are publicly available from the official and scholarly sources cited in the article.

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