Techno-Economic Feasibility of Small-Scale Copra Processing across Coconut-Producing Districts in Buton Regency, Indonesia

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Abstract.
Copra remains the principal market outlet for coconut smallholders in many Indonesian islands, yet evidence on the financial feasibility of household-scale processing across heterogeneous producing districts remains limited. This study assessed the techno-economic feasibility of small-scale copra processing in seven coconut-producing districts of Buton Regency, Indonesia. A field-based cross-sectional design combined structured interviews, production records, direct process observation, and secondary district production statistics collected between September and December 2024. The analysis mapped the production base, documented the prevailing process, disaggregated fixed and variable costs, and estimated revenue, net income, and the benefit-cost ratio. Coconut production increased from 1,353.30 t in 2022 to 1,472.00 t in 2023 despite a small decline in cultivated area. The observed process uses dehusking, splitting, initial drying or smoking, kernel removal, final drying, cutting, and bagging. Mean total cost per processing cycle was IDR 9,103,942.98, of which variable costs accounted for 88.5%. Mean revenue was IDR 13,605,489.71 and mean net income was IDR 4,501,546.72. All districts were financially feasible, with benefit-cost ratios from 1.480 to 1.505. Lasalimu achieved the highest revenue and net income, while narrow interdistrict differences show a common low-technology production regime. The principal constraint is therefore not basic profitability but process dependence on raw-material and labour costs, weather-sensitive drying, and weak quality control. The study recommends low-cost dryer upgrading, standardized moisture and cleanliness control, collective input procurement, and district-specific technical support to convert existing production potential into more resilient rural agroindustry.
Keywords: *benefit cost ratio; copra processing; coconut agroindustry; rural technology and techno economic feasibility.*

I. INTRODUCTION

Coconut is a multipurpose perennial crop whose kernel, shell, husk, water, inflorescence, and biomass residues can support food, energy, industrial, and rural-enterprise activities. Its economic value, however, is not determined by production volume alone. The technologies used after harvest determine the proportion of physical output that meets buyer specifications, the amount of labour and fuel needed to obtain it, the exposure of producers to weather and quality loss, and the share of value retained in rural areas. Copra remains an important intermediary product because dried coconut kernel can be stored, transported, and sold into oil-processing chains. For smallholders it is often more accessible than higher-capital products such as virgin coconut oil or refined coconut products. Yet the accessibility of copra does not automatically establish that processing is financially sound or technically resilient. The practical question for district development is whether the household-scale process generates a reliable surplus after all costs are counted and, if so, which technical bottlenecks most constrain its improvement.

International research increasingly presents coconut agroindustry as a system of linked product choices rather than a single commodity chain. Mardesci et al. [1] identified coconut oil, coconut sugar, and shell charcoal as prospective integrated products in Indonesia, while technological surveillance by González et al. [5] emphasizes digitalization, process efficiency, circularity, and product diversification as major directions for the sector. These studies are valuable because they show why rural processing should be assessed as a pathway for upgrading local resources. However, an integrated-agroindustry agenda still needs basic enterprise evidence. Small processors cannot adopt a dryer, a grading practice, or a new product line unless current production generates cash flow, operating margins, and sufficiently predictable returns.

Techno-economic feasibility analysis provides that evidence by linking process steps and input use to observable financial outcomes.

The drying stage is central to copra quality and economics. Conventional sun drying and smoking are widely used because equipment requirements are low and the method is familiar, but both expose operators to variability in weather, smoke deposition, uneven heat, sanitation problems, and long process duration. Research on passive solar drying [9], indirect heat systems [12], and biomass-powered dryers [2] demonstrates that more controlled heat can shorten drying time and improve consistency. Related studies of infrared and hot-air drying also show that drying conditions influence moisture removal and quality characteristics of coconut products [18,19]. Such evidence does not imply that every smallholder should immediately purchase complex equipment. Rather, it establishes that a feasibility study must identify whether the cost structure and local throughput could justify incremental technological upgrading.

Evidence on copra quality strengthens this point. Processing arrangements affect the moisture condition and storage stability of dried kernel, which later influence oil quality and buyer acceptance. Comparative work on single- and multi-bed dried copra reported measurable quality differences associated with drying configuration [11], while observations of traditional processors in Sri Lanka underline the continuing importance of maintaining output quality in decentralized systems [4]. In small-scale settings, quality failure is not merely a technical issue: it translates into lower grades, price discounts, lost volume, and weaker bargaining power. Thus, a financially feasible enterprise can still be vulnerable if its return depends on a narrow range of buyer-tolerated quality conditions.

Indonesia offers a particularly relevant context because the coconut economy combines broad resource availability with geographically dispersed islands, rural transport constraints, and varied access to post-harvest technology. Contract farming evidence from North Sulawesi shows that cost and revenue structures can be altered by institutional arrangements around input, marketing, and risk sharing [6]. Studies from Malaysia similarly identify production constraints among coconut smallholders that extend beyond agronomy to labour, finance, technology, and information access [8]. These findings caution against treating feasibility as a universal ratio independent of place. A benefit-cost ratio has practical meaning only when interpreted with the scale of the operation, the local raw-material base, the labour organization, and the technological choices actually available to producers.

Buton Regency in Southeast Sulawesi is an appropriate setting for this analysis. Coconut is cultivated across Lasalimu, Lasalimu Selatan, Kapontori, Pasarwajo, Siotapina, Wolowa, and Wabula. Processing is largely household based and relies on familiar manual tools, locally available fuel, family labour, and bagged marketing. The district therefore reflects a common island-agroindustry condition: a meaningful supply base exists, but the capacity to transform that base into standardized products with predictable returns remains uneven. The study does not test an engineering prototype. Instead, it evaluates the techno-economic performance of the existing technology regime, identifies the cost and return profile generated by that regime, and provides an empirical benchmark for future improvements.

The study addresses four questions. First, how did the district production base change between 2022 and 2023? Second, what process configuration characterizes household-scale copra production in the study area? Third, how are processing costs distributed across districts? Fourth, are revenues and benefit-cost ratios sufficient to establish financial feasibility, and what do their patterns imply for technology and management interventions? This combination is relevant to IJSTM because it connects process technology, production management, and economic performance rather than treating any one of these dimensions in isolation.

The article contributes in three ways. Empirically, it reports comparable cost and return evidence from seven districts rather than a single case. Methodologically, it places descriptive production data, observed process flow, cost structure, and financial indicators in one ordered analytical sequence. Practically, it specifies why low-cost upgrading should focus on reducing process variability and cost exposure rather than assuming that all profitable small enterprises need the same technology. The paper is organized as follows: the next section explains the data and analytical procedure; the results first establish the production context, then describe the process, and finally evaluate cost and feasibility; the discussion interprets the results in relation to rural technology choice and management; the final section presents conclusions and targeted recommendations.

II. METHODS

This study used a cross-sectional field-based techno-economic design. The empirical work was undertaken in Buton Regency, Southeast Sulawesi, between September and December 2024. The study area comprises seven coconut-producing districts: Lasalimu, Lasalimu Selatan, Kapontori, Pasarwajo, Siotapina, Wolowa, and Wabula. The design was selected because the objective was to estimate the actual cost and return profile of prevailing household-scale processing, not to impose a controlled experimental technology. The unit of analysis was one observed or reported processing cycle at the processor level, aggregated to district averages. The analysis therefore represents current operating conditions rather than a forecast of returns under a new capital investment.

Primary data were obtained through structured interviews with active copra processors, direct observation of process steps, and examination of operating records where available. Respondents were selected purposively from producing districts because they had operated for at least two years and could report production volumes, input use, labour, and selling prices. The study included 489 copra processors distributed across the seven districts. Secondary data on cultivated area and coconut output were compiled from local agricultural records. The combination of processor evidence and administrative production statistics served two purposes: district statistics established the scale and recent trajectory of the raw-material base, while processor-level evidence established the economic logic of transformation into copra.

The process was documented from receipt of mature nuts to bagged copra. Field observation identified dehusking, nut splitting, initial drying or smoking, kernel removal, final drying, cutting, and bagging as the dominant sequence. This documentation is analytically important because each step creates a distinct source of material loss, labour requirement, fuel use, quality risk, or handling cost. The study did not measure moisture content, thermal efficiency, or emissions; consequently, technical assessment is confined to the observed configuration and its economic consequences. These limitations are stated explicitly because a full engineering assessment would require repeated instrumental measurement under controlled process conditions.

Cost analysis separated fixed and variable components. Fixed cost was represented by depreciation of processing equipment. Variable cost included raw coconut material, labour, kerosene, matches, and sacks. Total cost was calculated as the sum of fixed and variable cost for each district average. Revenue was calculated as copra output multiplied by the prevailing selling price. Net income was calculated as total revenue minus total cost. The benefit-cost ratio was calculated as total revenue divided by total cost. A ratio above one indicates that revenue exceeds the cost incurred during the processing cycle and is conventionally interpreted as financial feasibility for the observed operation. The analysis uses Indonesian rupiah (IDR) and reports values to two decimal places where supplied by field records.

The interpretation of the benefit-cost ratio follows two principles. First, it is a screening indicator, not a complete investment appraisal. It does not substitute for net present value, internal rate of return, payback period, or sensitivity analysis where a processor faces a new multi-year capital investment. Second, it must be read jointly with absolute income and cost composition. Two districts can have similar ratios but different cash requirements, operational scale, or exposure to volatile inputs. This distinction is important for small processors because liquidity constraints can limit viable technology adoption even where an enterprise is profitable on average.

For presentation, results are arranged in the same decision order faced by a district planner or processor. Table 1 first establishes the coconut resource base. Figure 1 then presents the existing process through which the resource becomes copra. Table 2 identifies the cost structure created by that process. Table 3 reports revenue, income, and benefit-cost outcomes. This ordering prevents the common problem of presenting financial ratios before readers understand the supply base and technical process that generate them. Descriptive comparisons are used because the objective is to identify operational patterns across all producing districts rather than test causal differences between randomly assigned groups.

Data credibility was supported through source and method triangulation. Production statistics were compared with field observations of processing activity, while reported volumes and prices were checked against the internal consistency of revenue and cost calculations. The analysis retains the practical character of smallholder records: figures are district averages rather than audited enterprise accounts. For this reason, the results should be interpreted as an evidence base for screening, benchmarking, and technology targeting. Future research should pair the present approach with direct measurement of moisture, yield loss, energy use, labour time, and quality grades so that the technical and financial components can be estimated with greater precision.

III. RESULT AND DISCUSSION

3.1 Coconut production base and supply implications

Table 1. Coconut cultivated area and production in Buton Regency, 2022-2023

District	Area 2022 (ha)	Area 2023 (ha)	Production 2022 (t)	Production 2023 (t)	Production change (%)
Lasalimu	893.00	905.00	730.00	785.00	+7.53
Lasalimu Selatan	561.00	570.00	191.75	217.70	+13.53
Siotapina	433.00	433.00	151.86	150.00	-1.23
Pasarwajo	478.00	472.00	151.81	169.00	+11.32
Wolowa	112.00	112.00	43.45	46.86	+7.85
Wabula	72.00	64.00	9.28	12.45	+34.16
Kapontori	262.00	242.00	75.15	91.00	+21.10
Buton Regency	2,811.00	2,798.00	1,353.30	1,472.00	+8.77

Source: Agricultural production records and field compilation, 2024.

Table 1 shows that the raw-material base expanded in output even though total cultivated area declined slightly from 2,811.00 ha in 2022 to 2,798.00 ha in 2023. Production increased by 118.70 t, or 8.77%, over the same period. This combination is important for a copra feasibility study. A stable or increasing output base improves the likelihood that processors can obtain mature nuts without raising collection distances or transaction costs excessively. At the same time, the area decline indicates that output growth should not be interpreted automatically as permanent capacity expansion. It may reflect better harvesting, temporal variation, or improved utilization of existing trees. Technology investment should therefore be scaled to verified throughput rather than to a single year of production growth.

Lasalimu had the largest cultivated area and production in both years, with output rising from 730.00 t to 785.00 t. Its size gives local processors a potential advantage in raw-material aggregation and continuity. Lasalimu Selatan also recorded a notable 13.53% increase in production with only a modest expansion of area. Kapontori and Wabula registered strong output growth despite declining area. These patterns suggest that district development cannot rely on area alone as a proxy for processing opportunity. A processor needs information about harvest concentration, collection logistics, and seasonal availability, not only total plantation hectares. Studies of coconut cultivation economics likewise show that productivity, input management, and tree condition materially shape economic outcomes [3,14,15].

Siotapina was the only district with a small production decline while area remained unchanged. This result does not establish a causal production constraint, but it highlights why technical support should not be distributed uniformly. Districts with stagnant output may require attention to crop husbandry, tree age, harvesting, or input access before they can sustain expanded processing. Conversely, districts with increasing production but shrinking area may need productivity monitoring to determine whether the pattern is durable. Smallholder constraints documented in Malaysia include labour shortages, high input costs, technical knowledge gaps, and uncertain marketing conditions [8]; these constraints are also plausible mechanisms in dispersed island systems and should be assessed locally before promoting additional processing capacity.

The aggregate production increase creates an opportunity for more reliable small-scale processing, but it also raises a management challenge. If drying capacity does not increase with harvest peaks, more nuts may be processed under rushed or poorly controlled conditions. This can worsen moisture variation, smoke exposure, and storage losses. The production table therefore functions as more than background information. It establishes the supply conditions against which the adequacy of existing drying and handling technology must be assessed. In practical terms, capacity planning should begin with the volume and timing of available nuts, followed by the throughput that manual and drying stages can sustain without reducing quality.

The evidence also supports a differentiated district strategy. Lasalimu, Lasalimu Selatan, and Kapontori can be considered priority locations for demonstrations or shared facilities because their production levels and observed processor activity indicate the ability to use equipment regularly. Pasarwajo should be assessed in light of its production growth despite reduced area, while Siotapina requires diagnostic support to understand its minor decline. Wolowa and Wabula may benefit more from modular, low-capital improvements than from large fixed equipment because their total production bases are smaller. Such differentiation is consistent with technology management principles: equipment should be matched to local feedstock, utilization rate, operating skill, and maintenance capacity rather than selected solely for technical sophistication.

3.2 Existing copra process and technology constraints

Fig. 1. Observed household-scale copra processing sequence in Buton Regency.
Source: Field observation, 2024.

Figure 1 presents the observed household-scale processing sequence. Mature coconuts are first dehusked to separate fibrous husk from the shell. The nuts are split manually, after which they undergo initial drying through sun exposure, smoking, or a combination of the two. The partially dried kernel is removed from the shell, dried further to reach marketable condition, cut into manageable pieces, and bagged for storage or sale. The sequence is technically simple, but it contains multiple points at which time, weather, heat control, and manual handling affect both cost and product quality.

Dehusking and splitting are low-capital operations but set the conditions for later drying. Consistent splitting improves exposure of the kernel and facilitates removal after initial drying. In practice, manual variation can produce uneven pieces that dry at different rates. This issue matters because the market value of copra depends on sufficiently dry, clean, and stable output. Research on coconut drying indicates that controlled systems can improve temperature distribution and reduce drying duration compared with unprotected sun drying [2]. The present field process does not demonstrate a need for immediate mechanization of all upstream operations, but it does indicate that simple standard operating procedures for splitting size, loading density, and cleaning could improve process consistency at low cost.

Initial drying is the most weather-sensitive stage. Sun drying has the advantage of negligible purchased energy cost, yet it can be interrupted by rain, constrained by available drying surface, and exposed to contamination. Smoking or direct-heating practices can provide continuity when sunlight is insufficient, but fuel use and smoke contact introduce new quality and occupational concerns. Earlier studies of copra dryers report that indirect heat, solar-assisted systems, and passive solar configurations can provide more stable conditions [9,10,12]. These technologies should be interpreted as a menu of design principles - heat control, airflow, shielding, and moisture management - rather than as a single device to be transferred without local adaptation.

Kernel removal occurs after the initial drying stage because moderate shrinkage makes separation from the shell easier. This creates a direct connection between heat exposure and labour productivity. If initial drying is too limited, removal requires more force and time; if it is excessive or uneven, kernel quality and breakage may be affected. The subsequent final drying stage is therefore not only a technical finishing operation but a quality-assurance step. Studies comparing dried copra configurations show that drying method can influence the quality of extracted oil [11]. For a processor selling raw copra rather than oil, the immediate concern is market acceptance; nevertheless, downstream quality implications matter because buyers may ultimately incorporate them into price and procurement decisions.

Cutting and bagging complete the transformation from fresh kernel to a tradable intermediate product. These final steps receive less attention than drying but are relevant to transport, storage, and inspection. Pieces that are relatively uniform and sufficiently dry can be packed more efficiently and are easier for buyers to assess. Grading evidence for dehusked coconuts shows that measurable physical attributes can reduce pricing ambiguity [16]. A practical implication for Buton is that even before formal laboratory testing is available, producer groups can introduce simple visual and handling standards for clean bags, separation of visibly defective material, and more uniform piece size. These practices can reduce the risk that a technically feasible process yields an inconsistent market product.

The technology implication is incremental upgrading, not wholesale replacement. The observed system has low entry barriers and is compatible with household labour, but it is exposed to variations in weather and manual execution. Improvements should be sequenced: first, standardize hygiene, splitting, drying surfaces, loading, and bagging; second, introduce simple moisture checks and insulated or covered drying arrangements; third, evaluate a shared indirect-heat or biomass dryer only where throughput, maintenance, and demand are sufficient. Such sequencing limits capital risk and aligns with evidence that rural technology adoption is more durable when the new configuration fits local skills, biomass availability, and operating incentives [2,5,17].

3.3 Cost structure of small-scale copra processing

Table 2. Average cost structure of small-scale copra processing by district

District	Fixed cost (IDR)	Raw material cost (IDR)	Other variable cost (IDR)	Total cost (IDR)
Lasalimu	1,069,412.12	5,635,454.55	3,130,172.73	9,836,039.39
Lasalimu Selatan	1,041,178.57	5,439,574.47	3,022,478.72	9,439,119.05
Kapontori	1,060,997.47	5,446,969.70	3,026,560.61	9,534,527.78
Pasarwajo	1,039,632.01	4,800,495.05	2,670,113.86	8,510,240.92
Siotapina	1,046,068.52	5,312,555.56	2,952,005.55	9,310,629.63
Wolowa	1,061,970.59	4,882,352.94	2,713,176.47	8,657,500.00
Wabula	1,054,573.53	4,747,058.82	2,637,911.77	8,439,544.12
Mean	1,053,404.69	5,180,637.30	2,878,917.57	9,103,942.98

Note: Other variable cost comprises labour, kerosene, matches, and sacks. Source: Field survey and calculation, 2024.

Table 2 shows that the enterprise is dominated by variable rather than fixed costs. Mean fixed cost was IDR 1,053,404.69, while mean total cost was IDR 9,103,942.98. Thus, depreciation represented only about 11.5% of total cost and variable requirements represented about 88.5%. Raw material alone averaged IDR 5,180,637.30, or approximately 56.9% of total cost. The remaining variable cost, which includes labour, fuel, matches, and sacks, averaged IDR 2,878,917.57. This structure means that financial performance is highly sensitive to the availability and price of mature nuts and to the organization of labour, rather than to the annualized cost of equipment.

Lasalimu recorded the highest total cost at IDR 9,836,039.39, followed by Kapontori and Lasalimu Selatan. Higher cost does not necessarily indicate lower efficiency. It may reflect larger throughput and greater use of purchased material and labour. The relevant managerial question is whether increased outlay produces proportionately greater output and revenue. At the other end of the range, Wabula had the lowest total cost, IDR 8,439,544.12, partly because raw-material and labour-related requirements were lower. A smaller absolute cost base can assist liquidity, but it can also signal limited scale and reduce the ability to spread fixed facilities or adopt new equipment economically.

The modest variation in fixed cost across districts indicates a common technology regime. Existing equipment is inexpensive, manually operated, and likely to be repaired locally. This characteristic lowers barriers to market entry and explains why household processing can persist. However, it also means that improvements cannot be evaluated only by asking whether new equipment lowers depreciation. A dryer or handling improvement may raise fixed cost but reduce weather delay, fuel waste, rejected output, or labour intensity. The appropriate feasibility comparison for future investment is therefore not between zero technology and expensive technology; it is between the total cost and reliability of the current manual process and the total cost and reliability of an adapted upgraded process.

Raw-material cost is the largest controllable economic exposure. In a dispersed plantation system, processors may use their own nuts, buy from neighbours, or combine both. Even when household-produced nuts are not paid for in cash, they have an opportunity cost and should be valued in feasibility calculations. Failure to include that value can overstate the apparent profitability of processing. The present calculations include raw-material value, which produces a more conservative and decision-relevant estimate. The result is aligned with cost and revenue analyses of coconut farming that recognize material and labour costs as central determinants of enterprise performance [3,6].

Labour and fuel costs require a different management response. Labour is embedded in dehusking, splitting, kernel removal, drying supervision, cutting, and bagging. Time-consuming manual stages create an opportunity for work organization, shared tools, or equipment that reduces repetitive handling. Fuel cost is linked to the extent of smoking or assisted drying. Where weather conditions increase reliance on smoke, energy expenditure may rise without guaranteeing uniform heat. Literature on biomass and solar-assisted drying suggests that efficiency gains can come from improved airflow, enclosed chambers, and use of locally available biomass rather than from reliance on electricity alone [2,9,10]. Before adoption, however, processors need records of actual labour hours, fuel quantities, and downtime, because average monetary cost alone does not identify the most efficient technical option.

Packaging and small consumables are minor in value but important in process discipline. Inconsistent bag quality, storage moisture, and mixing of clean and defective copra can undermine the value generated by otherwise adequate drying. The same is true for delayed transport after bagging. A feasible processing cycle does not guarantee that its product reaches the buyer in the same condition. Management support should therefore integrate cost control with a basic quality-management protocol: clean drying surfaces, protected storage, labelled bags, routine sorting, and a simple buyer-aligned acceptance checklist. The purpose is not to impose costly certification prematurely, but to make the existing operation more reproducible and less vulnerable to avoidable discounts.

3.4 Revenue, income, and financial feasibility

Table 3. Revenue, net income, and benefit-cost ratio of small-scale copra processing

District	Copra output (kg)	Price (IDR/kg)	Revenue (IDR)	Total cost (IDR)	Net income (IDR)	B/C ratio
Lasalimu	1,409.60	10,500	14,800,800.00	9,836,039.39	4,964,760.61	1.505
Lasalimu Selatan	1,350.59	10,500	14,181,166.67	9,439,119.05	4,742,047.62	1.502
Kapontori	1,362.67	10,500	14,308,000.00	9,534,527.78	4,773,472.22	1.501

District	Copra output (kg)	Price (IDR/kg)	Revenue (IDR)	Total cost (IDR)	Net income (IDR)	B/C ratio
Pasarwajo	1,200.13	10,500	12,601,351.49	8,510,240.92	4,091,110.56	1.481
Siotapina	1,331.76	10,500	13,983,433.33	9,310,629.63	4,672,803.70	1.502
Wolowa	1,220.59	10,500	12,816,176.47	8,657,500.00	4,158,676.47	1.480
Wabula	1,195.00	10,500	12,547,500.00	8,439,544.12	4,107,955.88	1.487
Mean	1,295.76	10,500	13,605,489.71	9,103,942.98	4,501,546.72	1.494

Source: Field survey and calculation, 2024.

Table 3 establishes that the observed small-scale copra operations were financially feasible in every district. Mean revenue reached IDR 13,605,489.71 per processing cycle, mean net income reached IDR 4,501,546.72, and the mean benefit-cost ratio was 1.494. Since all ratios exceeded one, revenue was sufficient to cover the measured fixed and variable costs. The finding is meaningful because the calculation includes raw-material value and labour-related cost rather than representing processing as a costless use of household coconuts. It indicates that copra can serve as a viable intermediate product for rural producers under prevailing price and cost conditions.

Lasalimu generated the highest output, revenue, income, and benefit-cost ratio. Its average output was 1,409.60 kg, revenue was IDR 14,800,800.00, net income was IDR 4,964,760.61, and the benefit-cost ratio was 1.505. The result is consistent with its larger production base and supports the interpretation that scale and raw-material availability can support better financial performance. Yet the difference from other districts is small. Lasalimu Selatan, Kapontori, and Siotapina each obtained ratios close to 1.50, while Wabula reached 1.487. This narrow range suggests that processors face broadly similar output prices, technologies, and cost conditions across the district.

The lowest ratios were recorded in Wolowa (1.480) and Pasarwajo (1.481), but both remained above the feasibility threshold. Their lower ratios should not be misread as evidence of failure. They show that a small reduction in output relative to cost can materially affect the surplus retained by a household enterprise. This is precisely why a benefit-cost ratio should be accompanied by absolute income and process information. A processor operating at a ratio of 1.48 may remain profitable, but may have limited liquidity to absorb a sudden increase in nut price, a period of rain, a fuel shortage, or a quality-related discount. Financial feasibility is therefore a necessary condition for sustainability, not a guarantee of resilience.

The uniform selling price of IDR 10,500 per kilogram clarifies the source of interdistrict variation. Because output price did not vary across the table, differences in revenue and ratio arise primarily from throughput, material conversion, and cost management. This is advantageous for diagnosis: rather than assuming that better performance requires higher market prices, district interventions can focus on technical and managerial factors under greater local control. These include reducing unnecessary handling, lowering drying delay, improving kernel recovery, organizing labour, controlling fuel use, and matching production batches to available drying capacity. Such measures can improve the numerator through greater marketable output and improve the denominator through lower avoidable cost.

The results also show why technology upgrading should be evaluated through incremental scenarios. An indirect-heat, solar-assisted, or biomass-powered dryer may improve reliability and quality, but its purchase and maintenance costs should be tested against the existing mean surplus. For instance, a new dryer should demonstrate not only a shorter drying time but also a credible pathway to reduce rejected output, stabilize throughput during wet periods, or reduce labour and fuel expenses. Evidence from biomass-powered drying shows substantial reductions in drying duration under controlled operation [2], and solar-greenhouse systems can offer emissions advantages alongside performance gains [10]. Those results provide useful design benchmarks, but the financial decision in Buton must be made using local capacity utilization, repair access, and the processor seasonal cash flow.

practical first intervention is a processor record system. Each enterprise or producer group should record number of nuts received, kernel weight, copra output, days or hours of drying, labour days, fuel used, rejected material, selling price, and buyer comments. These records would allow future work to estimate conversion efficiency, labour productivity, and sensitivity to input prices. They would also transform the current cross-sectional feasibility evidence into a management tool. Without such records, decisions about dryers or handling tools are likely to be based on anecdote rather than evidence. With them, processors can compare batches and identify whether a technology change actually improves the benefit-cost ratio.

The findings support a circular-economy perspective but do not require speculative diversification. Copra processing produces husk and shell streams that can be used or marketed separately if collection, quality, and buyers are available. Recent work on white-copra production highlights the relevance of circular-economy approaches [13], while broader supply-chain research identifies diversification and value recovery as important technological trends [5]. For Buton, the immediate priority remains stable and financially sound copra production. Residue utilization should be pursued as a complementary pathway only when it does not divert labour or capital from the quality control necessary for the core product. This sequencing prevents the common mistake of promoting multiple products before the primary process is technically reliable.

The broader development implication is that profitability exists but is fragile in its technology base. Small processors do not require an argument that copra has no value; Table 3 shows positive income in all districts. They require support that converts current feasibility into repeatable performance. Local government, extension services, and producer organizations can facilitate this by conducting district-specific dryer demonstrations, establishing simple quality standards, supporting collective purchase of sacks and maintenance materials, and connecting processors with buyers who specify transparent quality requirements. Where production is sufficiently concentrated, shared dryers should be tested through a business model that specifies ownership, booking, fuel responsibility, maintenance, and cost recovery before installation.

3.5 Implications for technology and rural enterprise management

The ordered evidence in this study leads to a clear interpretation. Buton has a meaningful coconut resource base; household processors already possess a functioning transformation process; that process generates a positive financial surplus; and its principal weaknesses lie in reliability, cost exposure, and quality consistency rather than in the absence of economic rationale. This interpretation differs from a purely production-oriented diagnosis. Expanding plantation area alone would not resolve weather-sensitive drying, inconsistent handling, or variable labour productivity. Equally, importing advanced machinery without verifying utilization and maintenance would introduce a new financial risk. The appropriate strategy is technology management: progressively match process controls to the volume, cash flow, and skills of each producing district.

Technical interventions should be ranked by feasibility. Low-cost improvements include raised or protected drying surfaces, standard batch loading, clean cutting tools, protected storage, and simple moisture-testing routines. Intermediate improvements include improved smoke channels, indirect heat arrangements, biomass heaters, and better airflow management. Higher-cost interventions include shared mechanical dryers, collective grading equipment, and organized logistics. The present cost structure indicates that a small increase in fixed cost can be justified only if it reduces a larger variable cost or reliably increases marketable output. This is a more defensible criterion than adopting technology because it appears modern or because it has been successful under different climatic, energy, and market conditions.

Quality management must accompany financial management. The uniform output price in Table 3 may conceal quality variation that was not priced differently at the point of observation. As markets become more demanding, moisture, cleanliness, aflatoxin risk, smoke contamination, and storage condition may become more important. Research on drying configurations and coconut quality [4,11,18,19] suggests that process control matters for downstream performance. Buton processors can begin with achievable indicators: defined drying end-point practices, clean bag storage, separation of visibly defective material, and buyer feedback logs. These indicators can later be connected to instrumental moisture measurement and formal grading when market incentives justify the added cost.

Institutional arrangements are also part of feasibility. Individual households may not generate enough volume to use a shared dryer continuously, purchase a moisture meter, or negotiate transport efficiently. A producer group can pool volumes, schedule equipment, procure inputs, and collect quality information. Contracting arrangements can also reduce uncertainty when they improve transparency rather than transfer excessive risk to producers. Evidence from North Sulawesi points to the importance of cost and revenue relationships within coconut farming arrangements [6], while Ghanaian studies of value-added coconut businesses emphasize that livelihood gains depend on the distribution of labour opportunities and the terms through which producers enter commercial chains [7]. The lesson for Buton is that technology support should include governance rules for access, pricing, maintenance, and benefit distribution.

Environmental performance should be treated as a co-benefit, not an unverified claim. Biomass and solar drying can potentially reduce reliance on fossil fuels and improve combustion management, but this study did not measure energy use or emissions. It therefore cannot claim that the current process is low carbon or that a particular alternative would reduce emissions in Buton. The relevant next step is a field experiment measuring fuel input, drying duration, temperature, moisture, and product quality under the current and upgraded configurations. The resulting data could support a full techno-economic and environmental assessment, including energy productivity and emissions per kilogram of marketable copra. Such evidence would connect the financial baseline reported here with the sustainability orientation increasingly expected in technology and management research.

The study has limitations. It is based on a single cross-sectional period and uses district averages, so seasonal price variation, rainfall shocks, and household-level heterogeneity are not estimated. The benefit-cost ratio is appropriate for current-cycle feasibility but does not replace discounted-cash-flow appraisal for a new dryer investment. Process data are observational; no moisture, heat, fuel-consumption, or oil-quality measurements were taken. The study also does not estimate causal effects of district location, labour organization, or technology choice. These limitations do not negate the results. They define their use: the article provides a credible baseline for operational benchmarking and intervention design, while future research should test specific technologies with repeated measurements and explicit investment scenarios.

A future research agenda follows directly from these limitations. First, collect batch-level data across wet and dry periods to estimate yield, drying time, energy use, and quality variability. Second, compare existing smoke- and sun-based practices with a locally designed indirect-heat or biomass dryer using the same kernel inputs. Third, calculate net present value, internal rate of return, payback period, and sensitivity to nut price, labour wage, fuel cost, and utilization rate. Fourth, assess whether producer groups can operate shared equipment at adequate capacity. Fifth, include buyer-side quality requirements and transport cost so that the analysis follows copra from raw material to accepted sale. These steps would generate the stronger causal and engineering evidence required before large-scale equipment deployment.

IV. CONCLUSION

Small-scale copra processing in Buton Regency was financially feasible in all seven observed coconut-producing districts. The district resource base increased in production from 1,353.30 t in 2022 to 1,472.00 t in 2023, while the prevailing manual process transformed mature nuts through dehusking, splitting, staged drying, kernel removal, final drying, cutting, and bagging. Average total cost was IDR 9,103,942.98, dominated by variable inputs, especially raw material and labour. Average revenue and net income were IDR 13,605,489.71 and IDR 4,501,546.72, respectively, and the mean benefit-cost ratio was 1.494. The narrow ratio range of 1.480-1.505 indicates a common low-technology production regime across districts rather than sharply divergent financial conditions.

The principal policy implication is to protect and improve an already viable enterprise. Interventions should prioritize standard operating procedures for drying and handling, simple quality control, reliable batch records, collective input procurement, and carefully tested shared drying technology where throughput supports it. New equipment should be justified by measurable improvements in output quality, drying reliability, labour productivity, fuel use, or loss reduction, not by novelty alone. This approach can convert the current positive financial surplus into a more resilient and technically managed coconut agroindustry for Buton.

V. ACKNOWLEDGMENTS

The author acknowledges the coconut processors, local agricultural officers, and field assistants in Buton Regency who supported data collection and verification.

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