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OPTIMIZING COMMUNITY FISH PROCESSING THROUGH INTEGRATED FORECASTING, LINEAR PROGRAMMING, AND ECONOMIC VALUATION IN THAILAND

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Abstract

Community-based fish processing enterprises face severe uncertainties in raw material supply and market demand, leading to persistent underutilization of capacity and significant opportunity costs. To address these complex challenges, this applied research study developed a production planning system for salted fourfinger threadfin producers in Thailand. Using a participatory action research approach, the study successfully integrated time-series forecasting with a linear programming (LP) optimization model guided by bottleneck analysis. Results showed that exponential smoothing clearly outperformed alternative forecasting methods in handling data volatility. Furthermore, the LP model effectively optimized raw material allocation across preparation, drying, and storage stages. Bottleneck analysis identified sun drying as the primary constraint; scenario simulations demonstrated that expanding drying and cold storage capacities substantially reduce distress sales and improve throughput. A five-year economic evaluation validated the intervention's financial viability, yielding a Benefit-Cost Ratio of 1.95 and an Internal Rate of Return of 32.49%. Ultimately, integrating forecasting with LP-based planning significantly enhances operational efficiency, economic value, and sustainability for community-scale fishery enterprises.

Keywords: Production Planning Optimization, Linear Programming, Time-Series Forecasting, Bottleneck Analysis, Community-Based Enterprises

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Introduction

Community-based enterprises for fish processing (CEFPs) play a critical role in adding value to coastal fishery products. However, they typically operate under substantial uncertainty in both raw-material availability and market demand. In Nong Chik District, Pattani Province, salted fourfinger threadfin (Kulao) producers regularly face fluctuating landings driven by weather variability, leading to unstable capacity utilization and cash flow. Similar challenges are widely reported in small-scale fisheries, where climatic uncertainty and seasonal consumption patterns create persistent mismatches between supply and demand (Yanfika et al., 2022). When fresh fish landings exceed processing capacity, CEFPs are often compelled to sell raw fish at low prices rather than converting them into higher-value salted products, resulting in lost opportunities (Kumaran et al., 2021). These problems are intensified by limited drying and storage capacity, working-capital constraints, and operational bottlenecks that restrict throughput and flexibility (Clegg, 2018). Decision-making is further constrained by fragmented data practices and reliance on tacit knowledge, which weakens production and inventory control (Kościelniak & Puto, 2015). Although advanced forecasting and optimization methods are well established, their data and expertise requirements limit their applicability at the community scale (Klemm & McPherson, 2017). The practical challenge, therefore, lies in transforming limited and volatile data into a transparent, auditable production plan aligned with real processing constraints. Scenario-based planning offers a suitable pathway in such contexts (Teerasoponpong & Sopadang, 2021). Accordingly, this study adopts a forecast-to-plan approach that integrates simple time-series forecasting with linear programming (LP) in a spreadsheet environment to coordinate decisions on receiving, processing, storage, and sales. It evaluates it using mean absolute percentage error (MAPE). The framework is reinforced by the Theory of Constraints (TOC) and sales and operations planning (S&OP) to focus on dominant bottlenecks and reconcile forecasts with feasible capacity (Rota & de Souza, 2021). Beyond operational performance, the study also evaluates economic implications, as inefficient capacity utilization contributes to income instability in small-scale fisheries (Bassett et al., 2021). The study aims to develop a forecasting system, implement an LP-based planning tool, and assess the resulting economic benefits through a participatory action research approach.

Literature Reviews

TOC and S&OP as System Pacemakers

TOC and S&OP are widely recognized as central mechanisms for regulating throughput in production systems. TOC's drum-buffer-rope logic defines the production pace according to the system's bottleneck, protects flow with buffers, and synchronizes work release to reduce variability-induced losses (Orue et al., 2021). Complementarily, S&OP integrates strategic and operational decision making by reconciling demand forecasts with capacity constraints into a single, shared plan. By aligning sales, operations, and related functions around common assumptions and data, S&OP enhances coordination and responsiveness under uncertainty (Tuomikangas & Kaipia, 2014).

Community-Scale Seafood Supply Chains

In community-level seafood processing, effective supply chain management is essential to stabilize raw-material availability and minimize waste in systems that depend on seasonal and weather-sensitive resources. In Thailand, the absence of systematic forecasting and flexible inventory policies has been identified as a key risk to sustainability in small-scale fisheries and processing enterprises (Sampantamit et al., 2020). Studies show that integrating sourcing, production, and marketing information—particularly through digital tools—significantly improves efficiency compared with silo-based operations (Tsolakis et al., 2021). Moreover, small-scale fisheries with diversified sales channels and strong domestic market linkages

demonstrate greater resilience to demand and supply shocks (Mangano et al., 2022), underscoring the importance of strengthening community-level supply chain capabilities.

Forecasting Techniques for Small Enterprises

For community-based enterprises, the goal of forecasting is not methodological sophistication but usability and suitability in limited-data environments. Simple methods such as simple moving average (SMA), weighted moving average (WMA), and exponential smoothing (ES) often offer the most favorable cost-benefit trade-off. While SMA and WMA are appropriate for relatively stable series, ES is more responsive to recent changes and better suited to volatile conditions (Gruevski & Gaber, 2021; Sinaga & Irawati, 2018). Although advanced models such as ARIMA can yield high accuracy, their data and expertise requirements often exceed the practical capacities of small enterprises, making simplicity and data fit more appropriate criteria for method selection (Estrada et al., 2020).

Production Planning, LP, and Economic Evaluation

Production planning is central to small enterprise management because labor, equipment, and raw materials are inherently constrained. Prior research shows that demand signals influence performance mainly through coordination and integration mechanisms rather than direct capacity expansion, particularly in resource-limited operational contexts, providing a conceptual basis for translating demand-supply alignment into bottleneck-constrained production planning (Mooleng & Khongyoung, 2025). Spreadsheet-based tools combined with LP enable systematic planning of production, storage, and sales decisions while explicitly accounting for capacity limits and operational trade-offs faced by small enterprises (Ivanov et al., 2019). When integrated with TOC, LP supports focused improvement at binding constraints and enhances responsiveness to demand variability. From an economic perspective, the Resource-Based View (RBV) explains how such planning interventions generate value by improving utilization of tangible and intangible resources (Barney, 1991). Accordingly, economic evaluation frameworks—such as cost-benefit analysis, BCR, and IRR—are widely used to assess whether coordination and capacity-utilization improvements yield net benefits in small-scale fisheries and agro-processing systems (Stacey et al., 2021).

Applied Research and Participatory Action Research

Combining applied research with participatory action research (PAR) provides a suitable foundation for community-based production studies. Applied research ensures analytical rigor, while PAR emphasizes stakeholder participation throughout problem definition, tool design, and implementation, enhancing ownership and sustainability of outcomes (Islam, 2020). Such participatory approaches are consistent with S&OP principles and have been shown to strengthen socio-economic resilience in community enterprises (Kaipia et al., 2017).

Research Methodology

Research Design

This study employs an applied research design grounded in PAR to translate forecasting and production-planning knowledge into practice for CEFPs operating under persistent resource constraints and uncertainty in dynamic community-based production environments. The objective is to develop a raw-materials and production-management system aligned with local operational realities while improving efficiency and stabilizing community income in a sustainable, participatory manner. PAR places small-scale fishers and CEF members at the center of the research process, involving them in problem diagnosis, data collection, tool development, testing, and evaluation through continuous engagement and iterative feedback cycles. This collaborative approach promotes shared learning, local ownership, and sustained use of the resulting tools (Ateweberhan et al., 2018). Explicit attention to local physical, social, and institutional constraints further strengthens community resilience to economic and environmental change (Zamroni et al., 2019).

Study Site and Participants

The study was conducted in Bangtawa Subdistrict, Nong Chik District, Pattani Province, a coastal community whose livelihoods depend on small-scale fishing and fish processing. Raw material availability and market demand are highly variable. The target groups comprised (i) two small-scale fisher groups (six households each) that recorded daily landings of Kulao and (ii) two processing groups (three operators each) that provided data on processing practices, raw-material purchasing, and product sales. Participants were selected using purposive sampling to ensure direct involvement and contextual knowledge relevant to an in-depth case study (Borges et al., 2021). Participation was voluntary, with the right to withdraw at any time, ensuring ethical and transparent data collection. Ethical approval for this research was granted by the Human Research Ethics Committee, College of Public Health Sciences, Yala Province, under approval number SCPHYLIRB-069/2565.

Research Procedures

The research followed a staged PAR process adapted from Apgar et al. (2017). First, system reconnaissance mapped the production process, identified bottlenecks, assessed space utilization, and documented working-capital constraints. Second, baseline data were collected, including daily fresh-fish landings and monthly customer orders. Third, a preliminary spreadsheet-based forecasting model using simple time-series methods was developed. Fourth, initial results were discussed in a focus group to refine assumptions and parameters. Fifth, a prototype production-planning system was created by integrating the forecasting module with an LP formulation implemented via Solver to generate feasible plans under real capacity constraints. Sixth, improvement scenarios were jointly reviewed in a second focus group. Seventh, operators received hands-on training in inputting data, running Solver, and interpreting results. Finally, follow-up observations and evaluations assessed real-world use and informed system refinement.

Instruments, Data Collection, and Analysis

Both quantitative and qualitative instruments were employed. These included daily fresh-fish logs, monthly business ledgers, and a forecasting-and-planning spreadsheet for model selection, planning, and scenario analysis. Forecast accuracy was evaluated using MAPE to ensure practitioner interpretability. Semi-structured interviews captured user perceptions, which were analyzed using content analysis and descriptive statistics. Monthly production-plan forms enabled before-and-after comparisons. Instrument content validity was reviewed by experts, yielding an average Index of Item-Objective Congruence (IOC) of 0.95, exceeding the accepted threshold of 0.67 (Obiero et al., 2019). To enhance methodological rigor and transparency, particular attention was given to data reliability, model validation, and practitioner usability throughout the research process. Prior to formal analysis, raw data obtained from fisher logs and enterprise records were screened for completeness, outliers, and internal consistency through cross-checking with interview notes and on-site observations. Missing or implausible entries were discussed with participants during feedback sessions and corrected only when corroborated by multiple sources, in line with participatory action research principles. For forecasting model selection, accuracy was not the sole criterion. In addition to MAPE, methods were evaluated based on interpretability, ease of implementation, and compatibility with spreadsheet-based decision making, which are critical for sustained use in community enterprises. Although higher forecasting precision is desirable, the study prioritizes robustness and transparency over marginal gains in statistical accuracy, recognizing that forecasts function primarily as planning signals under structural uncertainty rather than precise predictions. With respect to the LP model, structural validity was ensured by grounding all constraints and parameters in empirically observed process capacities. Capacity values for preparation, drying, and storage were derived from time-and-motion observations, equipment specifications, and operator experience, rather than theoretical maxima. Scenario simulations

were then used as internal validation to assess whether model outputs remained feasible and economically plausible under alternative capacity configurations. Finally, the integration of forecasting, LP, and bottleneck analysis was iteratively refined through practitioner feedback. This iterative validation ensured that the resulting planning system was not only analytically sound but also operationally feasible, auditable, and aligned with local decision-making practices, thereby increasing the likelihood of continued adoption beyond the research period. A five-year cost-benefit analysis (CBA) assessed the economic implications of the optimized system, following standard appraisal practice for community-scale investments (Akinyi et al., 2022). Benefits included increased processed-fish throughput, reduced distress-sale losses, improved utilization of drying and storage capacity, and income gains along the local value chain; costs comprised equipment upgrades, training, and system development. Economic performance was summarized using the Benefit-Cost Ratio (BCR), Social Return on Investment (SROI), and Internal Rate of Return (IRR), based on appropriate discount-rate assumptions, consistent with participatory planning objectives and long-term community development priorities.

Research Results

Forecasting For Supply and Demand

To support production planning amid volatility, a forecasting module was developed based on disciplined yet simple record-keeping that local actors could consistently maintain over time without imposing an excessive administrative burden or requiring advanced technical skills. Small-scale fishers maintained daily logs of fresh kulao landings, while processing groups recorded monthly customer orders using standardized templates designed to ensure data consistency and comparability across reporting periods. Analysis revealed high variability in both supply and demand, with no temporal synchronization across the observed periods. From January to May, supply consistently exceeded demand, reflecting limited processing capacity and the absence of structured plans to convert surplus raw material into value-added products in a timely and coordinated manner. Conversely, from July to September, demand exceeded supply, requiring procurement from outside the locality to maintain market continuity and meet existing contractual obligations. This seasonal mismatch suggests that deliberate inventory building during oversupply periods—supported by adequate drying and cold-storage capacity—could improve fulfillment during low-supply months, stabilize order satisfaction rates, smooth production schedules, enhance planning reliability, and reduce reliance on external sourcing. Three time-series methods were implemented in a spreadsheet environment: SMA, WMA, and ES. Forecast accuracy was evaluated using MAPE. For supply, MAPE values were SMA = 409%, WMA = 352%, and ES = 144%; for demand, MAPE values were SMA = 102%, WMA = 127%, and ES = 50%. ES consistently outperformed averaging methods and was selected for both series. Although supply-side MAPE remained relatively high, this reflects structural volatility typical of small-scale fisheries rather than model inadequacy or poor data management practices. Overall, the forecasting module provides a transparent, practical, and implementable decision-support signal for monthly production planning under real operational constraints.

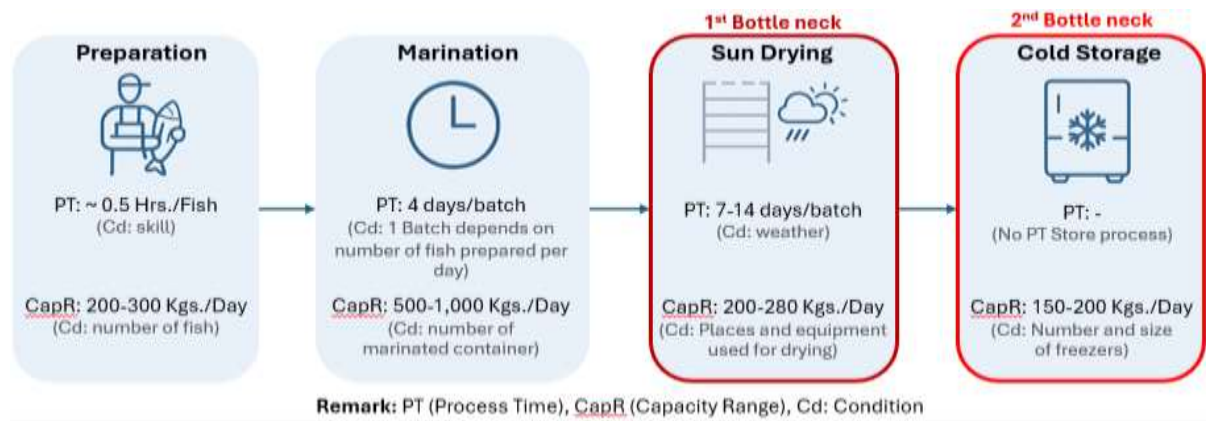


Figure 1 Main process flow and bottleneck identification

Bottlenecks and the LP-Based Planning System

A spreadsheet-based production-planning system was developed to minimize opportunity loss when fresh fish cannot enter processing within the monthly cycle, thereby supporting more consistent operational decision-making over time while respecting binding operational constraints. Prior to optimization, on-site observations and in-depth interviews were conducted to map the production flow, quantify step-wise capacity, and identify bottlenecks (BN). The analysis consistently identified drying as the dominant BN. Drying space was limited, some equipment was worn, and the drying cycle was lengthy (approximately 7-21 days) and weather dependent, resulting in discontinuous flow and persistent work-in-process (WIP) queues. Preparation capacity was also constrained because activities were concentrated in the morning, with labor handling only about 200-300 kg/day, limiting intake on high-landing days. Cold storage initially consisted of a single freezer (approximately 150-200 kg), which was not a primary BN under baseline conditions but was expected to become a secondary BN once drying capacity was elevated. Building on this diagnosis, monthly forecasts of fresh-fish receipts and customer orders were linked to an LP model implemented in a spreadsheet and solved using Solver. The model allocates quantities among processing, storage, and immediate sales under constraints that represent preparation capacity, drying capacity, cold-storage limits, warehouse space, and inventory balance. Outputs include feasible receive-produce-store-sell calendars, projected WIP levels, overload indicators, and KPI summaries. Under baseline capacities, the optimized plan distributed intake to match preparation and drying limits while using freezers as buffers to avoid forced low-price sales. However, the drying BN continued to generate backlogs during peak supply, indicating that optimization alone is insufficient without elevating the dominant constraint. Scenario simulations showed that targeted investments were effective. A two-tier drying-house scenario substantially increased effective drying capacity, reducing WIP accumulation; field piloting indicated roughly 500 kg/day of additional effective capacity per house. A freezer-expansion scenario increased cold storage from about 200 kg to 600 kg, enabling pre-production and shifting sales to higher-demand periods. Together, these results demonstrate that investing at the dominant constraint and main buffer materially improves feasibility and reduces opportunity loss. The LP formulation is provided below for clarity and replication in similar community-based operational planning contexts.

LP formulation

Decision Variables x_t = quantity of fresh fish allocated to processing in the period t(kg) y_t = quantity of fresh fish sold immediately without processing in the period t(kg) s_t = quantity of semi-processed or processed fish stored at the end of the period t(kg) All decision variables are non-negative. Parameters S_t = forecasted supply of fresh fish in the period t(kg) D_t = forecasted demand for processed salted fish in the period t(kg) C^{prep} = preparation capacity per period (kg) C^{dry} = drying capacity per period (kg) C^{stor} = cold storage capacity (kg) p^{proc} = unit selling price of processed salted fish (THB/kg) p^{raw} = unit selling price of fresh fish sold without processing (THB/kg)	Objective Function The objective is to minimize opportunity loss: $\min Z = \sum_t (p^{proc} - p^{raw}) y_t$ Constraints 1) Supply balance constraint: The total allocation of fresh fish in each period cannot exceed the available supply: $x_t + y_t \leq S_t \forall t$ 2) Preparation capacity constraint $x_t \leq C^{prep} \forall t$ 3) Drying capacity constraint (bottleneck constraint) $x_t \leq C^{dry} \forall t$ 4) Demand constraint $x_t \leq D_t \forall t$ 5) Storage capacity constraint $s_t \leq C^{stor} \forall t$ 6) Inventory balance constraint $s_t = s_{t-1} + x_t - D_t \forall t$ 7) Non-negativity constraints $x_t \geq 0, y_t \geq 0, s_t \geq 0 \forall t$
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Economic Impacts of the Optimized System

To assess economic impacts, a five-year economic valuation quantified benefits generated across the salted kulao value chain. Gains arose from higher processed-fish throughput, reduced opportunity loss from distress sales during oversupply, improved utilization of drying and cold-storage capacity, and income improvements for related local actors enabled by a more stable processing cycle. These benefits were compared with costs for equipment upgrades, training, and system development using a cost-benefit analysis framework. The results indicate that the intervention is economically worthwhile from a societal perspective, with a BCR or SROI of 1.95 and an internal rate of return (IRR) of 32.49%. Consistent with operational findings, elevating the dominant constraint and strengthening buffering capacity through the forecast-to-plan system reduced avoidable losses and increased the share of raw material entering planned processing, generating measurable economic value over time under realistic community-level operating conditions and constraints across typical small-scale fisheries enterprise contexts worldwide.

Conclusion and Discussion

Forecasting Support Planning Under Uncertainty

The findings confirm that an appropriately designed forecasting system plays a foundational role in supporting production planning in CEFPs under uncertainty and in contexts characterized by fluctuating raw-material supply, seasonal demand patterns, and limited operational flexibility. Forecasting functions as a critical mechanism for aligning expectations with feasible actions rather than as a tool for precise prediction. Empirical results demonstrate that ES outperformed simple moving average and weighted moving average methods in both supply and demand forecasting, consistent with prior evidence that ES performs well in volatile

and irregular environments (Sinaga & Irawati, 2018). The suitability of ES extends beyond statistical accuracy. Its flexibility, interpretability, and low data requirements make it particularly appropriate for CEFs operating with sparse, noisy, and imperfectly recorded data. These characteristics are essential in community-scale settings, where advanced analytical expertise and continuous model recalibration are often infeasible. Although more sophisticated methods such as ARIMA can achieve high levels of forecasting accuracy in data-rich and stable contexts (El Filali et al., 2022), the literature consistently emphasizes that simpler forecasting approaches are more effective when data availability, technical skills, and system maintenance capacity are constrained (Sidqi & Sumitra, 2019). The relatively high MAPE observed for the fresh-fish supply should therefore be interpreted as reflecting structural volatility inherent in small-scale fisheries, driven by weather conditions, ecological variability, and fishing effort, rather than as evidence of methodological inadequacy. This reinforces the conceptualization of forecasting as a decision-support signal that informs planning under uncertainty, rather than as a precise point forecast. Embedding ES within a transparent and user-friendly planning system enables CEFs to anticipate seasonal mismatches, reduce managerial misalignment between supply and demand, and support more consistent production and inventory decisions over time. Such capabilities are particularly important under dynamic market and environmental conditions, where adaptive planning contributes directly to operational resilience, income stability, and long-term sustainability across local production systems (Mircetic et al., 2022).

LP-Based Planning and Bottleneck-Focused System Design

The results confirm that integrating LP with bottleneck analysis in a spreadsheet environment effectively bridges forecasting outputs and feasible operational decisions in CEFs. This integration transforms abstract demand and supply forecasts into actionable production plans that explicitly respect real capacity constraints. The identification of drying as the dominant bottleneck is consistent with prior studies indicating that long, weather-dependent drying processes constrain throughput and exacerbate raw-material losses in small-scale fish processing systems (Krisman et al., 2019). In such contexts, unmanaged bottlenecks not only limit output but also amplify variability across the entire production flow, leading to unstable work-in-process levels and inefficient resource utilization. Targeted technological interventions, such as two-tier drying houses, directly address these structural limitations by reducing effective drying time, mitigating exposure to adverse weather conditions, and improving hygiene standards, product quality, and shelf life (Krisman et al., 2019). Importantly, these interventions do not merely increase nominal capacity but enhance the reliability and predictability of the drying process, which is critical for coordinated production planning. When complemented by expanded cold-storage capacity, producers can buffer excess raw material during oversupply periods, avoid distress sales at unfavorable prices, and strategically shift product dispatch to more favorable market windows, thereby stabilizing income streams and reducing low-margin transactions (Sultan et al., 2023). From a managerial perspective, this pathway closely follows the TOC focusing steps, particularly the identification, exploitation, and elevation of the system's dominant constraint (Orue et al., 2021). Implementing LP via spreadsheet and Solver operationalizes these principles by quantifying trade-offs under real operational constraints and enabling scenario analysis to evaluate the economic and operational returns of targeted capacity investments (Guo, 2020). Moreover, when combined with TOC and S&OP, LP-based planning enhances transparency, auditability, and cross-functional alignment among actors involved in sourcing, processing, and sales decisions, thereby strengthening organizational resilience under persistent uncertainty (Rota & de Souza, 2021).

Economic Value Creation

The economic evaluation demonstrates that the optimized forecast-to-plan system generates tangible value across the salted Kulao value chain. A Benefit-Cost Ratio (BCR) of 1.95

indicates that the intervention is economically worthwhile from a societal perspective. At the same time, an internal rate of return (IRR) of 32.49 percent further supports this conclusion. Consistent with prior studies, the results suggest that income losses in small-scale fisheries are driven less by absolute capacity shortages and more by weak coordination, limited storage, and suboptimal sales timing (Bassett et al., 2021). By identifying drying as the primary bottleneck and aligning production plans accordingly, the system increased effective throughput and reduced unprocessed surplus, in line with the core logic of the Theory of Constraints (Chhalani et al., 2020). Importantly, economic gains arose mainly from improved utilization of existing resources rather than large-scale capacity expansion. The participatory, spreadsheet-based design further lowers adoption barriers and supports sustained use, reinforcing that community involvement enhances long-term economic benefits.

Implications, Robustness, and Future Directions

This study demonstrates that an integrated forecast-to-plan framework that combines forecasting, TOC, and LP can substantially improve operational and economic performance in community-based fish processing enterprises. The findings extend production-planning and supply-chain theory by showing that aligning demand and supply signals with bottleneck-focused optimization enhances system-level outcomes under uncertainty, even in data-constrained, community-scale settings. From a managerial perspective, the results indicate that significant gains can be achieved without large-scale capital expansion. Targeted investments at the dominant bottleneck (drying) and buffering capacity (cold storage), supported by accessible spreadsheet-based LP tools, reduce opportunity loss, stabilize production, and improve income timing. From a policy and development standpoint, the strong economic returns (BCR or SROI > 1; IRR > 30%) suggest that modest infrastructure upgrades combined with data-driven planning capabilities can deliver high social value. Several limitations should be noted. Forecasting relied on historical data from a single site with informal recording practices, and high volatility partly explains elevated MAPE values, underscoring that forecasts function as decision-support signals rather than precise predictions. Although tested in one community, the mechanism-based design supports transferability. Future research should apply the framework across multiple sites and incorporate scenario-based or stochastic analysis to capture external shocks and assess long-term impacts. In addition, the proposed framework offers several practical implications for capacity-building and governance in community-based fish-processing systems. First, the spreadsheet-based design lowers technological barriers and enables gradual capability development among operators with limited formal training. By embedding forecasting, bottleneck analysis, and linear programming within a familiar spreadsheet environment, the system supports learning-by-doing and enhances analytical literacy without requiring advanced software or external consultants. This characteristic is particularly relevant for community enterprises operating under budget constraints and limited digital infrastructure. Second, the framework provides a transparent basis for collective decision-making among producers, processors, and local development agencies. Shared visibility of forecasts, capacity constraints, and opportunity losses facilitates consensus on investment priorities, such as expanding drying or cold-storage capacity. It helps align short-term operational decisions with longer-term development goals. From a governance perspective, such transparency reduces reliance on tacit knowledge and ad hoc judgments, thereby strengthening accountability and trust within community organizations. Third, the economic results highlight the policy relevance of targeted, bottleneck-focused interventions. Rather than promoting broad capacity expansion, development programs may achieve higher social returns by supporting modest, constraint-oriented upgrades combined with data-driven planning tools. This insight is particularly valuable for public agencies and NGOs seeking cost-effective mechanisms to enhance income stability and resilience in small-scale fisheries. Collectively, these implications suggest that the forecast-to-plan approach is not only an

operational tool but also a scalable mechanism for strengthening managerial capability, coordination, and evidence-based policy support in community-level agri-food systems.

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