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System Dynamics-Based Rice Procurement Strategy to Support Food Stability in Critical Periods

Rizki Alifnur Harmawan¹, Erna Mulyati², Agus Purnomo³

¹Universitas Logistik dan Bisnis Internasional, Bandung, Indonesia, rizkialif2024@gmail.com

²Universitas Logistik dan Bisnis Internasional, Bandung, Indonesia, ernamulyati@ulbi.ac.id

³Universitas Logistik dan Bisnis Internasional, Bandung, Indonesia, aguspurnomo@ulbi.ac.id

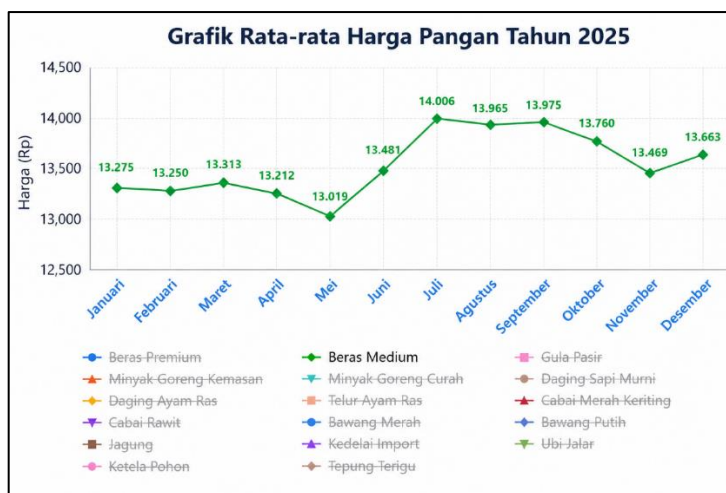
Corresponding Author: rizkialif2024@gmail.com¹

Abstract: Rice procurement strategies play a crucial role in ensuring supply availability and stabilizing prices in traditional markets, particularly during critical periods characterized by higher demand and limited supply. This study aims to implement a rice procurement method in traditional markets in Tangerang Regency, using system dynamics during critical periods. This study uses an AnyLogic-based simulation approach, utilizing secondary data on rice prices, stock availability, and rice demand sourced from the Tangerang Regency Food Information System and the Tangerang Regency Agriculture and Food Security Office. Simulations were conducted in four different scenarios: standard conditions in May 2025, the period after Eid al-Adha in July 2025, the dry season with decreased food distribution in September 2025, and the Christmas and New Year season in December 2025. The results show that the period after Eid al-Adha is the most critical scenario, with the largest stock deficit of 12,146 and the lowest service level of 89.88%. Based on simulation findings and risk assessments, a mixed procurement strategy emerged as the most effective option to ensure stock availability, mitigate the risk of supply deficits, and facilitate future rice price stability during critical times.

Keyword: Rice Procurement, System Dynamics, Supply Chain, Traditional Market, Critical Period

INTRODUCTION

Rice is a vital agricultural product that significantly contributes to food security and economic resilience in Indonesia (Saptana & Darmawati, 2019). As the primary food source for the majority of the population, fluctuations in rice prices and availability can impact inflation and public purchasing power (Anggraini et al., 2025). Therefore, rice supply chain management is crucial to ensure consistent availability and stable prices in the market (Fatchul Annaji et al., 2025).



Source: Tangerang Regency Food Information System (2025)

Figure 1. Rice Prices in Tangerang Regency 2025

Traditional markets serve as the primary distribution method for medium-grade rice, establishing a direct link between suppliers, traders, and consumers. In Tangerang Regency, there are 19 traditional markets that serve as hubs for various essential food items, including rice (Abdullah, 2023). Certain conditions, such as holidays, the dry season, or the end-of-year period, can cause spikes in demand, leading to price volatility and supply disruptions. Figure 1 illustrates that the price of medium-grade rice in Tangerang Regency increased in July, September, and December 2025. According to information from the Tangerang Regency Food Information System, this price increase was influenced by high consumer demand and variations in supply conditions at key times (Fadilah & Swastika, 2025). This scenario suggests that rice sellers face difficulties in determining purchasing methods that align stock levels, procurement costs, and meet customer needs.

This uncertainty regarding supply and prices poses significant challenges for rice traders in developing their procurement strategies. Traders not only face the possibility of stock shortages but also must navigate price fluctuations and competition for rice from suppliers. Poor procurement choices can result in stockouts, higher acquisition costs, and reduced service standards for consumers.

Previous research has examined various aspects of rice supply chain management. (Bidarti et al., 2019) assessed rice supply chain performance, while (Guritno et al., 2018) explored how to mitigate supply chain risks by managing demand and suppliers. (Magableh, 2024) created a model for selecting suppliers using a Multi-Criteria Decision Making (MCDM) approach. Furthermore, various studies have addressed price fluctuations and how to control rice stocks at various distribution levels. However, most of these studies have focused on supply chain evaluation, supplier selection, or inventory management separately.

What distinguishes this research is the limited number of studies that incorporate rice prices, stock levels, and demand into a dynamic model designed to assess purchasing strategies at the traditional market seller level, especially during critical periods. Furthermore, there has been limited use of simulation-based system dynamics methods to assist in decision-making regarding rice purchasing strategies in traditional markets located in Tangerang Regency (Madrigal et al., 2025).

The novelty of this research stems from the creation of an AnyLogic-based system dynamics simulation model, which combines rice prices, stock levels, and demand to test various procurement strategy options across a range of key scenarios. This research also links simulation results with Logical Framework Analysis (LFA), ensuring that procurement strategy recommendations consider not only simulation results but also factors related to risk,

success metrics, and the long-term effectiveness of implementing strategies to improve rice supply stability in traditional markets in Tangerang Regency.

Based on the current phenomenon, rice price data in Tangerang Regency, findings from previous studies, and research gaps, this study aims to determine how rice prices, available stock, and consumer demand influence rice purchasing strategies in traditional markets. Rice prices play a crucial role in determining purchasing methods because any price changes directly impact purchasing costs, profits, and sellers' ability to maintain a stable supply (Natasya L. Rawung et al., 2025). Furthermore, adequate stock availability is crucial to ensure smooth supply and meet sustainable consumer demand. On the other hand, rice demand is not constant and typically increases at certain times, such as after Eid al-Adha, during the dry season, and before Christmas and New Year. This situation suggests that the relationship between price, stock levels, and demand is crucial for determining the effectiveness of rice purchasing strategies in traditional markets (Abdallah et al., 2023).

This study uses system dynamics methods with AnyLogic simulations to illustrate how these variables interact, showing how the rice purchasing system changes under various scenarios. This method not only examines the situation in 2025 but also suggests various procurement policy options that can be used to address future changes in supply and demand. Furthermore, the simulation results are integrated with Logical Framework Analysis (LFA) to determine objectives, success measures, potential risks, and the best strategies for maintaining rice supply.

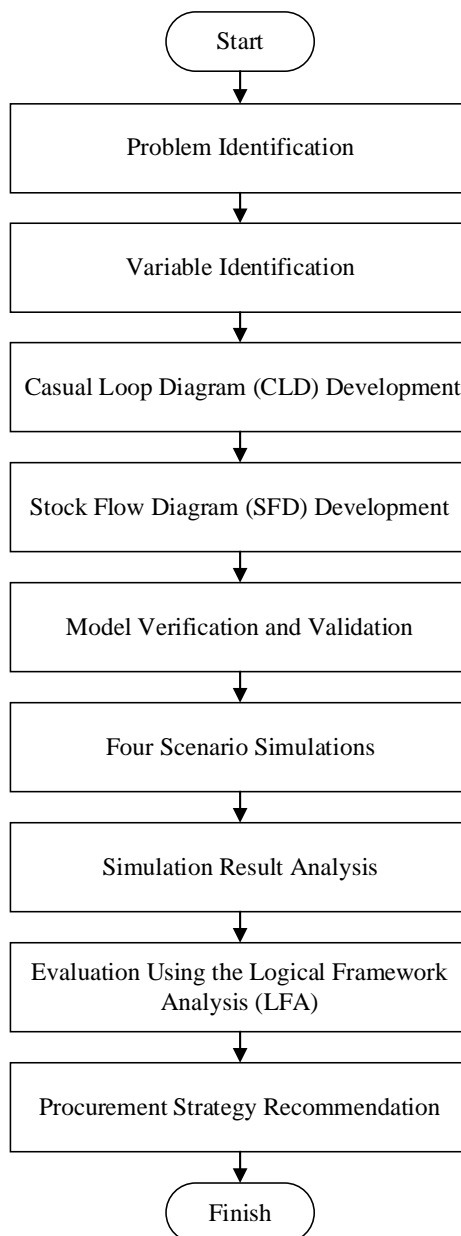
The purpose of this study is to examine the relationship between rice prices, inventory levels, and demand in shaping rice procurement methods in traditional markets in Tangerang Regency during critical times. System dynamics methods using AnyLogic simulations are used to illustrate the interactions within the rice procurement system and assess how variations in each factor affect inventory levels, service quality, and price consistency.

Furthermore, this study aims to develop the most efficient rice procurement approach based on simulation findings and assessments using Logical Framework Analysis (LFA). The proposed strategy is intended to provide guidance for traders and related parties in ensuring stock availability, reducing the likelihood of shortages, stabilizing prices, and increasing the resilience of rice supply in traditional markets in Tangerang Regency during critical times.

The resulting model is expected to assist traditional market traders in developing more flexible, efficient, and sustainable rice procurement methods. In addition to contributing to the advancement of system dynamics in the food supply chain, this research is expected to provide guidance for business leaders and policymakers in designing procurement strategies that enhance supply management and ensure rice price stability during critical times in Tangerang Regency.

METHOD

This study adopted a quantitative methodology utilizing system dynamics simulation techniques to test rice supply chain strategies for mitigating competitive risks from rice traders at key moments in traditional markets in Tangerang Regency (Prabakusuma, 2020). The system dynamics method was chosen based on its effectiveness in depicting interactions between variables in the supply chain and assessing how policy changes can impact the performance of the entire system. The simulation framework was developed using AnyLogic software, commonly used in supply chain analysis and simulation (Madrigal et al., 2025).

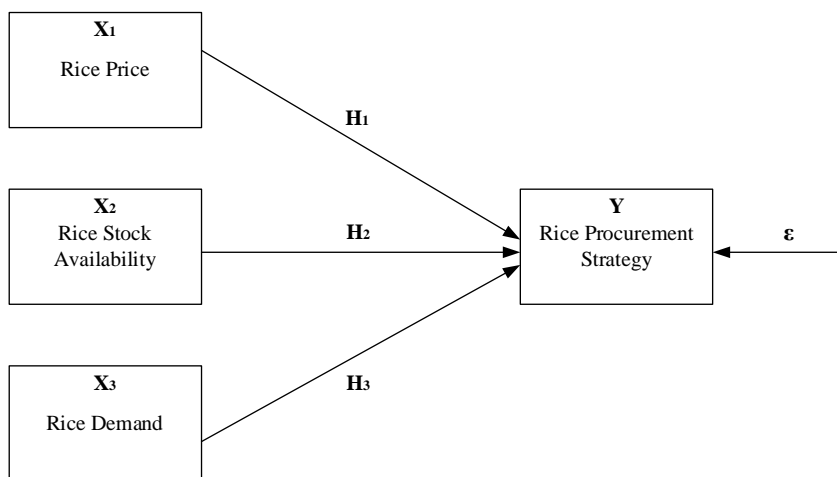


Source: Processed data (2026)

Figure 2. Research Framework

This study focused on the rice procurement process in traditional markets located in Tangerang Regency. The information used was secondary data sourced from the Tangerang Regency Food Information System (Sipangeran) and the Tangerang Regency Agriculture and Food Security Office. The collected data included rice prices, rice stock availability, and anticipated rice demand in 2025. These data points are crucial parameters in developing the simulation model (Syukur et al., 2024).

The variables observed in this study included rice prices (X1), rice stock levels (X2), and rice demand (X3). These three factors play a crucial role in characterizing rice market conditions, influencing purchasing decisions (Wio, 2025). Variations in supply and demand are crucial elements influencing supply chain performance and sustainable product availability at various levels of distribution (Davizon et al., 2023). Therefore, these variables are identified as key parameters in the simulation model.



Source: Processed data (2026)

Figure 3. Research Hypothesis Framework

- X1 : Rice Price
- X2 : Rice Stock Availability
- X3 : Rice Demand
- Y : Rice Procurement Strategy
- H1 : The Effect of Rice Price on Rice Procurement Strategy
- H2 : The Effect of Stock Availability on Rice Procurement Strategy
- H3 : The Effect of Rice Demand on Rice Procurement Strategy
- E : Other variables outside the research model

The relationship between variables in this study is represented by a research hypothesis framework, where rice price (X1), stock level (X2), and rice demand (X3) operate as independent variables that influence rice procurement strategy (Y), which is the dependent variable. This framework serves as a basis for building a system dynamics model using AnyLogic software to assess various rice procurement strategies over a significant time period (Wuri Ergaya et al., 2025).

Table 1. Operational Variables

Variables	Operational Definition	Indicator	Measurement Method
Rice Price (X1)	Selling price of medium rice in traditional markets (Source: Tangerang Regency Food Information System (SIPANGERAN), Tangerang Regency Agriculture and Food Security Service, 2025).	Average price (Rp/kg), Price Index (Source: Tangerang Regency Food Information System (SIPANGERAN), Tangerang Regency Agriculture and Food Security Service, 2025).	SIPANGERAN Data
Stock Availability (X2)	Amount of rice stock available (Source: Tangerang Regency Food Information System (SIPANGERAN), Tangerang Regency Agriculture and Food Security Service, 2025).	Stock volume, Stock Index (Source: Tangerang Regency Food Information System (SIPANGERAN), Tangerang Regency Agriculture and Food Security Service, 2025).	Tangerang Regency stock data

Variables	Operational Definition	Indicator	Measurement Method
Rice Demand (X3)	The amount of rice needed by the community (Source: Tangerang Regency Food Information System (SIPANGERAN), Tangerang Regency Agriculture and Food Security Service, 2025).	Demand volume, Demand Index (Source: Tangerang Regency Food Information System (SIPANGERAN), Tangerang Regency Agriculture and Food Security Service, 2025).	2025 demand data
Procurement Strategy (Y)	Procurement strategies to meet market needs (Source: Tangerang Regency Food Information System (SIPANGERAN), Tangerang Regency Agriculture and Food Security Service, 2025).	Short-term, long-term, hybrid strategies; Service Level; Stockout (Source: Tangerang Regency Food Information System (SIPANGERAN), Tangerang Regency Agriculture and Food Security Service, 2025).	<i>AnyLogic simulation output</i>

Source: Processed data (2026)

The operational variables used in the study were structured based on the specific characteristics of each variable studied. Variables related to rice prices were assessed by examining the average cost of medium-grade rice and the price index obtained from SIPANGERAN information. To evaluate stock availability, the inventory quantity and stock index for each simulation period were considered. The rice demand variable was analyzed using the total demand and demand index using data from 2025. Furthermore, the rice procurement strategy variable was assessed based on the strategic choices implemented, including short-term strategies, long-term strategies, and hybrid procurement approaches. The success of these strategies was measured by indicators such as service level, stockout rate, price consistency, and the ability to maintain stock availability.

The initial phase of the research began with problem identification, reviewing existing literature, collecting data, developing a conceptual framework, creating a simulation model, verifying and validating the model, designing procurement strategy scenarios, analyzing risks through Logical Framework Analysis (LFA), and suggesting improvements to the procurement strategy (Rosid et al., 2024). The simulation model was created using the stock and flow methodology, which includes variables such as rice stock, procurement efforts, sales figures, prices, inventory, and demand levels (Maitra, 2024).

This study evaluated several procurement strategies: short-term procurement methods, long-term procurement methods, and a hybrid strategy (Wardoyo et al., 2023). The direct procurement method focuses on modifying procurement actions according to current market conditions, while the long-term procurement method considers supply needs over a longer period (Stek, 2024). The hybrid strategy combines these two methods, aiming to achieve a balance between inventory availability and procurement cost efficiency.

Table 2. Simulation Scenario of Rice Procurement Strategy

Scenario	Period	Market Conditions	Characteristics	Tested Strategy
Scenario 1	May-25	Normal Condition (Source: Tangerang Regency Food Information System (SIPANGERAN), Tangerang Regency Agriculture and Food Security Service, 2025).	There are no major events that affect the price, stock and demand for rice.	Short Term, Long Term, Mixed
Scenario 2	July-25	After Eid al-Adha (Source: Tangerang Regency Food Information System (SIPANGERAN), Tangerang Regency Agriculture and Food Security Service, 2025).	There was a continued impact of increased demand after Eid al-Adha so that traders' stocks tended to decrease.	Short Term, Long Term, Mixed
Scenario 3	Sept-25	Dry Season and Reduction of BULOG's SPHP (Source: Tangerang Regency Food Information System (SIPANGERAN), Tangerang Regency Agriculture and Food Security Service, 2025).	BULOG SPHP distribution is reduced, the dry season is underway, and there is an increase in demand for the commemoration of the birthday of the Prophet Muhammad SAW	Short Term, Long Term, Mixed
Scenario 4	Dec-25	Christmas and New Year (Nataru) (Source: Tangerang Regency Food Information System (SIPANGERAN), Tangerang Regency Agriculture and Food Security Service, 2025).	Demand for rice increases ahead of Christmas and New Year, potentially affecting prices and stock availability.	Short Term, Long Term, Mixed

Source: Processed data (2026)

To illustrate various market scenarios, simulations were conducted for four different situations for the year 2025: standard conditions (May 2025), the period after Eid al-Adha (July 2025), the dry season with reduced distribution from BULOG's SPHP (September 2025), and Christmas and New Year celebrations (December 2025). These four scenarios were chosen because they reflect price fluctuations, inventory levels, and demand in the Tangerang Regency rice market (Ratutria et al., 2025).

After model validation, simulation trials were conducted for each procurement strategy in each scenario. Simulation results were examined using various metrics, including rice stock levels, purchased quantities, stockout rates, service effectiveness, and price stability. Using a system dynamics approach to analyze supply chain disruptions has proven effective in describing system function and assessing how strategic modifications affect overall supply chain performance (Madrigal et al., 2025).

In addition to system dynamics simulations, this study employed Logical Framework Analysis (LFA) techniques to identify, evaluate, and manage potential risks associated with the rice supply chain. The LFA approach was used to outline objectives, success indicators, verification sources, and risks and assumptions that influence the effectiveness of the procurement strategy. The findings from the LFA analysis served as the basis for formulating recommendations aimed at achieving a sustainable rice procurement strategy for traditional market traders in Tangerang Regency.

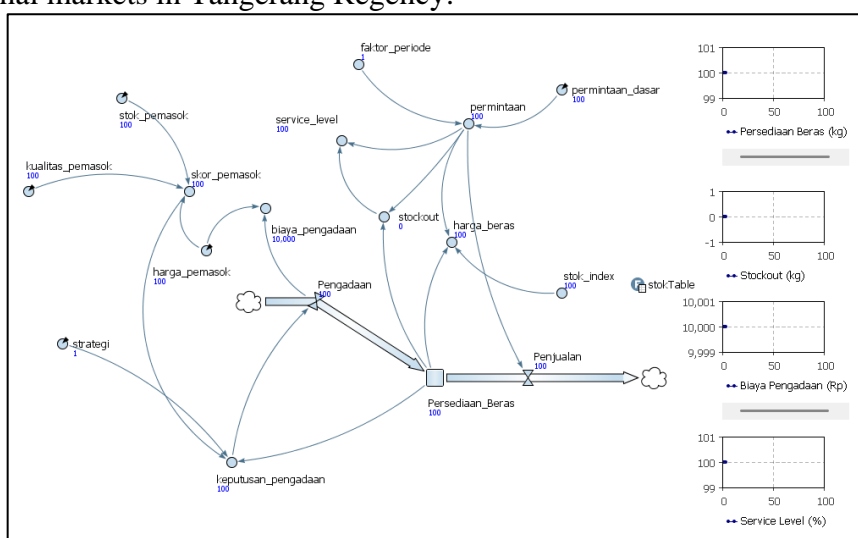
Integrating system dynamics and Logical Framework Analysis methodologies, this study aimed to develop an effective procurement strategy that ensures consistent supply

availability, reduces the risk of stock shortages, and helps maintain rice price stability during critical times.

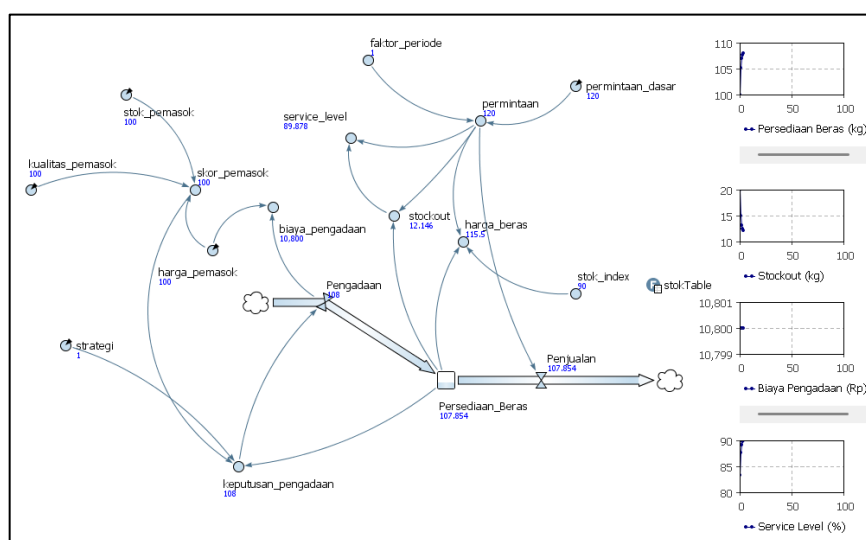
RESULTS AND DISCUSSION

This study uses AnyLogic-based system dynamics simulation to assess how fluctuations in rice prices, inventory levels, and demand affect purchasing strategies in traditional markets located in Tangerang Regency. Furthermore, this study uses Logical Framework Analysis (LFA) to identify risks, underlying assumptions, success metrics, and alternative strategies to ensure stable rice supply and prices during critical times.

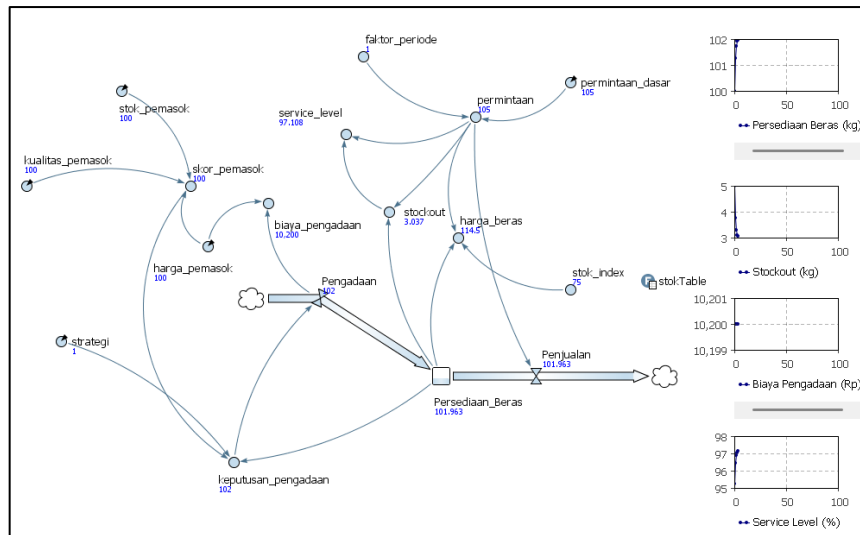
The simulation framework is designed based on a stock-and-flow model, with Rice Inventory as the primary stock, Procurement as the inflow, and Sales as the outflow. Additional factors influencing system behavior include rice prices, stock levels, rice demand, procurement decisions, stock-depletion events, service quality, and procurement costs. The interrelationships between these factors are used to illustrate the dynamics of the rice supply chain in traditional markets in Tangerang Regency.



Source: Processed data (2026)
Figure 4. Normal Conditions (May 2025)

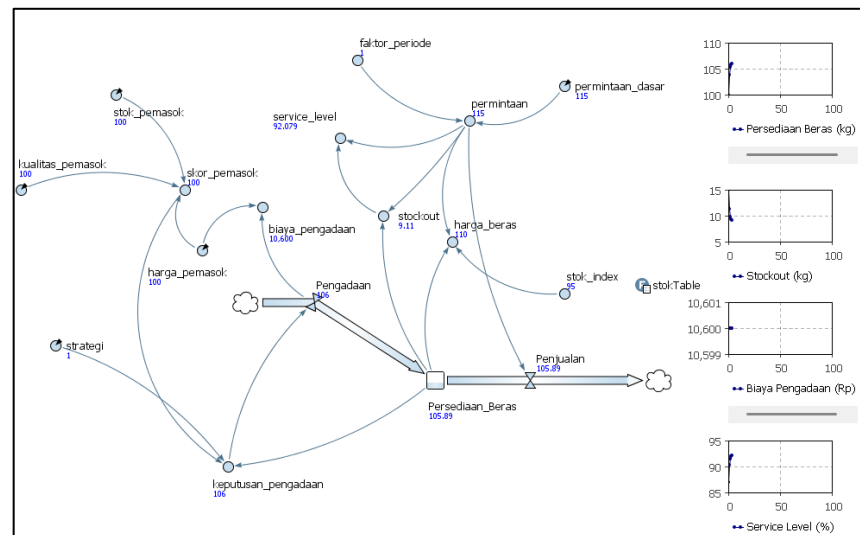


Source: Processed data (2026)
Figure 4. Post-Eid al-Adha Conditions (July 2025)



Source: Processed data (2026)

Figure 5. Dry Season Conditions and Lack of BULOG SPHP Distribution (September 2025)



Source: Processed data (2026)

Figure 6. Christmas and New Year conditions (December 2025)

Based on this model, scenarios were run for four situations reflecting the rice market landscape for 2025. These scenarios included normal conditions in May, post-Eid al-Adha in July, the dry season accompanied by a decrease in distribution of BULOG's Food Supply and Price Stability (SPHP) in September, and the Christmas and New Year celebrations in December. Each scenario used varying demand and stock figures to accurately depict the real-world scenario in Tangerang Regency.

The simulation results were used to assess supply chain efficiency, focusing on metrics such as rice stock levels, stockout occurrences, service quality, and price consistency. These findings were then analyzed using Logical Framework Analysis (LFA) to identify the most efficient procurement approach to ensure a stable rice supply. The simulation findings for each scenario studied are presented in Table 1.

Table 3. Simulation Results

Scenario	Demand	Stock	Price	Stockout	Service Level
May	100	100	100	0	100,00%
July	120	90	108	12,146	89,88%
September	105	75	107	3,037	97,11%
December	115	95	105	9,11	92,08%

Source: Processed data (2026)

According to Table 1, the standard conditions in May reflect the most efficient supply chain performance. In this scenario, demand, supply, and prices are at normal levels, resulting in no shortages (stock shortages = 0) and a 100% service level. This implies that purchasing volume is sufficient to meet all customer needs without burdening the inventory management system.

During July 2025, which follows the Eid al-Adha holiday, demand increased by 20% compared to the standard conditions. This spike resulted in an increase in rice prices, reaching an index of 108. Even with increased purchasing efforts, the system experienced 12,146 stock shortages, causing the service level to decline to 89.88%. These findings indicate that increased demand is a key factor placing significant pressure on the rice supply chain. This increased demand results in some customer needs not being fully met, contributing to a decline in service levels.

In contrast to the situation in July, the conditions observed in September 2025 were quite different. During this period, demand increases were relatively moderate, but supply faced challenges due to the dry season combined with reduced distribution from BULOG's SPHP program. The stock index dropped to 75, but the system managed to achieve a service level of 97.11% despite 3,037 stock shortages. These results indicate that the implemented procurement strategy was quite efficient in maintaining stock levels, even in the face of supply constraints. Despite this, rice prices remained high due to decreased availability in the market.

During the Christmas and New Year festive season (December 2025), demand increased to 115, accompanied by a stock index of 95. This resulted in a stock shortage rate of 9.11 and a service level of 92.08%. While these results exceeded those observed in July, the surge in demand continued to put pressure on the supply chain infrastructure. The increase in rice prices during this period suggests that increased consumer spending towards the end of the year impacts the stability of rice supply and its market price.

The simulation results show a strong relationship between demand, stock levels, rice prices, and supply chain efficiency. Increased demand leads to increased procurement needs, which can lead to stock shortages if not offset by increased supply. Conversely, insufficient stock levels can result in higher rice prices, even in the absence of increased demand. These results highlight that rice price stability is influenced not only by demand but also significantly by the system's capacity to ensure consistent supply.

According to the simulation results, July is the most critical period, characterized by the highest stockout rates and the lowest service levels. This scenario suggests that a procurement strategy focused solely on short-term demand fails to effectively manage the increase in demand. Conversely, in September, the primary challenge was insufficient supply, which caused prices to remain high despite maintained service levels. In December, two factors—increased demand and limited supply—impacted supply chain efficiency.

To address these challenges, this study examines three different procurement approaches: a short-term strategy, a long-term strategy, and a hybrid strategy. The short-term strategy aims to increase order frequency and procurement volume in response to increased demand. The long-term strategy involves establishing supply agreements with key suppliers, diversifying procurement sources, and building safety stocks before entering the critical

period. Simultaneously, the hybrid strategy synergizes these two approaches to achieve a balance between supply flexibility and sustainability.

Table 4. Logical Framework Analysis

PROJECT SUMMARY	INDICATORS	MEANS OF VERIFICATION	RISKS / ASSUMPTIONS
GOAL	Maintain the stability of medium-grade rice prices and availability in traditional markets of Tangerang Regency during critical periods.	- Rice prices remain within the index range of 100–108.- Stock availability is sufficient to meet market demand.	Tangerang Regency food price data and AnyLogic simulation results.
OUTCOME	Improve the effectiveness of procurement strategies to maintain supply continuity and reduce rice price fluctuations.	- Service Level > 90%. - Stockout < 10%.	AnyLogic simulation results.
OUTPUTS	1. Procurement strategy capable of maintaining supply stability during critical periods.	July: Service Level 89.88%, Stockout 12. 146. September: Service Level 97.11%, Stockout 3.037. December: Service Level 92.08%, Stockout 9.110.	AnyLogic simulation outputs.
	2. Stock protection mechanism established for critical periods.	Ending inventory remains above 100 units across all simulation scenarios.	AnyLogic simulation results.
	3. Hybrid procurement strategy developed.	Combination of primary supplier contracts, safety stock, and alternative suppliers.	Simulation analysis and Logical Framework Analysis (LFA).
ACTIVITIES	1. Identify critical periods based on Tangerang Regency rice price data for 2025.	Critical periods identified: July, September, and December.	SIPANGERAN database and rice price analysis results.
	2. Collect demand, inventory, and rice price data for 2025.	Simulation dataset is available and validated.	SIPANGERAN, BPS, and other relevant sources.
	3. Develop an AnyLogic simulation model using the System Dynamics approach.	The model successfully simulates changes in price, inventory, and demand.	Model validation results.
	4. Run simulations under four scenarios (May, July, September, and December).	Simulation result tables are generated.	AnyLogic outputs.
	5. Evaluate alternative procurement strategies.	Performance comparison of short-term, long-term, and hybrid procurement strategies.	Simulation and analytical results.
	6. Establish the hybrid procurement strategy as the primary recommendation.	Average service level exceeds 90%, while stockout risk is reduced.	Research findings.

Source: Processed data (2026)

Based on simulation results and risk evaluations conducted through Logical Framework Analysis (LFA), a hybrid procurement strategy emerged as the most appropriate option. This approach effectively ensures stock availability during peak demand, reduces the likelihood of stockouts, maintains higher service levels, and contributes to rice price stability during

critical periods. Furthermore, establishing safety stocks and engaging alternative suppliers before critical periods can mitigate the impact of supply disruptions caused by seasonal variations and food distribution regulations.

Using a hybrid procurement method can be an effective primary approach to address similar market situations in the future. By applying system dynamics methods, various changing circumstances such as increased demand, decreased stock levels, and price changes due to seasonal factors or food distribution regulations can be assessed before making purchasing decisions. This gives traders the opportunity to plan their purchases more effectively by setting aside additional stock (safety stock), diversifying suppliers, and forming long-term relationships with suppliers to help reduce the likelihood of stockouts and maintain a stable supply.

For example, if the demand for rice after the Eid al-Adha celebration is estimated to reach 1,000 kg, traders can adopt a diversified purchasing approach. This approach covers approximately 70% of demand through ongoing agreements with primary suppliers while maintaining a 10% buffer stock. They will meet the remaining demand through direct acquisitions from secondary suppliers in the event of increased demand. By using this method, traders not only secure stable supplies and prices through long-term agreements but also maintain the ability to adjust purchase quantities according to fluctuating market conditions. Such a plan can reduce the likelihood of stockouts, maintain service quality, and improve procurement cost-effectiveness compared to relying solely on a single purchasing method.

Furthermore, the simulation model can be used to aid decision-making by demonstrating various potential rice purchasing situations. When demand increases due to religious events, such as after Eid al-Adha, or when supply issues arise due to adverse weather, such as during the dry season, or when government regulations change, the model can show how these factors affect prices, product availability, the frequency of stockouts, and the level of service provided. The study's findings provide a clear picture of the rice market in 2025 and also offer suggestions for flexible purchasing strategies that can help ensure a stable rice supply during critical times.

The simulation model is dynamic, meaning it can be used as a tool for future decision-making. As long as people's purchasing habits, market characteristics, and key factors influencing the system remain unchanged, the model can still be used to guide purchasing plans for the next two to three years. However, if there are significant changes in consumer preferences, new government regulations, or how goods are manufactured and distributed, the model will need to be updated with the latest information to maintain accurate and up-to-date recommendations.

CONCLUSION

This study reveals that rice price, stock levels, and demand are interrelated factors that influence rice procurement in traditional markets in Tangerang Regency. Using a system dynamics approach with AnyLogic simulation, we can explore the changing interactions between these factors. This approach helps us visualize how the market changes during various key periods. The findings indicate that when demand increases without sufficient stock, there is a greater likelihood of stock shortages, which can reduce service levels and impact rice price stability. Consequently, the simulation model can serve as a decision-making tool that leads to better and more flexible procurement strategies.

In four scenarios run and considered through Logical Framework Analysis (LFA), a hybrid procurement strategy emerged as the best option. This strategy ensures stock availability, reduces the likelihood of shortages, maintains service quality, and helps maintain stable rice prices during key periods. In addition to outlining market conditions in 2025, the

model also allows for the assessment of various future scenarios, such as shifts in demand, price variations, and stock levels. In this way, traders and policymakers can create more forward-thinking procurement approaches, such as using safety stock, diversifying suppliers, and building strong long-term relationships with suppliers. Therefore, this research plays a key role in creating flexible procurement strategies that increase the resilience of rice supply in traditional markets in Tangerang Regency for critical periods in the future.

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