Forecasting Analysis of Rice Demand at SPPG and Demand Projections for the Free Nutritious Meal Program in Bandung City

(Analisis Peramalan Permintaan Beras di SPPG dan Proyeksi Permintaan untuk Program Makanan Bergizi Gratis di Kota Bandung)

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ABSTRACT

The Free Nutritious Meal Program (MBG) is expected to significantly increase food demand, particularly for rice as the main staple in meal preparation. However, studies linking operational kitchen data with city-level rice demand projections remain limited. This study aims to analyze operational rice demand at Nutrition Fulfillment Service Units (SPPG) in Bandung City and to project rice demand under different program expansion scenarios. A quantitative approach was employed using time series forecasting by comparing ARIMA, Holt-Winters, and Default Forecast (Mean in Window) models. Model performance was evaluated using RMSE and MAPE indicators. The dataset consists of operational data from 26 SPPG units, including rice purchases, meal portions produced, and the frequency of rice-based menus during April 2025–January 2026. Results show that ARIMA provides the best forecasting performance (RMSE 3859.634; MAPE 15.08%). Consumption calibration indicates rice usage of approximately 0.055–0.066 kg per portion. Scenario projections suggest that MBG expansion may substantially increase rice demand, highlighting the need to integrate program planning with regional food security policies.

Abstrak

Program Makanan Bergizi Gratis (MBG) diperkirakan akan meningkatkan permintaan pangan secara signifikan, terutama beras sebagai bahan pokok utama dalam penyajian makanan. Namun, penelitian yang mengaitkan data operasional dapur dengan proyeksi permintaan beras 20cenari kota masih terbatas. Penelitian ini bertujuan untuk menganalisis permintaan beras operasional di Satuan Pelayanan Pemenuhan Gizi (SPPG) di Kota Bandung serta memproyeksikan permintaan beras berdasarkan berbagai 20cenario perluasan program. Pendekatan kuantitatif digunakan dengan peramalan deret waktu melalui perbandingan model ARIMA, Holt-Winters, dan Default Forecast (Mean in Window). Kinerja model dievaluasi menggunakan 20cenario20 RMSE dan MAPE. Dataset terdiri dari data operasional dari 26 unit SPPG, termasuk pembelian beras, porsi makanan yang diproduksi, dan frekuensi menu berbasis beras selama April 2025–Januari 2026. Hasil menunjukkan bahwa ARIMA memberikan kinerja peramalan terbaik (RMSE 3859,634; MAPE 15,08%). Kalibrasi konsumsi menunjukkan penggunaan beras sekitar 0,055–0,066 kg per porsi. Proyeksi 20cenario menunjukkan bahwa perluasan MBG dapat secara substansial meningkatkan permintaan beras, yang menyoroti perlunya mengintegrasikan perencanaan program dengan kebijakan ketahanan pangan regional.

INTRODUCTION

The acquisition, availability, and ease of access to food constitute a human right [1]. Therefore, food security is achieved when food needs are met from the national to the individual level, with sufficient quantities and quality of food available to enable healthy, active, and productive lives on a sustainable basis [2]. A food supply shortfall relative to demand can trigger economic instability, as well as social and political unrest [3]. To ensure effective food strategies, food security rests on four pillars:

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availability, access, utilization, and stability [4]. Approaching this as a food system, it encompasses food production, processing, distribution, preparation, and consumption [5]. Urban areas reliant on external food supplies face pressures on distribution and availability; thus, food demand forecasting serves as a strategic instrument [6].

Food systems directly contribute to nutrition-related challenges. Indonesia reports a stunting prevalence of 21.6% [7]. The government's solution to reduce stunting involves the Free Nutritious Meal Program Program Makan Bergizi Gratis (MBG) [8]. MBG beneficiaries fall into four categories: early childhood education participants (PAUD/TK), elementary education (SD/MI), secondary education (SMP/MTs, SMA/SMK/MA), vocational education, religious education, special education and services, boarding school, children under 5 years, pregnant women, breastfeeding mothers, and other groups such as educators and support staff [9]. Centralized implementation of MBG poses challenges, including heightened import dependency and suppressed domestic investment [10], [11]. Consequently, a decentralized approach leveraging local food sources is the primary recommendation [12]. Moreover, robust governance is essential to ensure transparent and accountable program execution ([13].

Fig. 1. Location points of the Nutrition Fulfillment Service Unit [14]

Table 1. Number of Number of Recipient/Category [14]

Catergory	**Number of Recipient (**Beneficiaries**)**
Early childhood education	90,945
Elementary education	203,265
Junior secondary school (smp)	486,543
Senior secondary school (sma)	61,127
Pregnant women	516,407
Breastfeeding mothers	39,141
Total	1,397,428 (5.83% of implementation)

There are 26 kitchens implementing the Free Nutritious Meal Program (MBG) in Bandung City, which collectively serve 81,521 beneficiaries falling within the MBG categories. Rice commodity forecasting using time series approaches is widely used to predict rice prices, production, and demand across various spatial scales. These studies indicate that forecasting methods can provide reasonably accurate estimates to support food supply planning and anticipate demand dynamics within the food system [15], [16]. Model performance evaluation is typically conducted by comparing error measures such as MAPE, MAE, and MSE to identify the most suitable model for the characteristics of the time series data [17], [18], [19].

Regarding school feeding programs such as MBG, several studies have highlighted the effectiveness of school meal implementation, the nutritional quality of the provided menus, and operational challenges at the institutional level [20], [21], [22], [23]. Expanding school feeding programs requires sound food requirement planning to ensure that increased coverage does not exert excessive pressure on the food supply system [24]. Most rice forecasting studies focus on macro level variables such as market prices, national production, or aggregate demand, and therefore do not specifically address food requirements at the operational level of consumption based programs [16].

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THE PURPOSE METHOD

Research that leverages operational kitchen data, such as rice purchases, the number of meal portions, and the frequency of rice based menu provision, remains very limited. Yet these operational variables are crucial for representing actual food requirements at the program implementation level. Consequently, there is a need for an analytical approach that integrates time series based rice demand forecasting using operational data, calibrated per beneficiary portion consumption factors, and city scale demand projections to support more operational and evidence based food supply planning.

Based on this research gap, this study aims to analyze operational rice requirements in the Nutrition Fulfillment Service Unit (SPPG) within the implementation of the Free Nutritious Meal Program (MBG). The analysis employs a time series forecasting approach to identify the most appropriate predictive model based on program operational data. Furthermore, the study constructs rice requirement projections under several beneficiary coverage scenarios to estimate potential increases in rice demand at the city level.

METHOD

This study is a quantitative research that employs time-series forecasting, consumption calibration, and scenario-based rice-demand projection. The research adopts an analytical descriptive approach to characterize the pattern of rice requirements at the Nutrition Fulfillment Service Unit (SPPG) level and to analyze its implications for city-scale rice-demand projections in Bandung City.

Bandung is one of the metropolitan cities in West Java Province, with a population of 2,528,163 in 2024 [25]. Nutrition-related challenges remain significant: in 2023, 187,361 children under five were affected by stunting, and the proportion of under-five children at risk of malnutrition and stunting reached 43% [25], [26], [27]. Operational data were collected from the SPPG network during the period from 23 April 2025 to 12 January 2026, while data processing, time-series forecasting, consumption calibration, and scenario projection were conducted in three subsequent periods.

The research data consist of primary and secondary data. Primary data were obtained from 26 SPPG units in Bandung City, functioning as kitchens implementing the Free Nutritious Meal Program (MBG). These data include: Volume of rice purchases (kg) per two-week period, Number of MBG meal portions produced per day, Number of days rice-based menus were served per week and per period, and Number of beneficiaries in each SPPG.

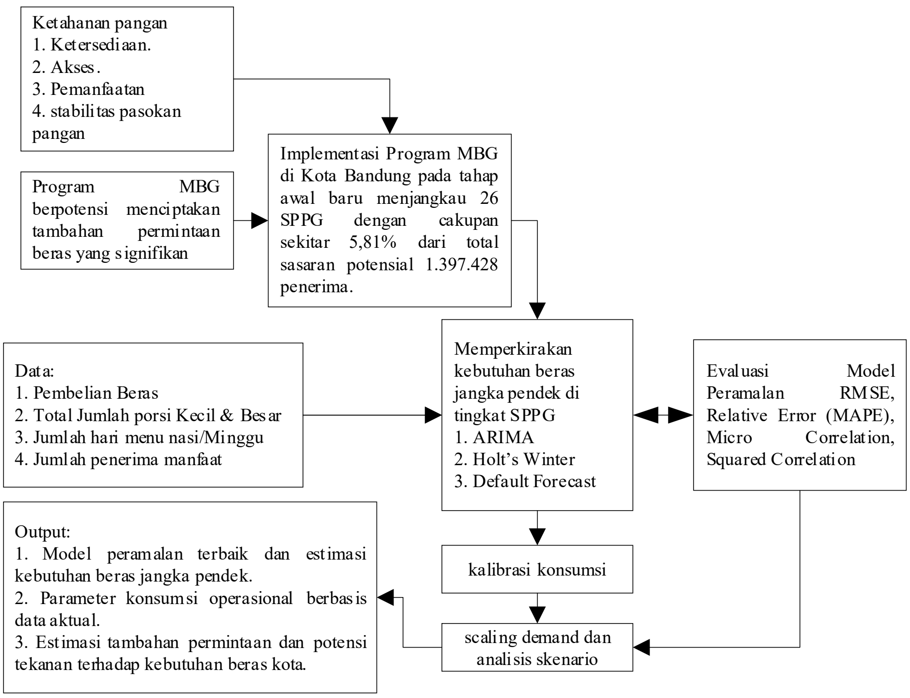

Fig. 2. Conceptual Frame Work

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These data were extracted from food-purchase summaries, kitchen production records, and periodic operational reports. Time-series data span the period from 23 April 2025 to 12 January 2026, with an observation interval of two weeks corresponding to the rice-procurement cycle in the field. Secondary data were used to provide contextual information and support scenario construction. These include the number of potential MBG participants in Bandung City, as well as population size and demographic composition. All secondary data were obtained from official documents, government-agency reports, and statistical publications through government data portals.

The Default Forecast Mean in Window

The Default Forecast Mean in Window is a simple forecasting technique that uses the most recent historical observations as future predictions, without constructing a complex statistical model [17].

$$\hat{y}_t = \frac{1}{n}\sum_{i=1}^{n} y_{t-i} \qquad (1)$$

Holt's Linier Trend Method

Holt's linear trend method is appropriate for time series that exhibit a clear linear upward or downward trend but do not yet reveal distinct seasonal patterns [18].

Level:

$$L_t = \propto y_t + (1-\propto)(L_{t-1} + T_{t-1}) \qquad (2)$$

Trend:

$$T_t = \beta\,(L_t - L_{t-1}) + (1-\beta\,)\,T_{t-1} \qquad (3)$$

Forecast:

$$\hat{y}_t + h = L_t + hT_t \qquad (4)$$

Arima (Autoregressive Integrated Moving Average)

The ARIMA (Autoregressive Integrated Moving Average) model is a widely used time-series forecasting method that combines three components: autoregressive (AR), differencing (I), and moving average (MA) [19].

$$\emptyset(B)(1-B)^d y_t = \emptyset(B)\varepsilon_t \qquad (5)$$

Accuracy Model

Forecast-model accuracy is assessed by comparing predicted values with actual observations using standard error measures: Mean Absolute Error (MAE), Mean Squared Error (MSE), and Mean Absolute Percentage Error (MAPE) [28]. MAE measures the average error in the original units of the data, whereas MSE places greater penalty on large errors by squaring the deviations, making it more sensitive to outliers [19]. MAPE expresses forecast errors as percentages, facilitating comparisons across different time periods; however, it has limitations that may introduce interpretative bias [19], [29]. MAPE values are commonly interpreted as follows: MAPE < 10% (highly accurate), 10% ≤ MAPE < 20% (good), 20% ≤ MAPE < 50% (reasonable), and MAPE ≥ 50% (inaccurate) [30], [31]. In contrast, MAE and MSE do not have standardized interpretative categories, so their evaluation is typically based on relative comparisons across alternative models [18], [19].

Consumption Calibration

Refers to the process of aligning operational data with estimated per-capita food requirements. This approach enables aggregate purchase data to be transformed into operational consumption parameters that are more interpretable and generalizable. Similar calibration methods are commonly used in food-planning studies to link logistical data with real-world consumption estimates [18]. This operational conversion aligns with food-planning practices that emphasize the integration of actual demand data with per-capita consumption parameters [17].

$$K_{pp} = \frac{B_t}{P_t * H_t} \quad (6)$$

Demand-scenario Projection

Demand-scenario projection plays a strategic role in anticipating potential pressure on the food-supply system. Without quantifiable projections, food-procurement planning risks becoming reactive and may trigger price volatility. The integration of operational forecasting, consumption calibration, and scenario projection therefore forms an important analytical framework to support local-level food policies [20].

$$D_{Kota} = K_{pp} * N * H \quad (7)$$

Scaling Demand

Scaling demand is the process of extrapolating forecast outputs to estimate food requirements at the scale of a broader beneficiary population. This scaling approach is consistent with practice in food-based programs, where operational data serve as an anchor point for projecting demand over larger target populations [18].

$$D_s = \widehat{D_{sppg}} * \frac{N_s}{N_{eks}} \quad (8)$$

Scenario Analysis

Scenario analysis is used to evaluate multiple plausible future demand trajectories under different assumptions. In urban food systems, scenario analysis is particularly important for anticipating demand shocks arising from large-scale public policies. Accordingly, the scenario results in this study serve not only as quantitative estimates but also as decision-support tools for policymakers [32].

$$D_{i,j,k} = N_{(i)} * H_{(j)} * Kpp_{(k)} \quad (9)$$

RESULTS AND DISCUSSION

Forecast Demand Result

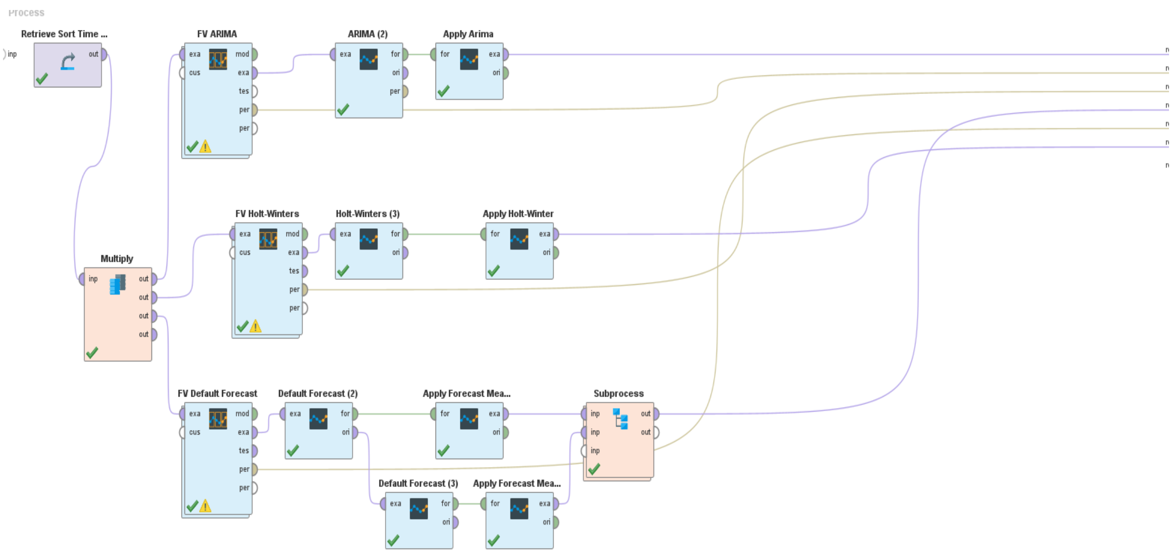

Fig. 3. Design Model Forecast & Forecast Validation

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Table 2. Forcasting Result (Kg)

Period	Arima	Holt's Winter	Default Forecast
23-Apr-25	37212	37212	37212
07-May-25	36951	36951	36951
21-May-25	37102	37102	37102
04-Jun-25	36955	36955	36955
18-Jun-25	43073	43073	43073
02-Jul-25	42312	42312	42312
16-Jul-25	42623	42623	42623
30-Jul-25	42229	42229	42229
13-Aug-25	42937	42937	42937
27-Aug-25	42229	42229	42229
10-Sep-25	42416	42416	42416
24-Sep-25	42454	42454	42454
08-Oct-25	42292	42292	42292
22-Oct-25	42337	42337	42337
05-Nov-25	36960	36960	36960
19-Nov-25	37356	37356	37356
03-Dec-25	36951	36951	36951
17-Dec-25	27322	27322	27322
12-Jan-26	21836	21836	21836
Forecast 7-Feb-26	19222	30091	39021
Forecast 5-Mar-26	16202	29186	39021
Forecast 31-Mar-26	12710	28281	39021

Indicator for the three models at Ai Altair Studio for design model forecast and forecast validation:

1. Arima
   $Time\ Series\ Attribute = Pembelian\ Beras$
   $Indices\ Attribute = Periode$
   $Window\ Size = 15;\ Step\ Size = 1;$
   $Horizon\ Size = 1$
   $p = 1;\ d = 0;\ q = 1$
   $Forecast\ Horizon = 3$
2. *Holt's Winter*
   $Time\ Series\ Attribute = Pembelian\ Beras$
   $Indices\ Attribute = Periode$
   $Window\ Size = 15;\ Step\ Size = 1;$
   $Horizon\ Size = 1$
   $\alpha = 0{,}3;\ \beta = 0{,}01;\ \gamma = 0$
   $Period : Lengt\ of\ One\ Period = 1$
   $Forecast\ Horizon = 3$
3. *Default Forecast*
   $Time\ Series\ Attribute = Pembelian\ Beras$
   $Indices\ Attribute = Periode$
   $Window\ Size = 15;\ Step\ Size = 1;$
   $Horizon\ Size = 1$
   $Forecast\ Horizon = 3$

Table 3. Model Evaluation

Model	RMSE	MAPE	MC	SC
ARIMA	3859,6	15.08%	0.803	0.645
Holt-Winters	9691,2	38.24%	0.000	0.000
Default Forecast	9650,1	37.80%	0.788	0.620

The evaluation results show that the ARIMA model performs better than both Holt-Winters and Default Forecast. This is evidenced by an RMSE of 3,859.634, which is significantly lower than that of Holt-Winters (9,691.230) and Default Forecast (9,650.083), indicating smaller prediction deviations from the actual data. In terms of MAPE, the ARIMA model yields a value of 15.08%, whereas Holt-Winters and Default Forecast reach 38.24% and 37.80%, respectively. According to the classification proposed by Lewis (1982), MAPE values in the range of 10–20% fall into the "good forecast" category, implying that ARIMA provides a good level of accuracy for short-term forecasting in this context.

Estimation of Rice Consumption /Portion, /Beneficiary, /Period

This stage involves estimating **rice consumption per portion** using Equation (6):

$$P_t = 81.521$$
$$K_{pp(23-April-2025)} = \frac{37212}{81521*7}$$
$$K_{pp(23-April-2025)} = \frac{37212}{570{,}647}$$
$$K_{pp(23-April-2025)} = 0{,}065210191\ \left(\frac{Kg}{Porsi}\right)$$

Table 4. Result Estimation of Rice Consumtion /portion/beneficery/period

(t)	(H_t)	$(P_{total,t})$	$(K_{pp,t})$
23-Apr-25	7	570,647	0.06521
07-May-25	7	570,647	0.06475
21-May-25	7	570,647	0.06502
04-Jun-25	7	570,647	0.06476
18-Jun-25	8	652,168	0.06605
02-Jul-25	8	652,168	0.06488
16-Jul-25	8	652,168	0.06536
30-Jul-25	8	652,168	0.06475
13-Aug-25	8	652,168	0.06584

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(t)	(H_t)	$(P_{total,t})$	$(K_{pp,t})$
27-Aug-25	8	652,168	0.06475
10-Sep-25	8	652,168	0.06504
24-Sep-25	8	652,168	0.06510
08-Oct-25	8	652,168	0.06485
22-Oct-25	8	652,168	0.06492
05-Nov-25	7	570,647	0.06477
19-Nov-25	7	570,647	0.06546
03-Dec-25	7	570,647	0.06475
17-Dec-25	6	489,126	0.05586
12-Jan-26	5	407,605	0.05357

The resulting rice consumption per portion $K_{pp(t)}$ falls within the range of 0.055–0.066 kg per portion, with most observations clustered around 0.065 kg or approximately 65 grams of rice per portion. This pattern indicates that the portion size of rice used in the implementation of the Free Nutritious Meal Program (MBG) is relatively consistent across periods, suggesting that this value can reasonably represent the actual rice consumption per portion at the initial stage of program implementation.

Scaling Demand

Based on the forecasting results presented in Table 2 (Forecast Output from the ARIMA, Holt's Winter, and Default Forecast Mean in Window methods), the scaling demand calculation is performed using Equation (8). The scaled results are then presented as follows:

$$\widehat{D_{sppg}} = \frac{19.222 + 16.202 + 12.710}{3}$$

$$\widehat{D_{sppg}} = 16.711 \text{ Kg}$$

Table 5. Result Estimation of Rice Consumtion /portion/beneficery/period

Skenario (%)	$\left(\frac{N_S}{N_{eks}}\right)$	(D_S)
5,83% (Existing)	1	16.711
25% (Moderat)	4,29	71.690,19
50% (Menengah)	8,57	143.213,27
100% (Penuh)	17,14	286.426,54

Scenario-based Rice Demand Projection

Projected rice requirements at the scale of Bandung City can also be explicitly expressed as a combination of consumption per portion, number of beneficiaries, and frequency of rice-based menu days. As shown in Equation (7), the calculation is carried out as follows:

$$D_{Kota,Existing} = 0{,}065210191 * 81521 * 7$$

$$D_{Kota,Existing} = 37.212\ Kg$$

Table 6. Projection Scenario

Proyeksi Skenario (%)	(N_S)	(D_{Kota})
5,83% (Existing)	81521	37212
25% (Moderat)	349357	159472
50% (Menengah)	698714	318943
100% (Penuh)	1397428	637886

Scenario Analysis

Scenario analysis is conducted to evaluate the sensitivity of rice requirements to changes in beneficiary coverage, frequency of rice-based menu days, and rice portion size per meal. Using Equation (9), the scenario-based calculations are displayed as follows:

$$D_{1,1,1} = 81521 * 5 * 0{,}059$$

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$D_{1,1,1} = 24048.7 \text{ Kg}$

$D_{2,2,2} = 34957 * 6 * 0{,}065$

$D_{2,2,2} = 136249.2 \text{ Kg}$

$D_{3,3,3} = 698714 * 7 * 0{,}068$

$D_{3,3,3} = 332587.9 \text{ Kg}$

$D_{4,4,4} = 1397428 * 8 * 0{,}07$

$D_{4,4,4} = 782559.7\text{Kg}$

Discussion

The projection results indicate that the expansion of the Free Nutritious Meal Program (MBG) could significantly increase rice demand in Bandung City. Under the existing condition, the program absorbs approximately 16.7 tons of rice per period, while in the 25%, 50%, and 100% expansion scenarios, requirements rise to tens and even hundreds of tons per period. The increase—up to four to seventeen times the initial requirement—suggests that MBG may become a new source of demand shock in the regional rice market. Thus, program expansion should not be treated merely as a sectoral-nutrition issue, but as a structural factor that reshapes food-demand dynamics at the regional level (Pemerintah Pusat, 2022; FAO, 2017).

From a food security perspective, this additional demand directly relates to the pillars of availability, accessibility, and stability (Committee on World Food Security, 2021). A large-scale increase in rice demand requires adjustments in local production, inter-regional distribution, and government rice-reserve management (Pemerintah Pusat Republik Indonesia, 2012; Pemerintah Kota Bandung, 2025). Without such adjustments, rising demand may squeeze stocks at the trader and miller level and trigger price increases, particularly in urban areas that rely heavily on external supplies, such as Bandung City (WRI Indonesia, 2022; FAO, 2017). This scenario could impair food access for low-income households, whose food expenditure is predominantly dominated by rice, and therefore runs counter to the government's broader goal of inclusive and equitable food-system transformation (Pemerintah Pusat, 2022).

For public policy, these findings underscore the need to integrate MBG explicitly into regional food-supply and price-stabilization planning. Program-coverage scenarios should be treated as new demand components in rice-procurement planning, including strategies for absorbing domestic production, managing government rice reserves, and coordinating inter-regional distribution (FAO, 2017; Pemerintah Pusat, 2022). Moreover, procurement governance by the SPPG network should be linked to more planned and smooth supply schedules to avoid sudden spikes in local demand that could destabilize prices and create political-economy frictions, especially in decentralized food-security arrangements (Pemerintah Kota Bandung, 2025; WRI Indonesia, 2022).

From a governance lens, the results highlight that MBG is not only a nutrition-targeting intervention but also a policy-driven demand-shifter in the regional rice market (Pemerintah Pusat Republik Indonesia, 2024). Therefore, the success of program implementation should be assessed not only by improved access to nutritious meals, but also by the government's capacity to maintain rice-supply and price stability within the local food system (FAO, 2017; Pemerintah Pusat, 2022). This implies that local-level MBG expansion decisions must be coordinated with agricultural, trade, and food-security policies at the subnational level to achieve coherent, evidence-based, and sustainable food-security outcomes (Pemerintah Kota Bandung, 2025; WRI Indonesia, 2022). In this way, MBG can be repositioned from a stand-alone school-feeding program to a key component of integrated agrifood-system policy at the city and regional scale.

CONCLUSION

This study analyzes operational rice requirements in the implementation of the Free Nutritious Meal Program (MBG) through an integrated approach that combines time-series forecasting, operational-data-based consumption calibration, and demand-scenario projection. The results show that the pattern of rice requirements at the Nutrition Fulfillment Service Unit (SPPG) level is relatively fluctuating yet stable within a certain range, indicating that short-term forecasting models can provide sufficiently reliable estimates of rice demand to serve as a baseline for operational planning. Consumption calibration, which links rice-purchase volume, number of produced portions, and frequency of rice-based menu days, yields an estimated consumption of approximately 0.059 kg of rice per portion, which remains relatively consistent across periods and can be used as a basic parameter for program-level rice-requirement calculations.

Scenario projections indicate that expanding MBG coverage from the existing condition to 25%, 50%, and 100% coverage is likely to increase rice requirements significantly and almost linearly with the growth in the number of beneficiaries. In the context of Bandung City, this increase may shift the regional rice-demand structure from tens to hundreds of tons per period under broader coverage scenarios. Without adjustments on the supply side and distribution governance, such demand growth may exert pressure on the availability and price stability of rice in local markets.

Conceptually, this study demonstrates that the MBG program is not only a nutrition-targeting intervention but also a new structural factor in the dynamics of urban food demand. Therefore, program-expansion planning should be integrated with rice-supply management policies, strengthening of food reserves, and price-stabilization strategies. The analytical framework developed in this study provides a quantitative basis for local governments to anticipate rice-demand implications arising from program expansion and to support the development of more data-driven and adaptive urban food-system planning.

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