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Article

Achieving Food and Nutrition Security for Indonesia's Free Nutritious Meal Program:A Provincial-Level Gap Analysis and Development Strategy

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Abstract

This study aims to analyze the sufficient food needs for the national Free Nutritious Meals (MBG) program in all provinces in Indonesia. The method employed is a quantitative approach, by calculating the production results of carbohydrate food in the form of rice in Indonesia. The dynamic system model uses three scenarios: Business as Usual (BAU), Economic Growth, and Sustainable Development to analyze the most effective scenario in meeting the society's carbohydrate needs. The sustainable development scenario is the optimal scenario to effectively achieve the objectives of the National Free Nutrious Meals program with the highest amount of food reserves. Based on these results, this situation must be addressed with several strategies, including both spatial economic and socio-statistical approaches. Optimization to meet food needs can be carried out by optimizing food resources in each province in the form of 1) fulfilling carbohydrate deficits through food diversification and economic cooperation, and 2) optimizing agricultural development through extensification and intensification in food production.

Keywords: dynamic system; Free Nutritious Meals (MBG); regional strategies.

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I. Introduction

Indonesia is estimated to experience the peak of its demographic bonus from 2020 to 2030, providing a window of opportunity to achieve the vision of a golden Indonesia by 2045 (Andriani et al., 2023; Badawi et al., 2024; Eze et al., 2023; Muhyiddin et al., 2024; Rahmawati, 2025, as cited in Suprapto et al., 2025; Ulhaq & Wahid, 2022). However, this goal cannot be achieved without the quality of supporting human capital. Access to adequate nutrition is a fundamental element in achieving the health and well-being of quality human capital, especially for vulnerable groups such as children and women (Febryanti et al., 2025). Therefore, a catalyst is needed to support the creation of a quality golden generation by preventing hunger and poverty, which can lead to health problems. In line with this, since 2015, Indonesia has been included among the 193 countries that have committed to ending hunger and poverty by 2030. However, despite its 10-year commitment, based on the 2025 Global Hunger Index, Indonesia is ranked 70th out of 123 countries with sufficient data to calculate its 2025 GHI score (Welthungerhilfe & Concern Worldwide, 2023). With a score based on 4 indicators, 6.3% of the population is undernourished, 22.6% of children under five are stunted, 8.4% of children under five are wasted, and 2.1% of children die before their fifth birthday. Indonesia's GHI score is 14.6 in 2025 and is at a moderate level (Welthungerhilfe & Concern Worldwide, 2023). These figures indicate that public welfare, particularly in terms of access to nutritious food, is suboptimal and triggers various health problems. To address this, the availability and access to nutritious food are key factors to improving community well-being and creating sustainable food security (Waluyo, 2025).

As a solution to this issue, Indonesia implemented a welfare improvement program through the fulfillment of nutritional needs, namely the Free Nutritious Meal (Makan Bergizi Gratis/MBG) program. According to the Ministry of State Secretariat of the Republic of Indonesia (2024), MBG is an initiative that aims to improve the quality of human resources, stimulate the economy through small businesses, and optimize the national food supply chain. This program is aimed at school children, toddlers, pregnant/breastfeeding mothers, and is even planned to include the elderly who need nutritional fulfillment. However, for now, the program is focused on students with the aim of supporting the teaching and learning process while maintaining the quality of Indonesia's next generation in the future. This is in line with several studies, one of which is from Febryanti et al. (2025), which explains that the condition of school children's nutrition and the quality of human resources have encouraged several countries to make breakthroughs by implementing healthy food policies.

In implementing the MBG, Indonesia's goals extend beyond nutrition and health. This program is also designed as a strategy to optimize the national food chain and encourage the maximum utilization of domestic food resources. In this regard, Indonesia's vast agricultural potential should be the backbone of meeting the needs of the Free Nutritious Food Program (MBG). However, in reality, national food security still faces challenges, with various key commodities dependent on imports (Damayanti, 2025). This dependency indicates a gap in the national food system that must be addressed immediately to ensure food security and the sustainability of various programs, one of which is the MBG program.

In addition to the pressing issues mentioned above, pressures on the national food system are increasingly complex with the emergence of various external challenges. Factors such as population growth, changing consumption patterns, limited natural resources, and uncertain climate conditions leading to frequent extreme weather events have created additional burdens on food supplies (Pradhan and Kropp, 2020, cited in Liang Xinyuan et al.). Therefore, the MBG program is presented not merely as a nutrition intervention, but as a strategic opportunity to strengthen independent and sustainable national food security. The synergy between health policies and domestic agricultural strengths in this program aligns with the government's strategy to build resilient food sovereignty (National Food Agency/Badan gizi Nasional, 2025). In a global context full of uncertainty, the integration of public health and local food systems has proven key to national resilience (Global Nutrition Report, 2024).

To achieve this, an in-depth analysis of the program's supply chain is crucial to maximize food sufficiency and affordability. Optimizing this supply chain will ultimately not only ensure the sustainability of the program but also promote improved community welfare and boost the national economy through the absorption of local products (Ministry of National Development Planning/Bappenas, 2023). To achieve these goals, it is crucial to assess the program's supply chain optimization to improve food security, community welfare, and contribute to national economic growth.

II. Methods

This research involved several parts, such as data collection, spatial analysis, and dynamic system simulation. The spatial-quantitative method, which utilizes spatial autocorrelation in Geoda, is used to analyze food availability in the provincial gap condition. Additionally, the dynamic system approach in Vensim is used to estimate the food security condition after implementing the Free Meals Program. Consequently, those methods complement each other by bridging the location and behavioral gap, particularly Geoda identifies the geographic targeting area, and Vensim estimates the temporal policy efficacy in food security. This investigation can be elaborated to pursue a reliable recommendation for improving food availability and supply based on the spatial cluster.

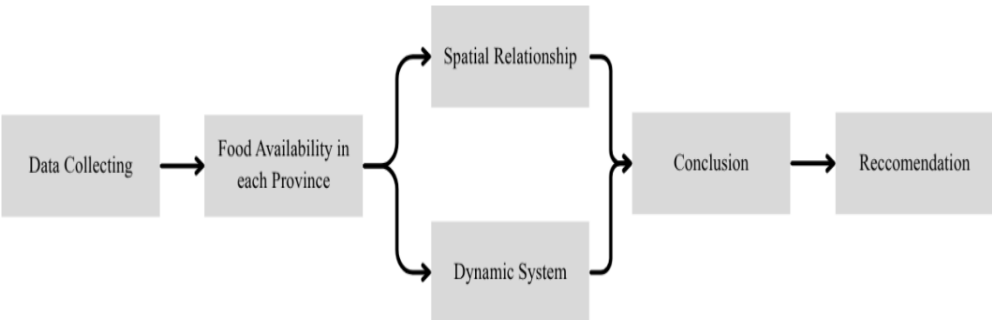

Figure 1. Research Framework.

2.1. Data Collection

This essay elaborates on several statistical data points from 2014, 2018, and 2024, including agricultural production, productive farmland, total students in each level, total toddlers, total elderly, and maternity mothers for each region in Indonesia. The data was collected from government publications, including the Central Bureau of Statistics, the Ministry of Health, and the National Food Agency. Furthermore, the analysis also uses spatial data of administrative boundaries published by the Geospatial Information Agency. A spatial join combines both types of data in QuantumGIS 3.38 to facilitate analysis. Moreover, this essay also uses several data points from research.

2.2. Spatial Relationship

Spatial autocorrelation is a spatial statistical method that assumes correlation in accordance with geographical proximity ("Spatial Autocorrelation," 1988). This method is used to avoid subjective observation assumptions, which is indicated by the quantification of the Geary Ratio and Moran Coefficient (Grifft, 2019). Moran's I calculate based on a measurement of covariance type (Dube & Legros, 2014) to identify the cluster as either high or low by categorizing the p-value of the data. Moran's local index can be interpreted as follows: a low p-value ($p < 0.10$) indicates a high association with the variable, whereas an overly high p-value ($p > 0.90$) suggests a weak association with the neighborhood values. Moreover, spatial autocorrelation also reveals individual contributions to global autocorrelation through the significance of local indicators of spatial autocorrelation (LISA). The classification is divided into four groups, with the addition of a threshold of 0 for LISA, including Low-Low (LL), High-High (HH), Low-High (LH), and High-Low (HL). These tools are used to investigate the spatial patterns of food security in each province in Indonesia. The local index of spatial autocorrelation was generated in Geoda 1.22.

2.3. Dynamic System

A dynamic system is an analytical approach applied to complex social, managerial, economic, and ecological problems that arise in various contexts, guiding policy design (Asosiasi Sistem Dinamik Indonesia, n.d.). Specifically, the basis of this system is feedback loops in the model, which can represent the set of realistic cause and effect relations and are capable of generating the reference model, with the simplest story explaining the dynamic behavior of the system (Albin, S.1997). In the context of this research, the dynamic system is used to analyze Indonesia's food self-sufficiency to meet national food needs by adjusting the community's nutritional needs standard. In more detail, the dynamic system analysis carried out is explained in the following graph.

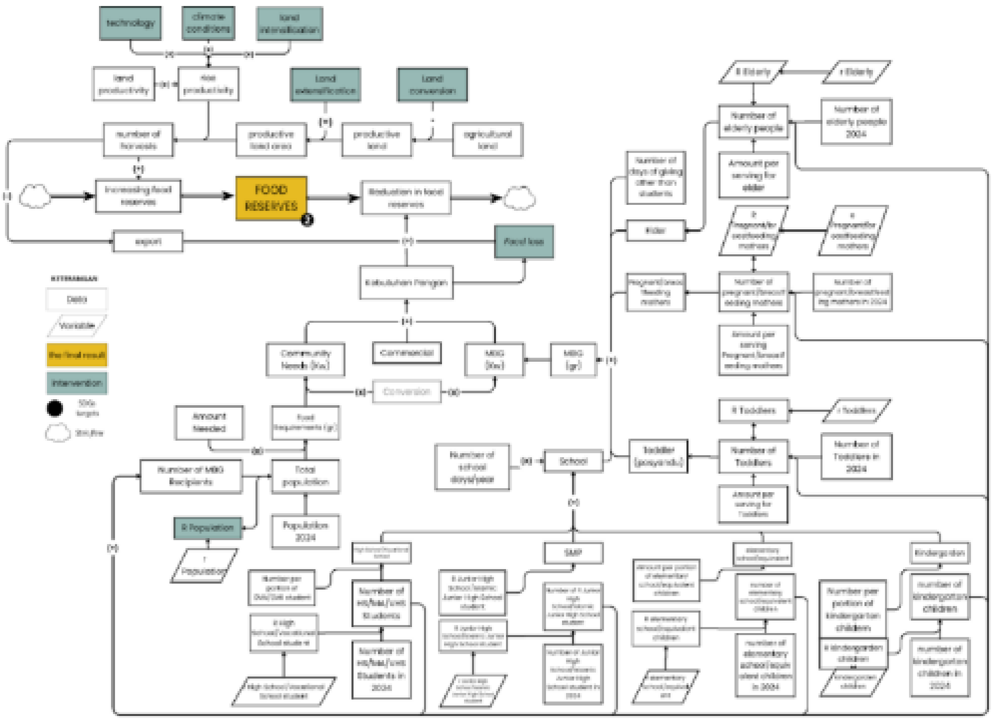

Figure 2. Research Framework of the Dynamic System

III. Results, Analysis, and Discussions

3.1 Spatial Relationship on Food Security

Agricultural productivity is closely tied to the productivity of farmland. Due to the differences in physical condition, each Indonesian province has a significant distinction in farmland productivity. As a result, several categories of farmland productivity in Indonesia affect agricultural production and supply. Based on the 2024 productive farmland data from Badan Pusat Statistik, several provinces share a commonality in the total area of productive farmland. Precisely, based on the spatial autocorrelation results, productive farmland in Indonesia is clustered into 3 clusters. Moran's I, which resulted in 0.208, shows a few spatial autocorrelations, yet the majority is not spatially autocorrelated.

Figure 3. Spatial Autocorrelation Map of The Productive Farmland

Provinces with low-productive farmland are significantly clustered in Eastern Indonesia, including Maluku, North Maluku, West Papua, Southwest Papua, South Papua, Papua Pegunungan, and Papua. Those areas have small productive farmland due to the geomorphological conditions (Supriadi, 2016). Moreover, Eastern Indonesia's climate is dry, which complicates agricultural activity. Meanwhile, highly productive farmland is located in Central Java and West Nusa Tenggara. Those provinces not only have a large farmland, but also have a good quality of irrigation and other related infrastructure. Moreover, technology for agricultural intensification is widely implemented in both provinces. In contrast, three provinces, which are Jakarta, Yogyakarta, and Bali, are categorized as low-high productive farmland. Those provinces have a small amount of productive farmland because most of the provinces have been developed into urban areas. Nevertheless, those are surrounded by large, productive farmland provinces.

Figure 4. Spatial Autocorrelation Map of The Total Production of Carbohydrate

Rice and corn, which become the primary sources of carbohydrates for Indonesians, have been cultivated in all provinces; however, the different geographical conditions significantly influence their production. As the primary carbohydrate intake, the demand for rice and corn supplies plummets as high as the total population in each province in Indonesia. Agricultural productivity plays a big role in fulfilling the demand and nourishing food (Baihaqi, 2025), yet differences in it influence the food supply in each province. Based on the results, Moran's I for the total carbohydrate production is 0.181, indicating a small positive autocorrelation throughout the data.

Rice and maize production are concentrated in geographical clusters. Provinces with low carbohydrate production are grouped in Eastern Indonesia, including Maluku, West Papua, South West Papua, South Papua, Central Papua, Papua Pegunungan, and Papua. This phenomenon shows that the lack of rice and corn production is spatially correlated due to the landscape's diversity. Eastern Indonesia lacks wetland areas that are used to cultivate rice and corn. Moreover, the development of rice and maize farming in this area is hindered due to the unsuitable soil characteristics. On the other hand, the provinces that have a high production of carbohydrates are centralized in Central Java, East Java, and West Nusa Tenggara. Most of the provinces on Java Island are larger rice producers due to the great potential of wetlands and soil conditions. Moreover, those areas have great accessibility to agricultural infrastructure, which strengthens the potential and increases productivity. The high number of total carbohydrates indicates this, as it has a large area of farmland. In addition, Yogyakarta and Bali are categorized as low-high production of rice and corn. Both of those provinces have small carbohydrate production, yet it surrounded by high carbohydrate production, which enables subsistence plus economy from the surrounding areas.

Figure 6. Spatial Autocorrelation Map of The Food Potential

Based on spatial autocorrelation analysis, 13 provinces are clustered on food security, yet the rest do not have any spatial autocorrelation. Seven provinces in Eastern Indonesia, including North Sulawesi, West Papua, South West Papua, Papua, Central Papua, and Papua Pegunungan, are clustered as having low food potential due to the limited food resources available in these areas. Meanwhile, South Papua is recognized as a high-low area, which means Papua Selatan has good food potential resources, yet is surrounded by provinces who has low food potential resources. On the other hand, the cluster of high-potential food is located in East Java and West Nusa Tenggara. Those two provinces are self-sufficient in carbohydrates and protein. This is supported by the agricultural potential, technologies, and access to related infrastructure. However, Aceh, Bengkulu, and Bali are located between provinces that have not achieved food self-sufficiency in carbohydrate and protein

3.2 Dynamic System

Food reserve dynamics scenarios in Indonesia are designed to investigate the implementation Free Nutritious Meals program, particularly in food security and support. Key indicators used in the model are land conversion rate, the number of agricultural export plans, agricultural intensification and extensification plans, climate influences, population growth rates, food loss, and technology influence that affects food production results. Three main scenarios were identified: Business as Usual (BAU) as scenario 1, Economic Development as scenario 2, and Sustainable Development as scenario 3. The business-as-usual (BAU) scenario is conducted using trends over the past 10 years for the key indicators, assuming no significant interventions are implemented in the future. The second scenario focused on an economic development scenario aimed at achieving various targets in the development plan. According to this scenario, massive technological development and maximized agricultural production are optimized. Meanwhile, the sustainable development scenario involves aligning the Sustainable Development Goals, especially goals 2, 12, and 13. This scenario considers sustainable development interventions such as mitigating climate change to support optimal agricultural production, and increasing land intensification and extensification. In addition, this also takes into account limited food losses due to responsible handling and consumption, as well as low crop failure rates.

Table 1. Variables In Each Scenario

Variable	**Scenario 1** Business as Usual	**Scenario 2** Economic Growth	**Scenario 3** Sustainable Developme nt	**Assumption and Sources**
Land Conversion	1-3%	5%	<1%	S1: Average farmland conversion rate 2018-2024 S2: In line with the Indonesian gross domestic product 2024 S3: In line with Indonesian farmland protection policy (LSD and LP2B)
Agricultural Exports (Rice)	0.07%	10%	5%	S1: Rice export data in 2022 S2: Indonesia's agricultural export target in 2028 S3: In line with the Indonesian gross domestic product 2024
Agricultural Intensification	1-5%	5-10%	5-7%	S1: Average rate of implementation of agricultural intensification S2: In line with the Indonesian gross domestic product 2024 S3: Assumptions with Indonesia's gross domestic product in 2024 elaborate on Sustainable Land Management
Agricultural Extensification	0.5-1.5%	3-5%	1.5-3%	S1: Average rate of implementation of agricultural extensification S2: chasing the target, the program of Cetak Sawah Baru S3: assumption in line with the target, the program of Cetak Sawah Baru, but with Sustainable Land Management
Climate Impact on Agriculture	1-5%	1-5%	1-3%	S1: (Jiang Z et al, 2019) (the assumption that current production has been affected by climate change) S2: (Jiang Z et al, 2019)

Variable	Scenario 1 Business as Usual	Scenario 2 Economic Growth	Scenario 3 Sustainable Developme nt	Assumption and Sources
				S3: Rapid approach to mitigate climate change in line with SDG 13; Wang et al (2024)
Population growth rate	0-1%	1-1.5%	0-1%	S1: Indonesia's long-term development plan document 2025-2045 S2: Average population growth rate in Indonesia 2014-2024 S3: Indonesia's long-term development plan document 2025-2045
Food loss	30%	20%	10%	S1: The assumption of FLW Indonesia in 2019 is 45% and rice is around 13.4% (Bappenas, 2021) S2: Align with S1, yet with higher GNI per capita, employment in agriculture, access to electricity, and export volume are associated with lower food loss (Daniel et al, 2023) S3: In line with SDG 12 for achieving responsible consumption and production
The Influence of Technology	0-10%	30-50%	20-30%	S1: Increased land productivity by 1.34% (Pratistya et al., 2024) S2: precision farming techniques can increase crop yields by 20-50% while reducing input waste, with vertical farming systems achieving up to 95% improvements in land and water use efficiency (Xie Chen, 2025) S3: Precision Agriculture (IoT, Sensors) can increase in crop yields by up to 33% (Anwar,I, 2026) Photosynthesis Engineering (modeled) can increase 5.3 to 19.1% in yield, depending on the

Variable	Scenario 1 Business as Usual	Scenario 2 Economic Growth	Scenario 3 Sustainable Developme nt	Assumption and Sources
				change, crop, and environment (Matthews & Burgess, 2024)

In general, the result shows that there are significant differences in food reserves (rice) until 2045. Scenario 1, which focused on business as usual, projected that around 1233.8 million quintals of food reserves would be needed to address the needs of around 223.17 million program recipients in 2045. However, the graph tends to decline and approaches zero, indicating that this scenario is at risk of a food crisis, especially before 2030. On the other hand, the economic growth scenario targets fulfilling the export target and program demand as well as the needs of the community, showing that food reserves are declining to minus 1325.9 million quintals in 2045. This indicates that Indonesia will experience a food shortage in a scenario where exports account for around 10% of harvests, and assuming that population demand is met. Meanwhile, scenario 3 indicates that Indonesia will have approximately 2.204,92 million quintals of food reserves (rice) by 2045, which will meet national food needs.

The analysis, which focuses on disparity areas (H-H areas), produced a similar pattern as the Sustainable Development scenario became the most productive scheme. The first scenario analysis illustrates that stagnant rice production around 2.5 to 3 million quintals per year, which calculated unmet the needs of a population of around 7.7-8.8 million people or around 15-19 million quintals of rice per year. Therefore, the food shortage of around 302.6 million quintals of rice is predicted to occur in 2045. Secondly, the second scenario or economic growth analysis explained that the rice production of around 3.3-4 million quintals per year is unable to address 7.7-8.8 million people or 14-18 million quintals of rice per year, which causes food insecurity. The third scenario also predicted the occurrence of food insufficiency around 234.6 million tons in 2045, indicated by rice production around 2.9-3.5 million quintals per year for 7.7-8.8 million people or 12-16 million quintals of rice per year. Although this scenario shows a negative trend, the third scenario indicates a lower food deficit.

All the scenarios can demonstrate a sustainable development approach by prioritizing social, economic, and environmental sustainability. These approaches can generate more favorable economic and ecological impacts for Indonesia's future. However, it should be emphasized that this scheme is a predictive model that relies on the quality and consistency of secondary data, where unexpected factors and fluctuations can still affect crop yields and meet community needs.

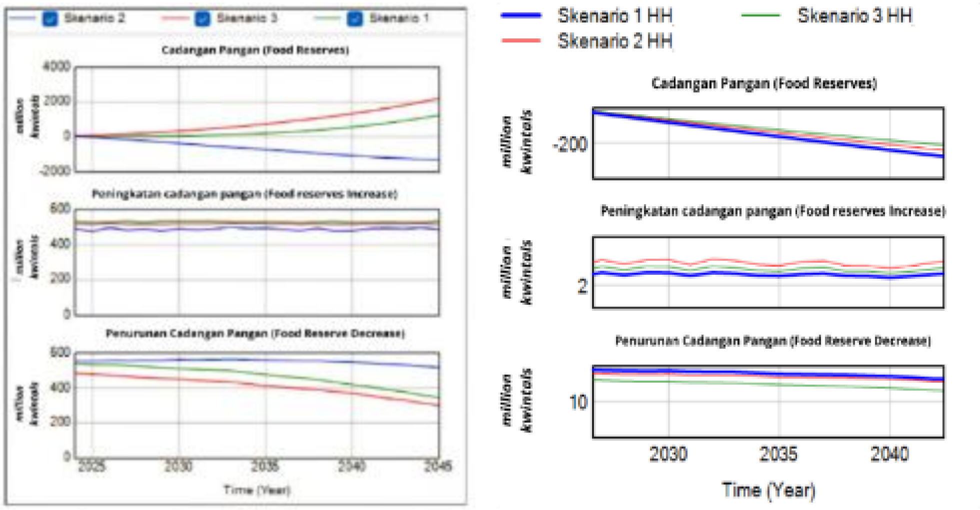

Figure 6. Indonesian Food Reserve Projection 2025-2045 (left) and H-H Cluster's Food Reserve Projection 2025-2045 (right)

3.3 Discussion

The convergence and clusterisation of spatial autocorrelation results and dynamic simulations show that Indonesian food security is not only a production problem but a geographic-structural problem. Systemic bottlenecks are persistently identified in the H-H Cluster. In this cluster, the hilly terrain and steep slopes described in the spatial analysis affect the food supply chain. These geographical constraints are incorporated into the dynamic model, reflecting a mutually reinforcing feedback loop between logistic cost and local price fluctuation, which directly threatens the sustainability of the Free Meal Program.

Moreover, limited access and supply of food contribute to inflation in Indonesia (Novita, 2024), which impacts the food accessibility for marginalized communities. Higher food prices might influence the community's willingness to purchase nutritious food. In terms of the implementation of the Free Meals Program, exorbitant prices cannot be covered by the limited budget allocation, which reduces the food quality. When the Free Meals Program is implemented simultaneously, demand for the ingredients used will surge. This situation will contribute to demand-pull inflation. The government must intervene in local pricing to prevent the Free Meals Program from causing economic side effects, which would actually increase food prices for the general public outside the program. To avoid this condition, subsistence plus the economy is required for the surrounding region that has met the sufficiency. However, a great distribution system and its management are necessary to evolve this strategy.

These conditions influence the quality of human resources due to the distribution of nutritional needs for the community (Huda, 2023). To optimize the food system and distribution and meet the distribution of nutritional needs, the government has implemented several programs, including prioritizing the development of logistics infrastructure and effective transportation to optimize food distribution in the H-H cluster (Somantri, 2016). Clear mechanisms are required to achieve and distribute food, ensuring food security is met.

Robust schemes are required for ensuring demand is met through community participation (Supriadi, 2016), including local farmers, fishermen, and suppliers in the surrounding SPPG areas. Furthermore, emphasizing the nutritional food distribution is also essential for developing a nourished community (Fatimah, 2024). Additionally, food standardization is required to ensure the quality of the demand in accordance with the program and nutritional requirements. Besides quantity and quality, various schemes and strategies need to be tailored to local conditions (Manikmas, 2016). To reduce the distribution friction in those areas, cluster-based procurement based on a local sourcing mandate is needed to ensure that the program budget is reinvested into the local economy rather than transportation costs. The empowerment of the local economy also boosts food diversification based on local foodstuffs that may reduce dependence on food supplies from other regions.

Inequality in food sufficiency strongly impacts public health, particularly in terms of adequate nutrition, as indicated by the large number of malnourished residents. Limited food accessibility contributes to the condition, particularly in Eastern Indonesia (H-H areas). The government responded to the condition by implementing various programs to reduce the high rate of malnutrition, e.g, the Supplementary Food Program (PMT), the Free Nutritious Food Program (MBG), etc, which aimed to improve health conditions. Moreover, the programs also have an impact on food security and local economic conditions. According to the spatial food security clusterization, the government should consider prioritizing programs in the H-H cluster. In addition to improving nutritional quality, these efforts could also have a more significant impact on local economic development and community food security (Fatimah, 2024).

The Free Nutritious Food Program (MBG) targets students, toddlers, mothers, and the elderly, particularly targeting 82.9 million beneficiaries by 2025. This is lower than the estimated number, which is approximately 130 million (calculated based on an analysis of the number of students, toddlers, mothers, and the elderly who should receive it in 2025). The National Food Agency (2025) guarantees that the Free Meals Program ensures local food absorption, thereby boosting farmer enthusiasm. This indicates the potential to achieve a significant impact on national food security, thus requiring a comprehensive approach to ensure food security is maintained and accessible to all.

IV. Conclussion and Recommendation

The Free Nutritious Food Program (MBG) requires significant support from the local market to meet demand. However, the potential supply has not met the community's needs. This condition must be addressed with several strategies, both spatial economic and socio-statistical approaches. The supply chain plays a significant role in addressing inefficiencies and ensuring food distribution throughout the country. Moreover, this also identifies regional clusters that require greater support related to community food security interventions. The analysis shows that the eastern region, consisting of the provinces of Maluku, West Papua, Southwest Papua, Papua, South Papua, Central Papua, and Highland Papua, falls into the cluster (H-H) that requires intervention to meet the community's food needs, both in optimizing food distribution and optimizing agricultural productivity. Meanwhile, the results of the dynamic system's third scenario (sustainable development) became the best scenario for development implementation, showing that Indonesia has the potential to fulfill domestic food needs. Through this scenario, the government can achieve the demand of the community to increase food sovereignty while supporting improved health without ignoring social, economic, and ecological factors. This condition indicates the need to develop an optimal distribution scheme to meet community needs, especially in areas with the highest need for intervention (H-H).

Limitations

This research was conducted using secondary data released by the government, which, despite its official status, may contain potential inconsistencies due to differing methodologies across provinces. Several factors rely on target assumptions and hypothetical scenarios owing to limited data availability, particularly regarding the granular impact of food distribution on nutrition security. Furthermore, the scope is primarily limited to the production and consumption of carbohydrates, thereby excluding essential nutritional components such as proteins, micronutrients, and vitamins necessary for holistic food security. Methodologically, the reliance on provincial-level data may overlook micro-level logistical variations and distribution barriers at the district level, especially within geographically challenging clusters like South Papua. In addition, the dynamic system simulation in this study relies heavily on the assumption of stability of external parameters and has not considered unexpected fluctuations such as global geopolitical crises that affect agricultural inputs or the dynamics of community cultural acceptability of local food diversification strategies. Finally, the system dynamics model is parameterized within the Indonesian context, meaning the findings may not be directly applicable to countries with different agroecological, economic, or political systems.

References

Anwae, I (2026). The Impact of Intelligent Agriculture on Sustainability and Food Security. Jurnal Sistem Informasi dan Teknik Informatika 4 (1) pp 9-15. 3031-2698.

Albin, S. (1997). Building a system dynamics model: Part 1: Conceptualization. MIT System Dynamics in Education Project. https://web.mit.edu/sysdyn/sd-intro/D-4527-1.pdf

Asosiasi Sistem Dinamik Indonesia. (n.d.). Apa itu sistem dinamik? Asosiasi Sistem Dinamik Indonesia. https://asdi.or.id/apa-itu-sistem-dinamik/

Beltran-Peña, A., Bocco, G., & Altieri, M. A. (2020). Global food self-sufficiency in the 21st century under sustainable intensification of agriculture. Environmental Research Letters, 15(9), Article 095004. https://doi.org/10.1088/1748-9326/ab9388

Badan Pangan Nasional. (2025). Optimis Program MBG Jadi Akselerator Ekosistem Pangan Nasional, NFA Siap Dukung Aspek Proyeksi Ketersediaan dan Keamanan Pangan. Badan Pangan Nasional. https://badanpangan.go.id/blog/post/optimis-program-mbg-jadi-akselerator-ekosistem-pangan-nasional-nfa-siap-dukung-aspek-proyeksi-ketersediaan-dan-keamanan-pangan

Badan Pangan Nasional (2024). Dukung program makan bergizi gratis, Badan Pangan Nasional perkuat pengawasan keamanan pangan segar. Badan Pangan Nasional. https://badanpangan.go.id/blog/post/dukung-program-makan-bergizi-gratis-badan-pangan-nasional-perkuat-pengawasan-keamanan-pangan-segar

Baihaqi, M. a. S. (2025). Dampak Produksi Beras, Indeks Kemahalan Kontruksi, dan Diversifikasi Pangan Terhadap Prevalensi Ketidakcukupan Pangan di Kawasan Indonesia Timur. Syntax Literate Jurnal Ilmiah Indonesia, 10(1), 959–970. https://doi.org/10.36418/syntax-literate.v10i1.23752

Clapp, J. (2017). Food self-sufficiency: Making sense of it, and when it makes sense. Food Policy, 66, 88–96. https://doi.org/10.1016/j.foodpol.2016.12.001

Chen, X. (2025). The role of modern agricultural technologies in improving agricultural productivity and land use efficiency. *Frontiers in Plant Science*, *16*, 1675657. https://doi.org/10.3389/fpls.2025.1675657

Chrisendo, D., Piipponen, J., Heino, M., & Kummu, M. Socioeconomic factors of global food loss. Agriculture & Food Security 12, 23 (2023). https://doi.org/10.1186/s40066-023-00426-4

Damayanti, A. (2025). BPS ungkap data impor komoditas pangan, capai 13.629 ton. Detiksumut. Retrieved from https://www.detik.com

Development Initiatives. (2024). Nutrition profile: Indonesia. Global Nutrition Report. https://globalnutritionreport.org/resources/nutrition-profiles/?country-search=indonesia

Fatimah, S., Rasyid, A., Anirwan, A., Qamal, Q., & Arwakon, H. O. (2024). Kebijakan Makan Bergizi Gratis di Indonesia Timur: Tantangan, Implementasi, dan Solusi untuk Ketahanan Pangan. Journal of Governance and Policy Innovation, 4(1), 14–21. https://doi.org/10.51577/jgpi.v4i1.641

Febryanti, I., Indiati, I., Pane, M. A., & Astuti, P. (2025). Implementasi kebijakan makan bergizi gratis (MBG) (studi kasus pada SDN 3 Kepanjen Kabupaten Malang). Dialogue: Jurnal Ilmu Administrasi Publik, *7*(1), 67–79. https://doi.org/10.14710/dialogue.v7i1.26628

Griffith, D. A. (2019). Spatial autocorrelation. In Elsevier eBooks (pp. 355–366). https://doi.org/10.1016/b978-0-08-102295-5.10596-7

Huda, A. C., Az-Zahra, A., Yasmin, F. P., Ningrum, I. W. K., Putra, W. S., & Budiasih, B. (2023). Analisis Regresi Spasial Persentase Kemiskinan di Kawasan Timur Indonesia Tahun 2022. Seminar Nasional Official Statistics, 2023(1), 747–756. https://doi.org/10.34123/semnasoffstat.v2023i1.1792

Indonesia.co.id. (2022). Penerima manfaat MBG mendekati 20 juta orang. https://indonesia.go.id/kategori/sosial-budaya/9842/penerima-manfaat-mbg-mendekati-20-juta-orang?lang=1

Jiang Z, Raghavan SV, Hur J, Sun Y, Liong S-Y, Nguyen VQ, van Pham Dang T. Future changes in rice yields over the mekong river delta due to climate change—alarming or alerting? Theoretical and Applied Climatology. 2019;137(1–2):545–55.https://doi.org/10.1007/s00704-018-2617-z

Kiftiyah, A., Palestina, F. A., Abshar, F. U., & Rofiah, K. (2025). Program Makan Bergizi Gratis (MBG) dalam Perspektif Keadilan Sosial dan Dinamika Sosial – Politik. Pancasila Jurnal Keindonesiaan, 5(1), 101–112. https://doi.org/10.52738/pjk.v5i1.726

Kutscherauer, A., CSc., Faculty of Economics, VŠB-Technical University of Ostrava, Ministry for Local Development of the Czech Republic, Fachinelli, H., Ph. D., Hučka, M., CSc., Skokan, K., Ph. D., Sucháček, J., Ph. D., Tománek, P., CSc., & Tuleja, P., Ph. D. (2010). Regional disparities in regional development of the Czech Republic – their occurrence, identification and elimination. VŠB-Technical University of Ostrava.

Manikmas, M. O. A. (2016). Merauke Integrated Rice Estate (Mire): Kebangkitan Ketahanan dan Kemandirian Pangan dari Ufuk Timur Indonesia. Analisis Kebijakan Pertanian, 8(4), 323–338. https://doi.org/10.21082/akp.v8n4.2010.323-338

Matthews, M. L., & Burgess, S. J. (2024). How much could improving photosynthesis increase crop yields? A call for systems-level perspectives to guide engineering strategies. Current Opinion in Biotechnology,88, 103144. https://doi.org/10.1016/j.copbio.2024.103144

Ministry of National Development Planning/Bappenas. (2024). Compilation of Long-Term National Development Plan (RPJPN) 2025-2045: Strengthening sustainable development towards Golden Indonesia 2045. Ministry of National Development Planning/National Development Planning Agency (Bappenas) of the Republic of Indonesia. https://www.bappenas.go.id/id/berita-dan-siaran-pers/indonesia-emas-2045 [Unpublished manuscript]

Ministry of State Secretatry of the Republic Indonesia. (2024. Makan bergizi gratis dan SDM unggul. Sekretariat Negara. Retrieved from https://setneg.go.id/baca/index/makan_bergizi_gratis_dan_sdm_unggul

Nordregio, UMS RIATE, RRG Spatial Planning and Geoinformation, Eurofutures Finland, LIG, Dubois, A., Gløersen, E., Lähteenmäki-Smith, K., Damsgaard, O., Grasland, C., Ysebaert, R., Zanin, C., Lambert, N., Schürmann, C., Hanell, T., Gensel, J., & Thomas, R. (2007). Regional disparities and cohesion: What strategies for the future? In Policy Department Structural and Cohesion Policies (Report No. IP/B/REGI/IC/2006_201). European Parliament. https://www.europarl.europa.eu/RegData/etudes/etudes/join/2007/379205/IPOL-REGI_ET(2007)379205_EN.pdf

Novita, D., Suharno, S., Nurmalina, R., & Nuryantoro, N. (2024). The effect of rice price on the Indonesian inflation in a new institutional economic perspective. Agrisocionomics: Jurnal Sosial Ekonomi Pertanian, 8(2), 621–636. https://doi.org/10.14710/agrisocionomics.v8i2.24146

Pratistya, S. D., Suharno, S., & Buono, A. (2024). Dampak teknologi informasi dan komunikasi terhadap produktivitas pangan di Indonesia. Agrikultura, *35*(3). https://doi.org/10.24198/agrikultura.v35i3.58339

Reardon, T., & Timmer, C. P. (2012). The quiet revolution in staple food value chains: Enter the dragon, the elephant, and the tiger. Asian Development Bank; International Food Policy Research Institute

Somantri, A.S., & Thahir, R. (2016). Analisis sistem dinamik ketersediaan beras di Merauke dalam rangka menuju lumbung padi bagi kawasan timur Indonesia. Buletin Teknologi Pasca Panen. https://repository.pertanian.go.id/handle/123456789/3459

Spatial autocorrelation. (1988). Choice Reviews Online, 26(01), 26–0446a. https://doi.org/10.5860/choice.26-0446a

Suprapto, F. A., Praditya, E., Dewi, R. M., & Adiyoso, W. (2025). A policy implementation review of the free nutritious meal (MBG) program. The Journal of Indonesia Sustainable Development Planning, 6(2), 297–312. https://doi.org/10.46456/jisdep.v6i2.798

Supriadi, H. (2016). Strategi Kebijakan Pembangunan Pertanian di Papua Barat. Analisis Kebijakan Pertanian, 6(4), 352–377. https://doi.org/10.21082/akp.v6n4.2008.352-377

United Nations. (n.d.). The 17 goals. Department of Economic and Social Affairs, Sustainable Development. https://sdgs.un.org/goals

Wang L, Wei Y, Li B, Zheng S, Ullah S, Sohail S. (2024). Renewable energy consumption and its impacts on agriculturalization under climate neutrality

targets. Energy and Environment. https://doi.org/10.1177/0958305X241230622

Waluyo, S. D. (2025). Kebijakan makanan bergizi gratis: Tinjauan ekonomi politik dalam kesejahteraan dan ketahanan pangan. Dinamika: Jurnal Ilmiah Ilmu Administrasi Negara, 12(1), April 2025.

Welthungerhilfe & Concern Worldwide. (2023). Indonesia - Global Hunger Index. Global Hunger Index. https://www.globalhungerindex.org/indonesia.html

Whelan, S., & Msefer, K. (1996). Economic supply & demand. MIT System Dynamics in Education Project. https://ocw.mit.edu/courses/15-988-system-dynamics-self-study-fall-1998-spring-1999/c0478ac5a8d6aa657cd82812fb91ce75_economics.pdf

Zulham, A., Sitorus, S. R. P., & Eriyatno. (2019). Supply chain strategy for convergence of regional economic growth East Coast North Sumatera, Indonesia. International Journal of Supply Chain Management, 8(5), 325–335.