AGRARIS: *Journal of Agribusiness and Rural Development Research*

Vol. 11 No. 1 January-June 2025,
Pages: 56-69

RESEARCH ARTICLE

Article history:
Submitted : January 30th, 2025
Revised : February 23rd, 2025
Accepted : March 7th, 2025

Ranita Rope* and Ekaria
Department of Agribusiness, Faculty of Agriculture and Fisheries, University of Muhammadiyah North Maluku, Ternate, Indonesia

**) Correspondence email: roperanita019@gmail.com*

Forecasting the Future: Trends in Population Growth, Rice Consumption and Rice Demand in North Maluku

DOI: https://doi.org/10.18196/agraris.v11i1.777

ABSTRACT

Food security is critical as consumption and population are growing rapidly. This study aims to predict population growth, rice consumption and rice demand in the province of North Maluku until 2028 used the ARIMA (2,2,0). Secondary data from BPS-Statistics Indonesia were used, covering population, consumption and rice demand from 2013 to 2023. The results indicated that the annual population growth in North Maluku ranges from 21,000 to 24,000. Simultaneously, the annual rice consumption is projected to increase by approximately two to three kilograms per capita. The predictive data revealed that rice demand was projected to increase from 71.37 million kg in 2024 to approximately 79.09 million kg by 2028, primarily stemmed by ongoing population growth and evolving consumption. These results signaled severe challenges in ensuring an adequate food supply, particularly in a region where rice serves as the primary staple food. These findings underlined the urgent need for data-driven policies, capable distribution networks, and crop diversification to guarantee sustainable food security. Moreover, this research has provided a roadmap for more efficient policy decision-making, highlighting the need for the utilization of modern technology in domestic food cultivation and distribution.

Keywords: Forecasting trends; Population growth; Rice consumption; Rice demand

INTRODUCTION

Nutritious food is not only a basic requirement for growth and development but is also a means to improve the living standards of individuals and foster the emergence of a healthy, productive, and prosperous society (Ekaria & Rope, 2023; Lin, Zhang, Khan, Mehmood, & Khan, 2024). The global food supply must not only expand but also adapt to evolving dietary habits, reflected as new business opportunities (Alexander et al., 2015; Beltran-Peña, Rosa, & D'Odorico, 2020). This growth is projected to elevate global rice production by around 26% by 2035, addressing the demands of a growing population and demonstrating much progress in global food production(Firdaus, Leong Tan, Rahmat, & Senevi Gunaratne, 2020; Lippit, 2018; Mboyerwa, Kibret, Mtakwa, & Aschalew, 2021).

As the staple food for more than half of the world's population and accounting for more than 12% of global agricultural land area, rice is vital in ensuring food sufficiency (Biggs et al., 2015; Buhaug, Benjaminsen, Sjaastad, & Magnus Theisen, 2015; Yoon, Lee, Choi, Yoo, & Hur, 2022). In Indonesia, rice remains the primary source of carbohydrates for most of the population. The rising population necessitates a sustainable and efficient enhancement in rice production (Ronquest-Ross, Vink, & Sigge, 2015). Rice is also a strategic commodity as its proper management can maintain national economic and social stability (Lin et al., 2024).

In North Maluku Province, rice consumption as a staple food reached 96.37% of the population (Iskandar, Duko, & Syahrain, 2023). Hence, rice has emerged as a significant staple food among the carbohydrate sources consumed by the local population. In 2011, the population was 1,063,117, and in 2021 it rose to 1,299,177, reflecting an annual growth of 2.22%. To achieve a growth rate of 7%, it is necessary to overcome consumption issues and improve nutrition, especially regarding rice consumption (Iskandar et al., 2023). Unfortunately, the growing global population and the unabated rice consumption pose significant challenges for food security policies (Tu, Kopp, Trang, Kontoleon, & Yabe, 2021).

One characteristic of food demand and distribution in North Maluku is that rice serves as a staple food commodity. However, extreme weather and logistical issues often disrupt sea transportation, upon which the archipelago relies heavily for food distribution. Inevitably, such reliance creates volatility in rice supply in local markets and price instability, often making it inaccessible for remote people. In North Maluku communities, the socioeconomic structure is predominantly characterized by fisheries and subsistence agriculture as the most significant contributors. This condition creates diversity in food habits compared to the rest of Indonesia. The demand pattern for rice is considerably impacted by the continued reliance of specific individuals on corn, sweet potatoes, or sago as substitute sources of carbohydrates. However, the lifestyle changes brought about by urbanization have made rice the primary food source in cities like Ternate and Tidore.

The amount of food consumption in the region has not been well documented, both historically and statistically, due to the difficulty of accessing remote areas. This obstacle complicates the collection of accurate data, necessitating a modeling approach that considers the geographic, sociological, and economic factors of North Maluku to produce a more accurate estimate of rice demand. To improve regional food security planning, this study employed the autoregressive integrated moving average (ARIMA) model as a prediction tool in estimating rice needs in the province.

The province of North Maluku has encountered food security challenges, and the ARIMA model has been adopted to provide excellent results with the prediction of time series data (Chengzhi, Sha, Shengnan, & Wenfang, 2025). The demand analysis model was based on food consumption patterns using secondary data from the Food Security Office, Statistics Indonesia, population trends, and crop yields data up to 2023. When appropriately applied, this method can yield precise predictions, making it highly popular in time series analysis to predict dependent variables from prior trends.

The ARIMA model was utilized in previous studies for predicting demand for food in different geographic regions. This model considers elements influenced by past trends and has been effective in predicting Indonesia's food production and consumption (Chengzhi et al., 2025). A time series ARIMA adds inputs such as population growth and trends in consumption to estimate food needs (Maganga, 2025). However, previous studies did not consider geographic variability, distribution of infrastructure, and local socioeconomic characteristics, which, in island regions such as North Maluku, have led to issues such as reliance on sea transportation, food distribution disparities, and lack of data on remote areas. Moreover, seasonality and external shocks like natural disasters impacting food dynamics in North Maluku were somehow not calibrated on the ARIMA model, declining the trustworthiness of estimates in this complex region. This study aims to predict population growth, rice consumption and rice demand in the province of North Maluku until 2028 used the ARIMA (2,2,0). Using this model, this research is expected to present a more accurate picture of fluctuations in food demand while also becoming a parameter for more effective and sustainable food management in the province. this research has provided a roadmap for more efficient policy decision-making, highlighting the need for the utilization of modern technology in domestic food cultivation and distribution.

RESEARCH METHOD

This study employed a descriptive approach, aiming to address the research problem by systematically summarizing the characteristics of the subject under investigation based on available data or observable conditions (Lim, 2025). The secondary data comprised results from prior research on rice, obtained from BPS-Statistics Indonesia (BPS-Statistic of Maluku Utara Province, 2024). The data were limited to the population, demand, and consumption of rice in the province of North Maluku from 2013 to 2023. This analysis adopted the Box-Jenkins forecasting using the ARIMA model (Cai, Lv, Wei, Zhang, & Cao, 2024).

The Box-Jenkins model forecasts time series values in the future. The ARIMA is often expressed in the notation ARIMA (p, d, q), with p indicating the order of the *AR* process, d signifying the differencing order required to make the data stationary, and q implying the order of the *MA* process. The three steps of building an ARIMA model include identification, estimation, and testing. ARIMA generates accurate short-term forecasts using both current and prior data on the dependent variable. The ARIMA model is a time series statistical method built on stochastic processes, including its applied formula (Chengzhi et al., 2025).

The Box-Jenkins method, developed by George Box and Gwilym Jenkins in the 1970s, is an approach to identify, model, and forecast time series with a stationary structure or can be made stationary (Box, Jenkins, Reinsel, & Ljung, 2016). Models frequently employed in the Box-Jenkins approach are as Formula 1-3.

1. Autoregressive Process (P,0,0)

$$X_t = \mu' + \Phi_1 X_{t-1} + \Phi_1 X_{t-2} + \ldots + \Phi_p X_{t-p} + e_t \quad (1)$$

2. Moving Average Process (0,0, q)

$$X_t = \mu + e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2} - \ldots - \theta_q e_{t-q} \quad 2$$

3. Moving Average and Autoregressive Process, (p, 0, q) or (p, d, q)

$$X_t = \mu' + \Phi_1 X_{t-1} + \ldots + \Phi_p X_{t-p} + et - \theta_1 e_{t-1} - \ldots - \theta_q e_{t-q} \quad 3$$

X_t refered to the variable's value at time t; μ' denoted the time series' average constant; Φ_1, Φ_2 ,..., Φ_p represent the impact of previous values on present values described by an autoregressive (*AR*) coefficient; $\theta_1,\theta_2,\ldots,\theta_q$ were the impact of historical errors on present results described by a moving average (*MA*) coefficient; et signified arbitrary mistakes or disruptions at time t; $t-1$, $t-2$,..., $t-p$ indicated time series lags utilized in the autoregressive model; $t-1$, $t-2$,..., $t-q$ demonstrated lags of the moving average model's errors; p illustrated the autoregressive component's number of lags; and q depicted the moving average component's number of lags.

RESULTS AND DISCUSSION

Population Trend

The time series analysis revealed that ARIMA with parameters (0,1,1) was the optimal model.

TABLE 1. RESULTS OF POPULATION PROJECTION ANALYSIS IN NORTH MALUKU

Parameter	Coefficient	Standard Error	T-Statistic
AR (1)_population	0.295	0.93	2.29
Constant	22.166	112.55	11.13

Table 1 illustrates the results of population estimates obtained from examining the forecasting models employed to project future population changes. This projection provided an overview of anticipated demographic trends, crucial to establishing regional policies on consumption and resource needs. Previous research has proven that more accurate references to population predictions could facilitate the planning of future rice stocks (Fachrurrazi et al., 2024; Meena et al., 2024). The population projection for the subsequent five years, derived from the ARIMA (0,1,1) model analysis, is detailed in Table 2.

TABLE 2. POPULATION PROJECTION FOR 2024 TO 2028

Year	Total Population (People)
2024	1,341,504
2025	1,363,670
2026	1,385,836
2027	1,408,002
2028	1,430,168

Table 2, depicting the projected population from 2024 to 2028, indicates a consistent annual growth in population. In 2024, the population was projected to reach 1,341,504 people, with further growth in the following years. The steady population growth in North Maluku, with an annual increase of around 21,000 to 24,000 people, must be contextualized

within the region's unique geographical, social, and economic characteristics. As an archipelago with limited sea transportation infrastructure, the population increase required better infrastructure planning, especially connecting remote islands. On the financial side, while population growth may enlarge the labor force, the primary challenge lies in creating jobs that match local needs. At the same time, pressure on natural resources and sustainability must also be managed carefully to maintain environmental balance.

Potential solutions to overcome this challenge included enhancing local agricultural productivity through modern technology, diversifying food products to reduce dependence on certain commodities, and optimizing marginal land for sustainable agriculture (Ben Hassen, El Bilali, & Al-Maadeed, 2020). In addition, policies must strengthen food security through regional food reserve programs, farmer training, and increased investment in distribution infrastructure such as storage and transportation. Proper planning could balance population growth with fulfilling sustainable food needs (Y. Chen & Lu, 2019).

Rice Consumption in North Maluku Province

The projection of per capita rice food consumption employed the auto-regressive (AR) regression model.

TABLE 3. ANALYSIS RESULTS OF RICE CONSUMPTION PROJECTION PER CAPITA

Parameter	Coefficient	Standard Error	t-Statistic
AR (1)_consumption	1.07	0.13	2.723
AR (2)_consumption	-0.36	0.15	-2.431
Constant	2.91	1.41	23.358

Table 3 exhibits that rice consumption was strongly influenced by prior consumption, as seen by the *AR (1)_consumtion* parameter, having a coefficient of 1.07. This value indicated a positive relationship, where an increase in the past consumption tended to drive a rise in the present consumption. This metric generated a statistically significant T-statistic of 2.723. The consumption of the preceding two periods possessed an adverse corrective effect on present consumption, as indicated by the *AR (2)_consumption* parameter's coefficient of -0.36. A T-statistic of -2.431, which was also significant, implied that while rice consumption tended to rise, an adjustment mechanism existed to maintain a balanced long-term consumption. Furthermore, the model's constant of 2.91, denoting the necessary level of rice consumption per person even in the absence of other factors, possessed a T-statistic of 23.358, indicating extremely high significance. Consumption of staple crops have transformed substantially due to climatic variations, and current food consumption trends have revealed new dimensions and trends due to climate change variations and anthropogenic pressures, necessitating the adaptation of climate-resilient agricultural practices (Yaqoob et al., 2022).

The model demonstrated that per capita rice consumption was significantly affected by the consumption in the previous period, both directly and by the correction effect in the last two periods. Per capita rice consumption in North Maluku exhibited fluctuations, varying from 51.47 kg in 2014 to 51.17 kg in 2023. These fluctuations reflected the dynamics of food

consumption, influenced by various factors, including socioeconomic conditions, food policies, and previous consumption of the community. It indicated the autoregressive behavior of rice consumption, beneficial for planning the future rice demand projection. Rice stock management strategies must consider this consumption fluctuation pattern to avoid surpluses or shortages.

TABLE 4. PROJECTED PER CAPITA RICE RICE CONSUMPTION FROM 2024 TO 2028

Years	Consumption (Kg per Capita)
2024	54.08
2025	56.99
2026	59.91
2027	62.81
2028	65.72

Table 4 displays the estimated per capita rice consumption for 2024 to 2028. Annually, the per capita consumption of rice rose. In 2024, the forecast per capita consumption of rice was 54.08 kg, with an anticipated annual rise of around 2 to 3 kg. The projected rice consumption was 56.99 kg in 2025, 59.91 kg in 2026, and 65.72 kg in 2028. The surge in rice consumption pointed to an escalation in overall food demand, particularly for rice, which could be driven by higher population growth and changes in people's eating patterns. This increase in per capita rice consumption must be considered when planning food production, food security policies, and rice distribution to ensure sufficient and equitable food availability and prevent future price inflation or shortages. The demand for accurate data on wheat germ protein content, the fierce need for food intake, and global market competition have experienced escalation (Xu et al., 2024). Given that per capita household food intake often overestimates food energy (with a correction factor of 2.63 for one-person households and 1.89 for households with more than one person), food security planning could be compromised in this scenario (Bromage et al., 2018). Hence, more accurate and contextualized prediction models should be created to account for the variation in food consumption in areas with various socioeconomic and geographic circumstances.

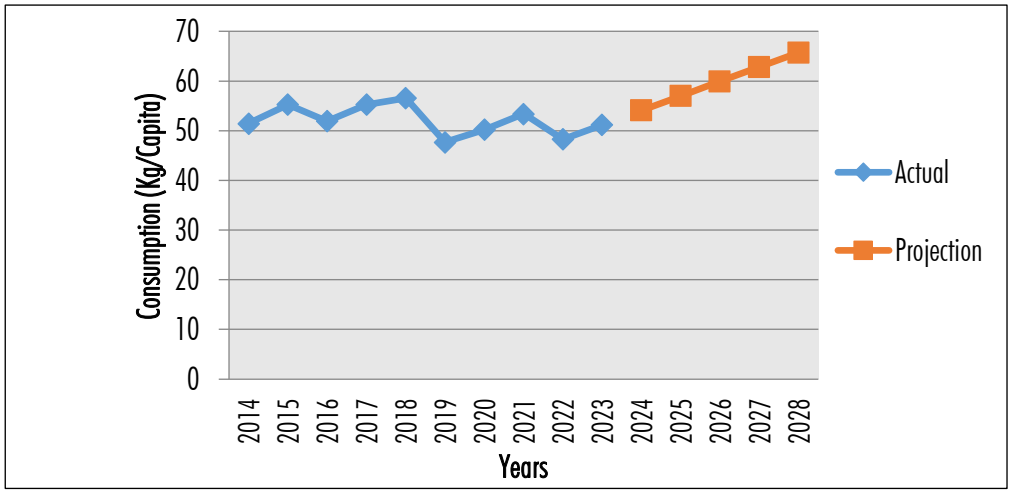


FIGURE 1. COMPARISON OF RESULTS OF ACTUAL DATA ANALYSIS AND RICE CONSUMPTION PROJECTION (KG/CAPITA) IN NORTH MALUKU PROVINCE

Figure 1 depicts a stable pattern of increase in rice consumption from 2014 to 2028 projections, necessitating a better and targeted production and distribution strategy to meet the food needs of the community.

Projected Rice Demands in North Maluku Province

The Box-Jenkins ARIMA model was employed to estimate rice demand. The test findings unveiled that the data fit an ARIMA model with parameters p = 2 and q = 0, expressed as ARIMA (2,2,0). It suggests that data on rice consumption during the previous two years impacted the demand prediction.

TABLE 5. RESULTS OF RICE DEMAND PROJECTION ANALYSIS

Parameter	Coefficient	Standard Error	T-Statistic
AR (1)_demand	0.253	0.172	-1.860
AR (2)_demand	0.481	0.193	-2.933
Constant	19.301	26.580	-1.087

Table 5 presents the results of the rice demand projection analysis using the ARIMA model. The *AR (1)_demand* parameter acquired a coefficient of 0.253, indicating a positive influence between the prior rice consumption and current rice demand. However, the t-statistic value of -1.860 suggested an insignificant statistical effect. Meanwhile, the *AR (2)_demand* parameter, with a coefficient of 0.481 and a t-statistic of -2.933, depicted a more substantial and significant effect on rice demand, indicating that rice consumption two years earlier contributed more to the projected rice demand. The constant of 19.301 reflected the base level of rice demand; however, the T-statistic of -1.087 signified that this value was not statistically significant. Overall, these analysis results unveiled that projected rice demand was predominantly influenced by rice consumption from two years earlier. Nonetheless, the influence of rice consumption in the preceding year was insignificant in this model. The equation should be modified to predict the number.

$$X_t = 19{,}301 - 0{,}253X_{t-1} - 0{,}481X_{t-2} + e_t$$

TABLE 6. RESULTS OF RICE DEMAND PROJECTION FOR 2024 TO 2028

Year	Consumption (Kg)
2024	71,374,200
2025	73,304,300
2026	75,234,400
2027	77,164,500
2028	79,094,600

Table 6 exhibits the projected rice demand in North Maluku Province from 2024 to 2028, with expectations of a continuous annual growth in demand. In 2024, rice demand was projected to reach 71,374,200 kg, with a steady annual growth forecast thereafter. In 2025, rice demand would attain 73,304,300 kg, rising to 75,234,400 kg in 2026. By 2027, the figure was projected to reach 77,164,500 kg; in 2028, rice demand was expected to attain 79,094,600 kg. This rise in rice demand aligned with the projected growth of a larger population and the

continued increase in rice consumption per capita. It underscored the importance of attention to the management of rice supply in the region, including in terms of local production and efficient distribution, to ensure that rice food needs are adequately met without any shortages.

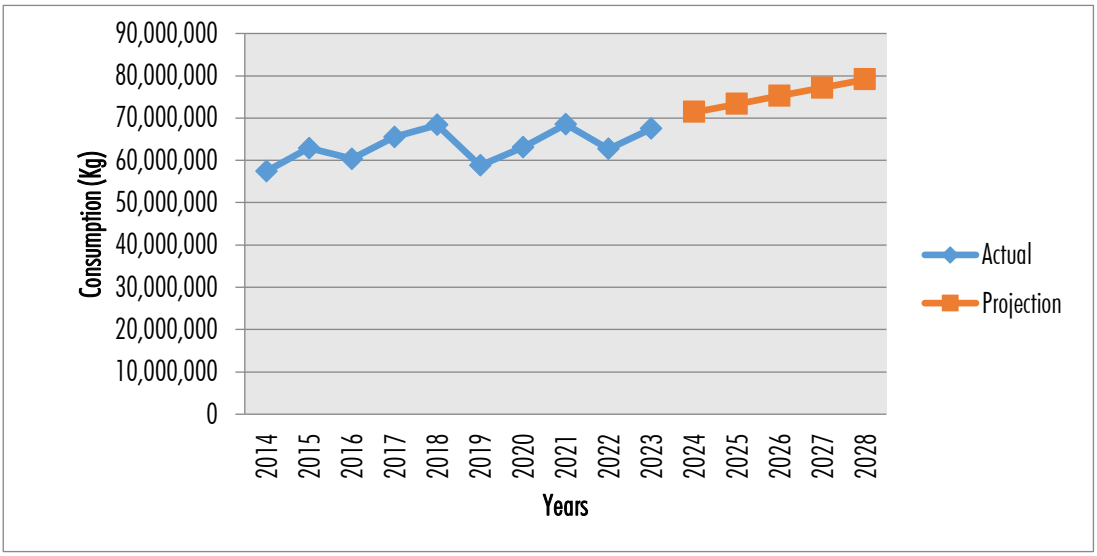


FIGURE 2. COMPARISON OF RESULTS OF ACTUAL DATA ANALYSIS AND PROJECTED RICE DEMAND IN NORTH MALUKU PROVINCE

Figure 2 depicts the demand for rice as a linear relationship, indicating a consistent and predictable growth pattern of rice demand.

Policy Implication

Considering the projected population, rice consumption, and rice demand from 2024 to 2028, several policy implications must be addressed to maintain food security and ensure adequate food availability.

Increased Rice Production

Policies should be enacted to elevate per capita rice consumption annually, achievable through the promotion of domestic rice production. Eliminating these programs would be a wrong decision, rendering programs such as good seed supply, land irrigation, and efficient agriculture technology unsustainable, hence hindering future agricultural productivity growth. Through advanced irrigation methods, farmers could reduce water consumption for irrigation while also improving water usage efficiency in food production and addressing climate factors hindering agricultural production and food security (Usman, Hameed, Saboor, & Almas, 2021). Consequently, the government must emphasize demand-oriented food production together with the need for farm-level crop diversification to meet the rising demand for food products due to rising income and urbanization (Bairagi, Mohanty, Baruah, & Thi, 2020). Enhancing productivity in the rice sector could positively influence farmers' membership in groups (Abdul-Rahaman & Abdulai, 2018).

Food Diversification

The need for food consumption diversification policies was dual-pronged in this regard; excess reliance on rice needs to be minimized. The government could promote evidence that eating other local foods, like corn, sorghum, or sweet potatoes, is better than rice. This initiative could be a proselytizing campaign to decrease the reliance on rice and assist people in maintaining a more nutritious and balanced diet. Moreover, the maintenance of export diversification and the enhancement of high-value-added products would facilitate sustainable development in the agrarian and food industries (Yakovenko, Rodionova, Ivanenko, Kireeva, & Sukhorukova, 2018). The product, price, place, and promotion (4P) approach in social marketing could address some factors that may enhance local rice consumption and current constraints in developing countries (Coffie, Tweneboah-Koduah, Ocloo, Nkukpornu, & Kastner, 2024). However, the impacts of agricultural added value, food price inflation for consumers, and population growth are contradictory regarding agricultural producer prices. This study revealed that information globalization, as the principal determinant, tended to elevate the prices of agricultural producers in both developing and developed nations (Nugroho, 2024).

Strengthening Food Distribution Infrastructure

Given the projected rise in the consumption of rice, there has been a pressing need for policies that improve and bolster the food distribution infrastructure to guarantee equal distribution of rice to all regions, including remote places and food-insecure areas. Efforts should also be focused on improving the logistics system and management of food reserves to stabilize rice prices (Ben Hassen et al., 2020). Economic conditions related to rice have been consistently susceptible to changes in supply, demand, and price due to varying phenomena (Widyawati, Hanani AR, Syafrial, & Sujarwo, 2025). Hence, support should be aimed at reinforcing food infrastructure, including warehouses, transportation networks, and modern logistics distribution centers. This infrastructure should cooperate to provide equitable and efficient food supply (Dhal & Kar, 2025; Shiratori, Abeysekara, Ozaki, Rafalimanantsoa, & Rasolonirina Andrianjanaka, 2024).

Food Security Monitoring

As food consumption was expected to rise, the authorities should regularly track food availability and access in all regions. Policies about national food reserves, such as rice, need to be reinforced to accommodate emergencies and food crises caused by nature disasters or supply disruptions. Nevertheless, keeping enough arable land has become essential to food (A. Chen et al., 2019). According to management studies, to remain self-reliant, rice needs to go through an innovation for planting and breeding systems, as well as farmer welfare management through incentives and subsidies, local food diversification systems, and innovative food techniques to enhance food diversification (Sutrisno et al., 2019). Protecting an agricultural system based on natural farming principles by emphasizing permanent paddy

fields without chemicals, selecting natural seeds without genetic engineering, and using natural food and straw sources should be performed to ensure the availability of safe food and soil fertility of natural soil over time (Gururani et al., 2021).

Socialization of Food Security Policies

Considering the evolving consumption, the government should introduce inclusive food security policies to the community. One crucial step is to expand food aid programs, such as rice aid for underprivileged families, and ensure that these programs are well targeted to accommodate population growth and increased food consumption. Indonesia has instituted a food price subsidy program called Rice for Poor Families (RASKIN) to help low-income families meet their needs and ease some of the financial burden (Amrullah, Susilawati, Hidayah, Rusyiana, & Ishida, 2023). In addition, the impact of urban expansion on food production potential and biodiversity issues until 2050 must be anticipated through land use planning integrated with policies across spatial scales (De Vos et al., 2024). Policies should also promote the processing and trade of locally produced traditional foods, as processing has become a significant factor in increasing urban consumers' preference for novel foods over conventional foods (Honfoga, N'tandou-Bonzitou, Vodouhè, Bellon, & Hounhouigan, 2018; Wang et al., 2024). On the other hand, the government and research and development institutions must facilitate farmers' access to high-yielding rice varieties to encourage sustainable adoption. It could improve the efficiency of rice farmers, augment crop yields, and support overall food availability (Akanbi et al., 2024).

CONCLUSION

This study employed the ARIMA model to forecast population growth, per capita rice consumption, and total rice demand in North Maluku from 2024 to 2028. The results indicate that the population is projected to grow steadily by 21,000 to 24,000 individuals annually, while per capita rice consumption is expected to increase by approximately 2 to 3 kilograms each year. Consequently, rice demand is forecasted to rise from 71.37 million kilograms in 2024 to 79.09 million kilograms by 2028. These trends highlight the growing pressure on regional food systems, especially in an archipelagic area like North Maluku with logistical and infrastructural challenges.

Considering the projected population growth, rice consumption, and demand in North Maluku from 2024 to 2028, several strategic policies are required to safeguard food security and ensure equitable food availability. The government should enhance rice production through support for agricultural technologies, irrigation systems, and the provision of quality seeds, while aligning production with actual demand. Food diversification is also essential to reduce overreliance on rice by promoting local alternatives. Strengthening food distribution infrastructure, including logistics networks and modern distribution centers, is critical to ensuring equitable and efficient supply, particularly to remote and food-insecure areas. Continuous monitoring of food availability and access is necessary, along with reinforced national food reserves to address potential crises. Moreover, inclusive food security policies

should be widely disseminated, including well-targeted food assistance programs, and support for the development of local food products and high-yielding rice varieties to enhance production efficiency, improve farmer welfare, and promote long-term agricultural sustainability.

Acknowledgments: Thanks to the financial support from the PPM Diktilitbang Council, especially the RISETMU Funding, for funding this research and enabling its proper execution. We also express our deepest appreciation and gratitude for the contributions and assistance provided. Special thanks to the Rector of the Muhammadiyah University of North Maluku and LPR2H (research, service, publication, and IPR institution), who have facilitated the smooth implementation of the research according to plan.

Authors' Contributions: RR: conceptualized the idea, analyzed the results, reviewed the manuscript, and addressed the reviewer's comments; EK: analyzed the data and wrote the manuscript.

Conflict of Interest: The authors declare no conflict of interest.

REFERENCES

Abdul-Rahaman, A., & Abdulai, A. (2018). Do farmer groups impact on farm yield and efficiency of smallholder farmers? Evidence from rice farmers in northern Ghana. *Food Policy*, *81*(1), 95–105. https://doi.org/10.1016/j.foodpol.2018.10.007

Akanbi, O. N., Olawuyi, S. O., Adepoju, A. A., Olarinde, L. O., Dlamini, S. G., & Dlamini, D. V. (2024). Food security drive and adoption of improved rice varieties on the production efficiencies of upland and lowland rice farmers in north-central Nigeria. *Journal of Infrastructure, Policy and Development*, *8*(6), 3341. https://doi.org/10.24294/jipd.v8i6.3341

Alexander, P., Rounsevell, M. D. A., Dislich, C., Dodson, J. R., Engström, K., & Moran, D. (2015). Drivers for global agricultural land use change: The nexus of diet, population, yield and bioenergy. *Global Environmental Change*, *35*, 138–147. https://doi.org/10.1016/j.gloenvcha.2015.08.011

Amrullah, E. R., Susilawati, P. N., Hidayah, I., Rusyiana, A., & Ishida, A. (2023). Do Food Price Subsidies Increase Nutritional Intake of Indonesian Households? *AGRARIS: Journal of Agribusiness and Rural Development Research*, *9*(2), 258–277. https://doi.org/10.18196/agraris.v9i2.172

Bairagi, S., Mohanty, S., Baruah, S., & Thi, H. T. (2020). Changing food consumption patterns in rural and urban Vietnam: Implications for a future food supply system. *Australian Journal of Agricultural and Resource Economics*, *64*(3), 750–775. https://doi.org/10.1111/1467-8489.12363

Beltran-Peña, A., Rosa, L., & D'Odorico, P. (2020). Global food self-sufficiency in the 21st century under sustainable intensification of agriculture. *Environmental Research Letters*, *15*(9), 095004. https://doi.org/10.1088/1748-9326/ab9388

Ben Hassen, T., El Bilali, H., & Al-Maadeed, M. (2020). Agri-Food Markets in Qatar: Drivers, Trends, and Policy Responses. *Sustainability*, *12*(9), 3643. https://doi.org/10.3390/su12093643

Biggs, E. M., Bruce, E., Boruff, B., Duncan, J. M. A., Horsley, J., Pauli, N., … Imanari, Y. (2015). Sustainable development and the water–energy–food nexus: A perspective on livelihoods. *Environmental Science & Policy*, *54*, 389–397. https://doi.org/10.1016/j.envsci.2015.08.002

Box, G. E. P., Jenkins, G. M., Reinsel, G. C., & Ljung, G. M. (2016). *Time Series Analysis: Forecasting and Control* (5th Editio). New Jersey: John Wiley & Sons, Inc. Retrieved from http://repo.darmajaya.ac.id/4781/1/Time Series Analysis_ Forecasting and Control %28 PDFDrive %29.pdf

BPS-Statistic of Maluku Utara Province. (2024). Luas Panen, Produktivitas, dan Produksi Padi Menurut Kabupaten/Kota di Provinsi Maluku Utara (Tahun), 2024. Retrieved from https://malut.bps.go.id/id/statistics-table/2/MjY4IzI=/luas-panen-produktivitas-dan-produksi-padi-menurut-kabupaten-kota-di-provinsi-maluku-utara-tahun-.html

Bromage, S., Rosner, B., Rich-Edwards, J. W., Ganmaa, D., Tsolmon, S., Tserendejid, Z., … Fawzi, W. W. (2018). Comparison of Methods for Estimating Dietary Food and Nutrient Intakes and Intake Densities from Household Consumption and Expenditure Data in Mongolia. *Nutrients*, *10*(6), 703. https://doi.org/10.3390/nu10060703

Buhaug, H., Benjaminsen, T. A., Sjaastad, E., & Magnus Theisen, O. (2015). Climate variability, food production shocks, and violent conflict in Sub-Saharan Africa. *Environmental Research Letters*, *10*(12), 125015. https://doi.org/10.1088/1748-9326/10/12/125015

Cai, C., Lv, L., Wei, S., Zhang, L., & Cao, W. (2024). How does climate change affect potential yields of four staple grain crops worldwide by 2030? *PLOS ONE*, *19*(5), e0303857. https://doi.org/10.1371/journal.pone.0303857

Chen, A., He, H., Wang, J., Li, M., Guan, Q., & Hao, J. (2019). A Study on the Arable Land Demand for Food Security in China. *Sustainability*, *11*(17), 4769. https://doi.org/10.3390/su11174769

Chen, Y., & Lu, C. (2019). Future Grain Consumption Trends and Implications on Grain Security in China. *Sustainability*, *11*(19), 5165. https://doi.org/10.3390/su11195165

Chengzhi, C., Sha, W., Shengnan, D., & Wenfang, C. (2025). Potential Yield of Potato Under Global Warming Based on an ARIMA-TR Model. *Potato Research*, *68*, 661–677. https://doi.org/10.1007/s11540-024-09745-w

Coffie, I. S., Tweneboah-Koduah, E. Y., Ocloo, E. C., Nkukpornu, A., & Kastner, A. N. A. (2024). Improving local rice consumption in Sub-Saharan Africa through social marketing: evidence from Ghana. *International Review on Public and Nonprofit Marketing*, *21*, 177–196. https://doi.org/10.1007/s12208-023-00370-w

De Vos, K., Janssens, C., Jacobs, L., Campforts, B., Boere, E., Kozicka, M., … Govers, G. (2024). African food system and biodiversity mainly affected by urbanization via dietary shifts. *Nature Sustainability*, *7*, 869–878. https://doi.org/10.1038/s41893-024-01362-2

Dhal, S. B., & Kar, D. (2025). Leveraging artificial intelligence and advanced food processing techniques for enhanced food safety, quality, and security: a comprehensive review. *Discover Applied Sciences*, *7*(1), 75. https://doi.org/10.1007/s42452-025-06472-w

Ekaria, E., & Rope, R. (2023). Effectiveness and Efficiency of Various Croping Methods on Rice Crops. *Agrikan Jurnal Agribisnis Perikanan*, *16*(1), 103–108. https://doi.org/10.52046/agrikan.v16i1.1522

Fachrurrazi, S., Ilhadi, V., Syukriah, S., Umaruddin, U., Ula, M., & Zohra, S. F. A. (2024). Application of autoregressive integrated moving average and vector autoregression prediction models for stock and price stabilization at perum bulog. *Edelweiss Applied Science and Technology*, *8*(6), 8034–8046. https://doi.org/10.55214/25768484.v8i6.3744

Firdaus, R. B. R., Leong Tan, M., Rahmat, S. R., & Senevi Gunaratne, M. (2020). Paddy, rice and food security in Malaysia: A review of climate change impacts. *Cogent Social Sciences*, *6*(1). https://doi.org/10.1080/23311886.2020.1818373

Gururani, K., Sood, S., Kumar, A., Joshi, D. C., Pandey, D., & Sharma, A. R. (2021). Mainstreaming Barahnaja cultivation for food and nutritional security in the Himalayan region. *Biodiversity and Conservation*, *30*, 551–574. https://doi.org/10.1007/s10531-021-02123-9

Honfoga, B. G., N'tandou-Bonzitou, G., Vodouhè, R. S., Bellon, M. R., & Hounhouigan, J. D. (2018). Assessing the role of market integration in the consumption of traditional foods in Benin: a joint price instability coefficient and diet composition approach. *Agricultural and Food Economics*, *6*, 2. https://doi.org/10.1186/s40100-018-0097-1

Iskandar, E., Duko, F., & Syahrain, R. (2023). Analisis Permintaan Beras di Provinsi Maluku Utara. *Journal of Tax and Business*, *4*(2), 364–374. https://doi.org/10.55336/jpb.v4i2.136

Lim, W. M. (2025). What Is Qualitative Research? An Overview and Guidelines. *Australasian Marketing Journal*, *33*(2), 199–229. https://doi.org/10.1177/14413582241264619

Lin, L., Zhang, X., Khan, M. A., Mehmood, M. A., & Khan, M. K. (2024). Eco-Conscious Consumption in the Climate Change Era: Decoding the Mediating Role of Food Safety and Environmental Concerns between Health Literacy and Take-Out Food Consumption in China. *Sustainability*, *16*(11), 4357. https://doi.org/10.3390/su16114357

Lippit, V. D. (2018). Agricultural Development. In *The Economic Development of China* (pp. 163–200). Routledge. https://doi.org/10.4324/9780429457562-7

Maganga, J. M. (2025). ARIMA consumption forecasting models and ATDC technological optimizations: the case of rice, maize and vegetable production in Mozambique. *Scientific African*, *28*(02), e02762. https://doi.org/10.1016/j.sciaf.2025.e02762

Mboyerwa, P., Kibret, K., Mtakwa, P., & Aschalew, A. (2021). Evaluation of Growth, Yield, and Water Productivity of Paddy Rice with Water-Saving Irrigation and Optimization of Nitrogen Fertilization. *Agronomy*, *11*(8), 1629. https://doi.org/10.3390/agronomy11081629

Meena, A. G., Gopalakrishnan, C., Patil, S. G., Kamalakannan, A., Jagadeeswaran, R., Sathyamoorthy, N. K., & Manonmani, S. (2024). Forecasting rice blast disease severity using weather-dependent regression and time series models. *Plant Science Today*, *11*(4). https://doi.org/10.14719/pst.4974

Nugroho, A. D. (2024). Comparing the Effects of Information Globalization on Agricultural Producer Prices in Developing and Developed Countries. *Agris On-Line Papers in Economics and Informatics*, *16*(3), 93–107. https://doi.org/10.7160/aol.2024.160307

Ronquest-Ross, L.-C., Vink, N., & Sigge, G. O. (2015). Food consumption changes in South Africa since 1994. *South African Journal of Science*, *111*(9/10), 12. https://doi.org/10.17159/sajs.2015/20140354

Shiratori, S., Abeysekara, M. G. D., Ozaki, R., Rafalimanantsoa, J., & Rasolonirina Andrianjanaka, B. H. (2024). Effects of Risk and Time Preferences on Diet Quality: Empirical Evidence from Rural Madagascar. *Foods*, *13*(19), 3147. https://doi.org/10.3390/foods13193147

Sutrisno, D., Ambarwulan, W., Nahib, I., Turmudi, T., Suryanta, J., Windiastuti, R., & Kardono, P. (2019). Cellular Automata Markov Method, An Approach for Rice Self-Sufficiency Projection. *Journal of Ecological Engineering*, *20*(6), 117–125. https://doi.org/10.12911/22998993/108651

Tu, V. H., Kopp, S. W., Trang, N. T., Kontoleon, A., & Yabe, M. (2021). UK Consumers' Preferences for Ethical Attributes of Floating Rice: Implications for Environmentally Friendly Agriculture in Vietnam. *Sustainability*, *13*(15), 8354. https://doi.org/10.3390/su13158354

Usman, M., Hameed, G., Saboor, A., & Almas, L. K. (2021). Research and Development Spillover, Irrigation Water Use and Agricultural Production in Pakistan. *WSEAS Transactions on Environment and Development*, *17*, 840–858. https://doi.org/10.37394/232015.2021.17.79

Wang, Y., Zhao, J., Jiang, L., Zhang, L., Raghavan, V., & Wang, J. (2024). A comprehensive review on novel synthetic foods: Potential risk factors, detection strategies, and processing technologies. *Comprehensive Reviews in Food Science and Food Safety*, *23*(4). https://doi.org/10.1111/1541-4337.13371

Widyawati, W., Hanani AR, N., Syafrial, S., & Sujarwo, S. (2025). Crafting the future of rice in Indonesia: sustainable supply through systems thinking. *Cogent Social Sciences*, *11*(1). https://doi.org/10.1080/23311886.2025.2488113

Xu, X., Zhou, L., Taylor, J., Casa, R., Fan, C., Song, X., … Li, Z. (2024). The 500-meter long-term winter wheat grain protein content dataset for China from multi-source data. *Scientific Data*, *11*, 1025. https://doi.org/10.1038/s41597-024-03866-0

Yakovenko, N. A., Rodionova, I. A., Ivanenko, I. S., Kireeva, N. A., & Sukhorukova, A. M. (2018). Export Potential as the Competitiveness Indicator of the Agri-Food Complex. *International Journal of Engineering and Technology*, *7*(4.38), 654. https://doi.org/10.14419/ijet.v7i4.38.24640

Yaqoob, N., Jain, V., Atiq, Z., Sharma, P., Ramos-Meza, C. S., Shabbir, M. S., & Tabash, M. I. (2022). The relationship between staple food crops consumption and its impact on total factor productivity: does green economy matter? *Environmental Science and Pollution Research*, *29*, 69213–69222. https://doi.org/10.1007/s11356-022-22150-5

Yoon, P. R., Lee, S.-H., Choi, J.-Y., Yoo, S.-H., & Hur, S.-O. (2022). Analysis of climate change impact on resource intensity and carbon emissions in protected farming systems using Water-Energy-Food-Carbon Nexus. *Resources, Conservation and Recycling*, *184*, 106394. https://doi.org/10.1016/j.resconrec.2022.106394