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FORECASTING THE BASIC CONDITIONS OF INDONESIA'S RICE ECONOMY 2019-2045

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Abstract: By 2045, Indonesia's population is expected to reach 321.4 million, the fifth largest in the world after China, India, Nigeria, and the United States. It is an excellent challenge for Indonesia to provide food in the future as it keeps pace with the rapid population growth. This study aims to analyze forecasting the basic conditions of Indonesia's rice economy 2019-2045. The research data use time-series data from 1961-2018, including data from the Central Bureau of Statistics (BPS), Ministry of Agriculture/Pusdatin, Food and Agriculture Organization (FAO), International Rice Research (IRR), Department of Commerce, United States Department of Agriculture (USDA), and ASEAN Food Safety Information System (AFSIS). Data analysis using the simultaneous equations model approach. The results show that in 2019-2045 the projection of rice productivity in 2025 is 64,465 quintals per hectare; in 2035, it is 68,797 quintals per hectare, and in 2045 it is 77,462 quintals per hectare. In 2045, the projected land area is 27.64 million hectares. Although Indonesia is forecast to experience a rice surplus of 37.80 million tonnes in 2045, the projected rice production and domestic rice consumption level indicate the potential for rice imports of 15 million tonnes.

Keywords: *rice economic model, policy, forecasting, gold Indonesia 2045*

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INTRODUCTION

Indonesia establishes a strategy to achieve the production of food crops through four strategies or what is known as the four Strategies to achieve the production of food crops including: 1) Increase productivity 2) Expansion of the area and land optimization 3) Reduce rice consumption and develop food diversification and 4) Improve management (Agbachom et al., 2019; Pichler, 2015; Sulaiman et al., 2019; Utami et al., 2020). Increasing rice productivity is carried out by accompanying, mentoring, advising, and coordinating the following activities: 1) Assemble, disseminate and implement appropriate technology packages specifically for technology application and development, 2) GP3K (Movement to increase business-based food production), 3) Protection of food plants against pests and IPR disturbances, and 4) A decrease in yield loss and increase in rice yield.

The development of food crops by expanding the planting area is carried out by 1) printing new land (rice fields); 2) land optimization by increasing the crop index (PI); 3) optimization of another agricultural land; and 4) optimization of abandoned land (Choi et al., 2019; Junaidi et al., 2020; Neilson et al., 2020; Wicke et al., 2011). The efforts made by the government do not seem to have achieved optimal results, where the achievement of rice production is relatively insignificant compared to the rate of population increase, and there is a tendency for rice production to have a declining pattern in recent years (Fadhliani et al., 2019; Graham et al., 2020; Maraseni et al., 2018).

Rice is a strategic commodity besides soybeans, maize, beef, shallots, and sugar (Sa'diyah et al., 2019). Rice is also the staple food source of carbohydrate food in Indonesia. The share of household expenditure on rice is the largest across all household income quintiles (Nikmatul et al., 2020).The food problem in Indonesia is problematic concerning the increasing population (Hidayaturrahman & Husamah, 2020; Rusliyadi et al., 2020.; Setiadi et al., 2020). By 2045, Indonesia's population is expected to reach 321.4 million, the fifth largest in the world after China, India, Nigeria, and the US. It is a big challenge for Indonesia to provide food because it keeps pace with the rapidly increasing population growth rate. Today's decisions will determine whether Indonesia can meet the food needs of a future with a population that continues to

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increase. The vision for the future in rice policy is to make Indonesia a world food barn by 2045 (Arifin et al., 2018). The scenario for a world food barn is through several stages. Each stage requires serious political will and action, including infrastructure support and technological innovation, strengthening agricultural institutional from all lines, both at the central and regional levels. The scenario towards a world food barn is through several stages. Each stage requires a serious political will and political action (Meuwissen et al., 2019; Mora et al., 2020; Movilla-Pateiro et al., 2020).

Research on the rice policy scenario has been carried out in several countries ie (Abdulai & Huffman, 2000; Acee-Eke, 2018.; Biondi et al., 2019; Graham et al., 2020; Maraseni et al., 2018; Moayedfar et al., 2020). Research on forecasting the basic conditions of the Indonesian Rice Economy in 2045 is still rare. Therefore, this study aims to analyze forecasting the basic conditions of Indonesia's rice economy 2019-2045. The research data uses secondary data in the form of time-series data from 1961-2018, derived from national and international data. Data analysis uses the Simultaneous Equation Model approach to project 12 rice economic models in 2019-2045. The research results are expected to be valuable input for the government to achieve food security, especially rice self-sufficiency towards a golden Indonesia in 2045.

METHODS

This research is a follow-up study from the initial research on the Indonesian rice economic model's overview. At the initial stage of the research, 12 models were tested to analyze the Indonesian rice economic model. The Indonesian rice economic model consists of 12 models (Table 1). The simultaneous analysis was carried out to obtain the parameters of all models (Santilano et al., 2018; Sarwar et al., 2017). Of the 12 models, 11 models are significant and only 1 model, namely rice imports, is not significant. In this study, the 12 models were simulated using the ex-ante method for the years 2019-2045.

Table 1. Indonesia's Rice Economic Models

No	Model	Formulation	Variables
1	Rice area	APt = ao + a1ASt + a2PPt + μ1	APt = paddy area (hectar) ASt = wet land area (hectar) PPt = paddy price (Rp/kg) Prediction mark of the expected parameters a1 >0, a2 >0, and a3 < 0
2	Rice production	QBt = a2*SPt	a2t = rice rendemen (percent) SPt = paddy suplpy (ton)
3	Rice productivity	YPt = bo + b1Lt + b2 FNt + b3 FPt + b4 FKt + b5 PESTt + b6 TEKt + μ2	YPt Paddy productivity (kwintal/hectar) Lt = labour usage (person) FNt = N Fertilizer usage (ton) FPt = P fertilizer usage (ton) FKt = K fertilizer usage (ton) Pestt = Pesticide usage (ton) Tekt = Level of technology application (Productivuty index) Prediction mark of the expected parameters b1 > 0, b2> 0, b3>0, b4>0, b5> 0, and b6> 0
4	Demand for Labour	Lt = c0 + c1PPt + c2 it + c3 KREt + c4 POPRt + μ3	Lt = Labour usage (person) PPt = paddy price (Rp/kg) it = rate of interest (percent) KREt = Total credit (rupiah) POPRt = agricultural sector labor wages (Rp/HOK) Prediction mark of the expected parameters c1>0, c2< 0, c3 > 0, and c4 > 0
5	Nitrogen fertilizer Usage	FNt = d0 + d1Pfnt + d2PPt + d3APt + d4 It + d5 KREt + μ4	FNt = N Fertilizer usage (ton) Pfnt = N Fertilizer price (Rp/kg) PPt = Paddy price (Rp/kg) APt = paddy area (hectar) It = rate of interest (percent) KREt = the amount of credit extended (Rp) Prediction mark of the expected parameters d1< 0, d2 > 0, d3 >0, c4 < 0, and d5 >0
6	Phosphat fertilizer usage	FPt = d0 + d1Pfpt + d2PPt + d3APt + d4 It + d5 KREt + μ5	FPt = P fertilizer usage (ton) Pfpt = P fretilizer price (Rp/kg)

No	Model	Formulation	Variables
			PPt = Paddy price (Rp/kg) APt = Paddy area (hectar) It = rate of interest (percent) KREt = the amount of credit extended (Rp) Prediction mark of the expected parameters d1 < 0, d2 > 0, d3 > 0, c4 < 0, and d5 >0
7	Kalium fertilizer usage	FKt = e0 + e1Pfkt + e2PPt + e3APt + e4 It + e5 KREt + µ6	FKt = K Fertilizer usage (ton) Pfkt = K fertilizer price (Rp/kg) PPt = Paddy price (Rp/kg) APt = luas areal padi (hectar) It = rate of interest (percent) KREt = the amount of credit extended (Rp) Prediction mark of the expected parameters e1 < 0, e2 > 0, e3 > 0, e4 < 0, and e5 >0
8	Pesticide usage	FPESTt = g0 + g1Ppestt + g2PPt + g3APt + g4 it+ d5 KREt + µ7	FKt = Pesticide usage (ton) Ppestt = Pesticide price (Rp/kg) PPt = Paddy price (Rp/kg) APt = Paddy area (hectar) It = interest rate (percent) KREt = the amount of credit extended (Rp) Prediction mark of the expected parameters g1 < 0, g2 > 0, g3 > 0, g4 < 0, and g5 >0
9	Individual Rice demand	DB0t = mo + m1PBt + m2INCt + m3PPHt + µ9	DB0t = individual rice demand year-t (kg/capita/year) PBt = rice price year-t (Rp/kg) INCt = income per capita year-t (Rp/capita/year) PPHt = desirable food pattern (Pola Pangan Harapan/PPH) year-t (percent) Prediction mark of the expected parameters m1< 0, m2 > 0, m3 < 0 Prediction mark of the expected parameters p1 > 0, n2 < 0, and n3 > 0
10.	Domestic rice price	PBt = n0 + n1 DBt + n2SBt + n3 Excht + µ10	PBt = domestic rice price year-t (Rp/kg) DBt = domestic rice demand year-t (ton) SBt = rice supply year-t (ton) Excht = exchange rate year-t (Rp/US $) Prediction mark of the expected parameters n1 > 0, n2 < 0, and n3 > 0
11	Paddy price	PPt = p0 + p1PBt + p2QPt + p3HPPt + µ10	PPt = paddy price p0 = contant p1PBt = rice demand in year-t P2QPt = rpaddy production in year t µ10 = Prediction mark of the expected parameters
12	Rice import	MBt = h0 + h1PBt + h2PWBt + h3QBt + h4DBt + µ8	MBt = The amount of rice imported in year t (ton) PBt = Domestic price rice year-t (Rp/kg) PWBt = world rice price year-t (US $/ton) QBt = rice production year-t (ton) DBt = rice total demand year-t (ton) Prediction mark of the expected parameters h1 > 0, h2 < 0, h3 < 0, h4 > 0 dan 0 < h5 < 1

Source: Author's modelling

Data

The data used in this research is time-series data and collected by the documentary method—data obtained by taking secondary data from various data that have been published by national and international institutions. The data based on time series from 1961 - 2018. The data collected are from 1. Central Bureau of Statistics (BPS) 2. Ministry of Agriculture/ Pusdatin, 3. Food Agriculture Organization (FAO)) 4. International Rice Research (IRR) 5. Ministry of Trade 6. United States Department of Agriculture (USDA), and 7. ASEAN Food Security Information System (AFSIS).

RESULTS AND DISCUSSIONS

1. Model validation

The results of the analysis of the Indonesian rice economic model using the Root Mean Square Error (RMSE) and Root Means Square Percent Error (RMSPE) indicators are represented by the deviation value, which is the difference between the actual average value (actual mean) and the predicted average (predicted mean). The result is presented in Table 2.

Tabel 2: Validation Results with Deviation Value Indicators

No.	Variabel	*Actual Mean*	*Predicted Mean*	Deviasi (%)
1.	Paddy Area (AP)	21576933	24475426	0.13
2	Paddy Supplay (SP)	82344056	97450000	0.18
3.	Paddy productivity (YP)	65.3492	51.6875	-0.21
4.	Paddy production (QP)	118600000	148000000	0.25
5	Rice production (QB)	65307613	54499243	-0.17
6.	Kehilangan Padi (KP)	4758058	6863398	0.44
7.	Rice Supply (SB)	36237064	74695071	1.06
8.	Labor Usage (L)	32442.1	47322	0.46
9.	N fertilizer usage (FN)	4664088	7469556	0.60
10.	P Fertilizer usage (FP)	901705	1130058	0.25
11.	K fertilizer usage (FK)	5071368	4129320	-0.19
12.	Pesticide usage (FPest)	3597	4047	0.13
13.	Rice demand (DB)	38220992	41190000	0.08
14.	Rice demand per capita (DBO)	129.8	229.7	0.77
15.	Rice import (MB)	8223625	1793291	-0.78
16.	Rice price (PB)	12057.3	14755.5	0.22
17.	Paddy price (PP)	667.4	1049.2	0.57
	Rates			0.22

Sumber: Authors computation

The predicted average value that is closer to the actual average value shows better validity. Table 2 shows that the lowest deviation value (regardless of the sign) is 0.13%, and the highest deviation value is 78%, while the average deviation is 22%. The value of this deviation occurs considering that the period used for forecasting is 27 years; taking into account the length of the time, the rice economic model built is quite valid because the predictions made can approach the actual value.

Table 3 shows the results of validation analysis using statistical indicators for the U-Theil value (Theil Inequality Coefficient) and their decomposition, namely proportion bias (MW), variance bias (US), and covariance bias (UC) of the Indonesian rice economic model. The statistical indicators are used to evaluate a model's ability to analyze simulations, historical simulations, and ex-ante simulations. The principle is that the smaller it is, the better the estimation of the model. Good UM and US values are close to 0, while a good UC value is close to 1.

Table 3 also shows that the lowest U-Theil value is 0.0720, and the highest U-Theil value is 0.8542, while the average U-Theil value is 0.34. The lowest MW was 0.61, and the highest MW was 0.99, while the average MW was 0.83. The lowest US value was 0.0000, and the highest US value was 0.33, while the US average was 0.016. The lowest UC was 0.0000, and the highest UC was 0.15, while the average UC was 0.02. Because the average U-Theil value is relatively small, and the US value is close to one, the model is quite valid and can be used in the simulatory analysis.

Table 3. Validation test with Indicator U-Theil, U^M, U^S, dan U^C

No.	Variable	U-Theil	U^M	U^S	U^C
1.	Paddy Area (AP)	0.0720	0.74	0.26	0.00
2.	Paddy Supplay (SP)	0.8981	0.93	0.07	0.00
3.	Paddy productivity (YP)	0.1304	0.80	0.18	0.02
4.	Paddy production (QP)	0.8542	0.94	0.06	0.00
5.	Rice production (QB)	0.3254	0.84	0.07	0.09
6	Kehilangan Padi (KP)	0.0974	0.85	0.15	0.00
7.	Rice Supply (SB)	0.3589	0.92	0.08	0.00
8.	Labor Usage (L)	0.2022	0.85	0.00	0.15
9.	N fertilizer usage (FN)	0.2554	0.78	0.22	0.00
10.	P Fertilizer usage (FP)	0.4341	0.79	0.21	0.00

No.	Variable	U-Theil	U^M	U^S	U^C
11.	K fertilizer usage (FK)	0.1083	0.82	0.18	0.00
12.	Pesticide usage (FPest)	0.5775	0.86	0.14	0.00
13.	Rice demand (DB)	0.0720	0.99	0.22	0.00
14.	Rice demand per capita (DBO)	0.2995	0.84	0.14	0.01
15.	Rice import (MB)	0.6710	0.78	0.22	0.00
16.	Rice price (PB)	0.1213	0.67	0.33	0.00
17.	Paddy price (PP)	0.2605	0.71	0.22	0.07
	Rata-rata	0.34	0.83	0.16	0.02

Source: Authors computation

2. Forecasting the Basic Conditions of Indonesia's Rice Economy

The results of the forecast analysis for the basic economic conditions of Indonesian rice for the 2019-2045 period are shown in Table 4. Table 4 shows that rice's world price is $ 401.72/ton, and the domestic price of Indonesian rice is 683.53/ton. The world price of rice, which is cheaper than the domestic price of rice, will encourage market players to import rice from abroad by taking advantage of this sizeable price difference and can disrupt the market balance between rice producers (farmers) and consumers.

Due to Indonesia's rice harvest area of 16,384,243.89 hectares and Indonesian rice productivity of 54.9335/hectare, Indonesia's paddy production is 86,090,811.88 tons, and if it is turned into rice, it will produce rice of 53,391,029.56 tons. Meanwhile, the amount of demand for rice in this base year is 35,030,336.13 tons. It illustrates that domestic rice production can meet 100% of all Indonesian rice demand, and it is even open for Indonesia to become a rice exporter considering that there is a rice surplus of 18,360,693.4 tons.

The increase in population will cause an increase in food consumption. In 2015, Indonesia's total population was 257 million, with a population increase rate of 1.29 percent compared to the previous year. Suppose the increase in population growth rate cannot be suppressed. In that case, it will lead to a relatively large increase in rice needs' fulfillment regarding the community's considerable dependence on large amounts of food as a source of food and a burden for efforts to increase economic growth rates.

Table 4. Forecasting the Basic Conditions of Indonesia's Rice Economy

No	Variable	Based value
1	Paddy Area (AP)	16,384,243.89
2	Paddy Supplay (SP)	74,540,265.14
3	Paddy productivity (YP)	54,933.50
4	Paddy production (QP)	86,090,811.88
5	Rice production (QB)	5,213,693.09
6	Kehilangan Padi (KP)	53,391,029.56
7	Rice Supply (SB)	36,239,784.57
8	Labor Usage (L)	3,177,950.00
9	N fertilizer usage (FN)	3,910,254.88
10	P Fertilizer usage (FP)	684,340.41
11	K fertilizer usage (FK)	2,537,654.06
12	Pesticide usage (FPest)	1,597.00
13	Rice demand (DB)	35,030,336.13
14	Rice demand per capita (DBO)	131,026.00
15	Rice import (MB)	2,408,266.04
16	Rice price (PB)	401.72
17	Paddy price (PP)	10,082.00
18	Domestic Price Rice (PB) (US$/ton)	683,53
19	Paddy Price (PP) (Rp/kg)	6,915.04

Source: Authors computation

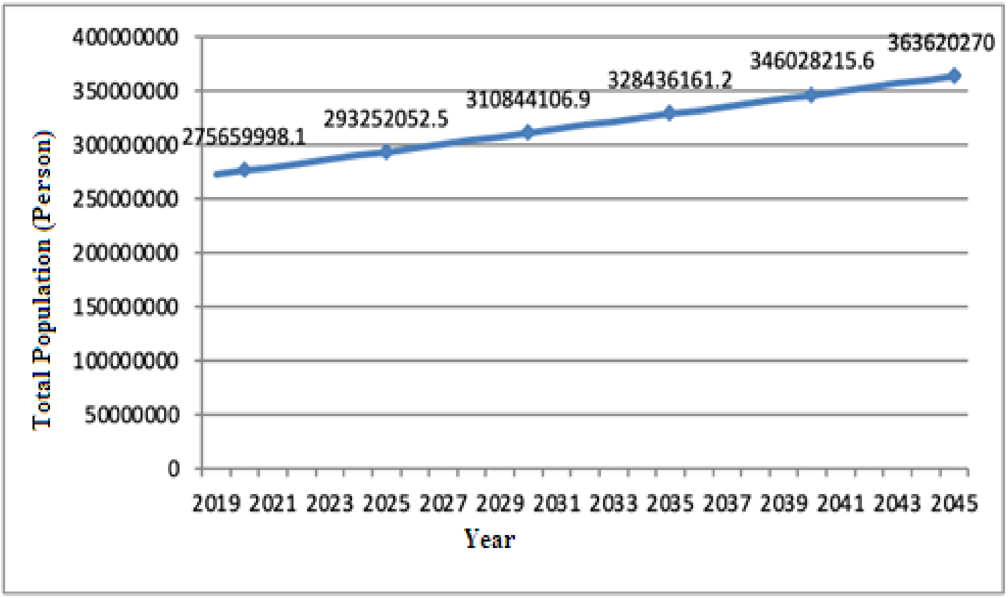

Figure 1. Forecasting of Indonesia's Population in 2020 - 2045

The movement to suppress the population growth rate is expected to suppress the population growth rate at the level of 1.11 percent. Then the population in 2020 is projected to be 275 million people. This study indicates that the population growth rate in 2025 is 1.21 percent, in 2035 is 1.08 percent, and in 2045 is 0.98 percent. The average decline in the population growth rate of still 1.12 percent (Figure 2), with an average population growth rate of 1.12 percent in 2025, the total population of Indonesia is 293 million, in 2035 it will be 328 people, and in 2045, the projected population of Indonesia is 364 million. According to the data, the population of Indonesia in 2025 in 2925, 2 million people, in 2035 in 328.4 million people and in 2045 in 363.4 million people (Figure 1).

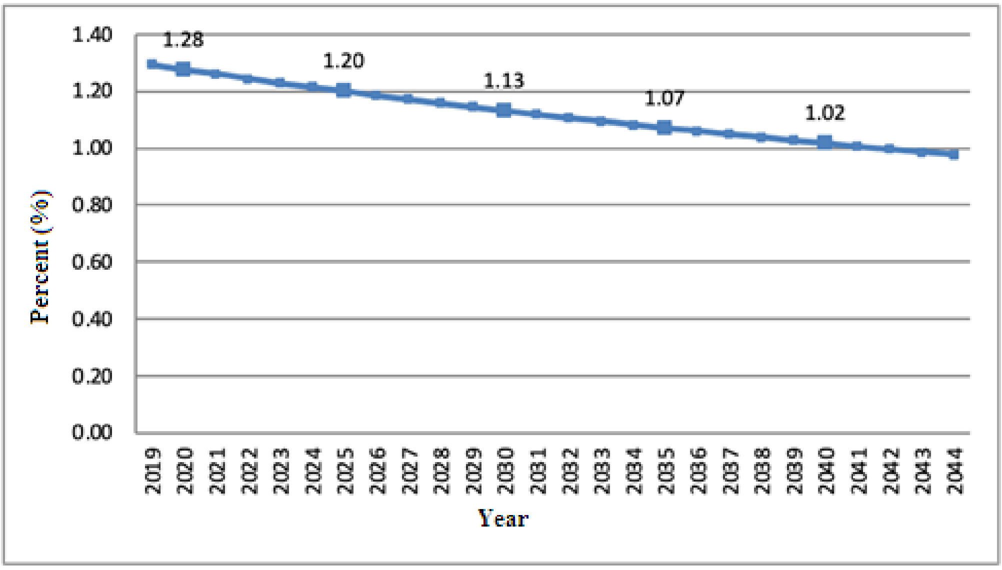

Figure 2. Projection of Indonesia's Population Growth Rate 2020 - 2045

Table 5 shows a slowdown in the population growth rate, although it is not too large. The demand for rice is calculated using the calculation of rice consumption, both direct rice consumption and indirect consumption per capita per year multiplied by the total population. Direct rice consumption is household consumption of the use of rice or rice-based foodstuffs. The figure for rice consumption per capita per year, for example, in 2012 was 132.98 kg (BPS and Ministry of Agriculture 2012). This figure is obtained from the sum of the rice consumption rate at the household level (Susenas result) of 97.65 kg per capita per year and rice outside the household of 35.33 kg per capita per year.

Table 5. Projected Population and Population Growth Rate of Indonesia 2019 - 2045

No	Year	Number of population (Person)	Growth (%)
1	2019	272.141.587	
2	2021	279.178.409	1.28
3	2023	286.215.230	1.24
4	2025	293.252.052	1.21
5	2027	300.288.874	1.19
6	2029	307.325.696	1.16
7	2031	314.362.517	1.13
8	2033	321.399.339	1.11
9	2035	328.436.161	1.08
10	2037	335.472.983	1.06
11	2039	342.509.804	1.04
12	2043	356.583.448	1.00
13	2045	363.620.270	0.98
Rata-rata		317.880.928	1.12

Source: Authors computation

The result of this study reflects decreasing rice consumption per capita per year. In 2019 rice consumption in Indonesia was 131. 23 kg per capita per year; In 2025, it is 130.39 kg per capita per year; in 2035, it is 129.33 kg per capita per year. It is estimated that in 2045, rice consumption will be 128.277 kg per capita per year. Although there has been a decline in rice consumption per capita per year, the population growth rate is higher than the growth rate of decline in rice consumption per capita per year, causing total consumption of rice is still increasing. Table 6 and Figure 3 shows that in 2015, rice consumption was 31.9 million tons. The amount of consumption was obtained by multiplying the assumed consumption figure of 124.89 kg capita per year, with 255.46 million people. In the same way, in 2020, it is projected that the need for rice consumption is 33.60 million tons, and in 2025 it will be 35.34 million tons. In 2030, it will be 36.70 million tons, and in 2035 it will be 37.8 million tons. In 2040, it will be 38.94 million tons, and in 2045 it will be 39.80 million tons (BPS, 2015).

Table 6. Projections of Total Population, Consumption Per Capita / year, and Rice Demand by Year 2019 - 2045

No	Year	Total Population (person)	Growth (%)	Consumption rice (Capita/year)	Growth (%)	Demand rice (%)	Growth (%)
1	2019	272141587		131.03		35030336	
2	2021	279178409	1.28	130.18	-0.57	35521206	0.70
3	2023	286215231	1.24	130.60	-0.08	36012076	0.69
4	2025	293252052	1.21	130.39	-0.08	36502946	0.68
5	2027	300288874	1.19	130.18	-0.08	36993817	0.67
6	2029	307325696	1.16	129.97	-0.08	37484687	0.66
7	2031	314362518	1.13	129.76	-0.08	37975557	0.65
8	2033	321399339	1.11	129.55	-0.08	38466427	0.64
9	2035	328436161	1.08	129.33	-0.08	38957297	0.63
10	2037	335472983	1.06	129.12	-0.08	39448167	0.63
11	2039	342509805	1.04	128.91	-0.08	39939037	0.62
12	2041	349546627	1.02	128.70	-0.08	40429907	0.61
13	2043	356583448	1.00	128.49	-0.08	40920777	0.60
14	2045	363620270	0.98	128.28	-0.08	41411648	0.60
Average		317880928	1.12	129.63	-0.08	38220991	0.65

Source: Authors computation

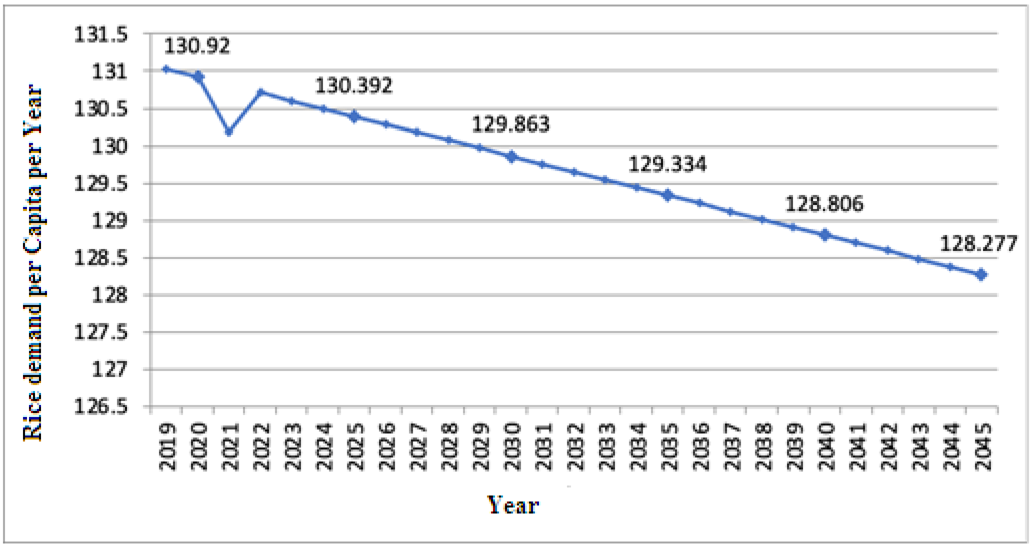

Figure 3. Forecasting of Rice Consumption Per Capita per Year, 2019 - 2045

The forecasting of rice demand in Indonesia in 2025 is 36.5 million tons, in 2035, 39.0 million tons, and in the amount of 2045, are estimated at 41.4 million tons. This difference can occur because the analysis results show that the population growth rate in Indonesia is only able to be reduced to 0.98 percent. In comparison, the expected projection from the BPS data is 0.95 percent. Moreover, this causes a difference in population forecasting in 2045.

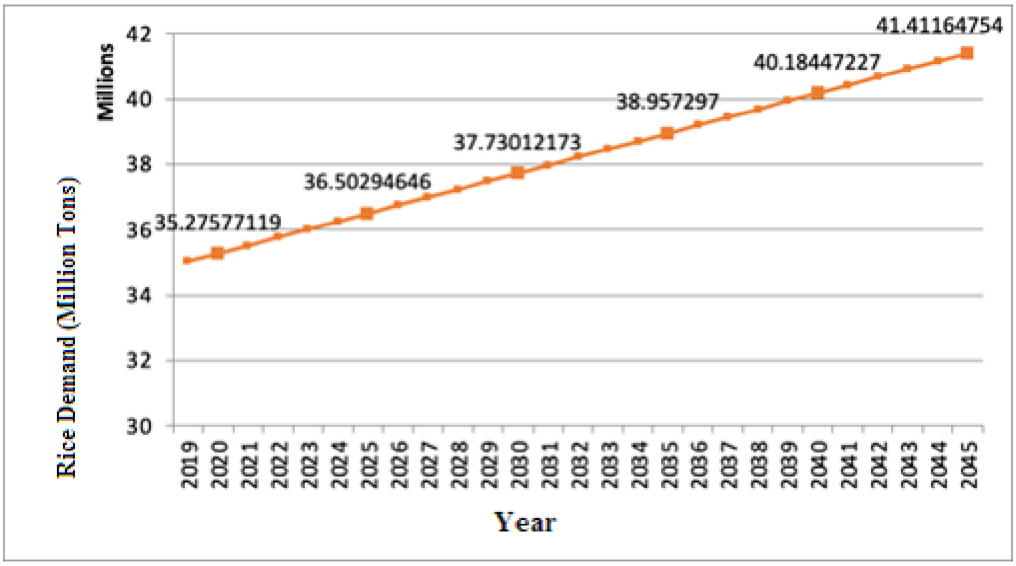

Figure 4. Forecasting of the Indonesian Rice Demand, 2019 - 2045

The total demand for rice above, with rice production in the form of dry rice amounting to 88.60 million tons in 2020, then in 2025 it will need 101.10 million tons, 113.62 million tons in 2030, 126.13 million tons / GKG in 2035, 138.65 million tons in 2040, and 151.15 million tons in 2045. With these projections, Indonesia will be able to meet the domestic consumption needs of rice until 2045.

CONCLUSION

This study describes Indonesia's rice economic forecasting in 2045, using an ex-ante approach. A total of 12 rice economic models were analyzed using the simultaneous equation model. The result of this study reflects decreasing rice consumption per capita per year. In 2019 rice consumption in Indonesia was 131. 23 kg per capita per year; In 2025, it is 130.39 kg per capita per year; in 2035, it is 129.33 kg per capita per year. It is estimated that in 2045, rice consumption will be 128.277 kg per capita per year. The forecasting of rice demand in Indonesia in 2025 is 36.5 million tons, in 2035, 39.0 million tons, and in the amount of 2045, are estimated at 41.4 million tons. This difference can occur because the analysis results show that the population growth rate in Indonesia is only able to be reduced to 0.98 percent. In comparison, the expected projection from the BPS data is 0.95 percent. Moreover, this causes a difference in population forecasting in 2045.

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