Households rice demand in East Kalimantan: A QUAIDS approach

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Abstract. As the new capital of Indonesia, East Kalimantan will drive population growth and increase demand for food (rice). Regarding food security, it is necessary to understand the economic and demographic factors that influence the demand for rice. SUSENAS 2021 data from BPS-Statistics Indonesia were used to analyse the impact of economic and demographic variables on rice consumption by including goods considered substitutes for rice as additional variables. The Quadratic Almost Ideal Demand System is employed to estimate the demand function and examine the effects of price, income, and demographic variables on seven food groups, including rice, maize, wheat, cassava, sweet potatoes, potatoes, instant noodles, and processed food. The study finds that increased household income leads to increased demand for all types of food and that rice consumption is more elastic in rural areas than in urban areas. Rice is income elastic for low-income households working in agriculture but is inelastic for other sectors and middle-high income. Maize and potatoes can be substituted for rice according to the cross-price elasticity, and rice is an independent good that is not affected by the prices of other goods. The government can reduce household rice consumption by increasing income and encouraging higher education.

1 Introduction

The province of East Kalimantan has gained importance as a site for Indonesia's new capital city, Nusantara, under Law Number 3 of 2022. Despite the COVID-19 slowdown, the region's economy is recovering, with the gross regional domestic product (GRDP) reaching IDR484 trillion in 2021. The mining and quarrying sector was the largest contributor to the economy (44.74%), followed by processing (18.01%), construction (8.5%), and agriculture, forestry, and fisheries (8.43%). Investment was the main driver of economic growth (3.31%), while household consumption contributed 17.7% to the economy, with a growth rate of 0.68% [1].

The population of East Kalimantan in 2020 was 3.77 million people, growing at a steady rate of 2.3% per year, which means an approximate increase of 73,755 individuals annually. Moreover, East Kalimantan is currently experiencing a demographic bonus phase, since 70.68% of its population is between 15 and 64 years old, which is considered productive [1].

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Consequently, food consumption is expected to rise as the population grows. However, it is essential to note that factors such as food preferences, cultural traditions, and economic conditions also affect the amount of food consumed in the region. One way to measure the population's welfare is by examining the percentage of income spent on food consumption.

It is of utmost importance to thoroughly understand the specific dietary requirements of the growing population in East Kalimantan. This includes considering cultural traditions, dietary preferences, and economic circumstances. According to the latest data from BPS-Statistics Indonesia in 2021, per capita non-food spending has marginally increased from 54.95% in 2020 to 55.36% in 2021 [1]. This suggests that there has been an improvement in the overall welfare in line with Engel's Law, which states that when incomes increase, the percentage of spending on food decreases. Therefore, it is critical to comprehend the food consumption patterns of rice in correlation with variations in prices and income.

Understanding the economic and demographic factors that affect the demand for rice in households is crucial. This is especially significant in East Kalimantan, Indonesia, which will soon become the country's capital. Studying household rice consumption in this region is necessary to prepare for the growing population and ensure food accessibility. One way to analyse this demand is using demand system analysis. In 2021, households in East Kalimantan are expected to allocate 4% of their total expenditure on grains, 0.3% on tubers, and 13.3% on processed food. The production of grains and tubers has remained relatively stable compared to the previous year, while the consumption of processed food has decreased by 2% [2]. Rice plays a critical role in food security as it is a household's source of calories. Unfortunately, East Kalimantan suffers from a rice deficiency [3]. East Kalimantan exceeds its production capacity, and an increase in population due to the government's decision to move the capital will require 498 thousand tons of rice for household consumption [4].

In conditions of limited income, residents will tend to prioritise meeting food needs. Population expenditure patterns in rural and urban areas also tend to be different. People in rural areas spend more than half of their income on food, while their urban counterparts invest more in non-food items [2]. This information sheds light on the gap in living standards between urban and rural communities. By incorporating demographic factors into the study of food demand, we can gain insight into how these differences influence demand. Demand system analysis is one analytical approach that can be utilised for this purpose.

The Quadratic Almost Ideal Demand System (QUAIDS) is a model that calculates the correlation between consumer behaviour and item demand, considering limited budgets. It estimates own and cross-price elasticities of demand for multiple goods and has become a popular tool for analysing food patterns on a national scale. Moreover, the model's application has extended beyond national research, as it has now become a popular tool for investigating food patterns at the regional level, as evidenced by studies conducted in South Sumatera [5], Bengkulu [6], East Kalimantan, and Jakarta [7]. The diversity of food consumption patterns between country and regional levels in Indonesia provides more detailed information on the development of consumer preferences in each region.

Through this study, we can understand how demand for rice among households in East Kalimantan has developed over time and how factors such as income, rice prices, and demographic changes influence rice consumption. Studying food consumption patterns in East Kalimantan can provide valuable insight into how the population responds to changes in food prices. Changes in food prices can significantly impact household budgets and food consumption patterns.

2 Methodology

The study utilised data from the Socio-Economic Survey (SUSENAS) 2021, provided by BPS-Statistics Indonesia, to examine household food consumption in East Kalimantan. In

total, 5,919 households were surveyed, and the QUAIDS method was employed to analyse consumer behaviour and estimate demand for specific items. This approach, which relies on budget share and total log income, employs a quadratic logarithmic function to create a demand system that aligns with the Engel curve and utility theory. By incorporating household preferences and demographic variables, the QUAIDS analysis provides insight into the impact of sociodemographic characteristics, income, and prices on household consumption demand. The study revealed a non-linear Engel curve, contrasting with the previously established Almost Ideal Demand System (AIDS) [8]. The QUAIDS model helps address this non-linearity, and sociodemographic variables play a critical role in shaping household demand patterns [9]. The general model of the QUAIDS demand system used in this study is formulated as follows:

$$\omega_i=\alpha_i+\sum_{j=1}^{n}\gamma_{ij}\ \ln P_j+\beta_i \ln\left[\frac{X}{\alpha(\mathbf{p})}\right]+\frac{\lambda_i}{b(\mathbf{p})}\left\{\ln\left[\frac{X}{\alpha(\mathbf{p})}\right]\right\}^2+d_k Z \tag{1}$$

where ω_i is the portion of household budget i (seven groups in Table 1), obtained from price, quantity, and total expenditure, Pj is the price of commodity j, X is household spending on food group per capita, $\alpha(\mathbf{p})$ and $b(\mathbf{p})$ are the price indexes, $\mathbf{p}$ is the vector of prices, Z is demographic variables (Table 2), and α, β, γ, and λ are the parameters to be estimated. All parameters must satisfy the adding-up condition, homogeneity condition, and Slutsky symmetry constraints. The QUAIDS model provides three categories of demand elasticity, which include:

1. Income elasticity,

$$\epsilon_x=1+\frac{1}{\omega_x}\left[\beta_x+\eta_x' z+\frac{2\lambda_x}{b(p)c(p,Z)}\ln\left\{\frac{k}{\bar{k}_0\,(Z)a(p)}\right\}\right] \tag{2}$$

2. Uncompensated price elasticity, and

$$\epsilon_{xy}=\frac{1}{\omega_x}\left\{\gamma_{xy}-\left(\beta_x+\eta_x' Z+\frac{2\lambda_x}{b(P)c(P,Z)}\left[\ln\left(\frac{k}{\bar{k}_0\,(Z)a(p)}\right)\right]\right)\times\left(\alpha_y+\sum_l^n\gamma_{yl}\ln P_l\right)-\frac{(\beta_y+\eta_x' z)\lambda_x}{b(p)c(p,Z)}\left(\ln\left[\frac{k}{\bar{k}_0\,(Z)a(p)}\right]\right)^2\right\}-\delta_{xy} \tag{3}$$

3. Compensated price elasticity is derived from the Slutsky equation:

$$\epsilon_{xy}^C=\epsilon_{xy}+\epsilon_x\omega_y \tag{4}$$

Equations (3) and (4) use price elasticity to model consumer behaviour and determine the demand for goods at different prices. The Marshallian demand function calculates the uncompensated elasticity, and the Hicksian demand function provides the compensated elasticity. These functions enable a more precise analysis of the substitution and revenue effects of price changes. The Slutsky equation is utilised [10] to convert Marshallian elasticity to Hicksian elasticity. The STATA statistical analysis program was utilised in this study to formulate the QUAIDS demand system [11]. Our analysis focuses on household consumption data for rice, including goods that are considered substitutes for rice. These types of foods are grouped into seven categories, which are listed in Table 1.

Table 1. Description of food groups (processed from SUSENAS 2021 data).

No.	Type of food	Details	Quantity (kg/day/capita)	Price (IDR)	S.D. of price
1	Rice	rice	0.178	11,498.79	1,966.07
2	Maize	maize	0.006	10,067.16	1,406.81
3	Wheat	wheat	0.010	10,617.68	1,537.17
4	Cassava & sweet potato	cassava, sweet potato	0.014	6,383.36	1,446.23
5	Potatoes	potato, taro	0.005	16,607.98	2,336.18
6	Instant noodle*	instant noodle	0.170	2,891.90	528.87
7	Processed food*	dry bread, *pecel* rice, fried rice, vegetable *lontong*, soto rice, *rawon* soup, fried noodles, chicken porridge	0.222	11,599.28	4,136.61

Note: *The data represents the average daily per capita purchase of instant noodles and processed foods in East Kalimantan, measured in IDR per portion.

Table 2 presents a breakdown of research sociodemographic variables in East Kalimantan for 2021. These variables consist of residence, education level, type of work, and income/expenditure level. According to Table 2, most households in East Kalimantan (60.99%) reside in urban areas, while only a small percentage (12.28%) possess a high level of education. Additionally, the non-agricultural sector employs most of the population (70.68%), and a relatively low percentage (13.55%) of households experience low income.

Table 2. Sociodemographic variables, SUSENAS 2021.

No.	Variable (Z)	Definition	Percentage (%)
1	Residence	Proportion of households in urban and rural areas (1: urban; 0: rural)	
	a. Urban	Households living in urban areas	60.99
	b. Rural	Households living in rural areas	39.01
2	Education	The proportion of high education (1: college; 0: non-college)	
	a. College	D1/D2, D3, D4, S1,S2, and S3	12.28
	b. Non-college	High school education level to lower	87.72
3	Occupation	The proportion of working in the agriculture sector (1: agriculture; 0: Other sectors)	
	a. Agriculture job	households working in the agricultural sector	29.32
	b. Non-agriculture job	households working in the non-agricultural sector	70.68
4	Expenditure/ income level*	The proportion of low expenditure level (1: low income; 0: middle-high income)	
	a. Low income	40% of households with the lowest expenditure	13.55
	b. Middle-high income	Top 60% of spending households	86.45

Note: * The distribution of household-level expenditure/income uses the BPS division method, with the bottom 40% of the expenditure quintile being low income, the middle 40% being the middle-income class, and the top 20% being high income.

3 Results and discussion

3.1 Estimation of parameter demand system of rice in East Kalimantan

Based on the QUIAIDS model, the rice demand function equation is presented in the Appendix. Our findings show that in East Kalimantan, rice's income/expenditure coefficient (-0.667) is significant at the 1% level, as are the coefficients for other food group variables. We also noted that expenditure squared has a significant impact on rice. The squared parameter showed that the Engel curve for rice commodities was non-linear concerning total expenditure (see Appendix). The negative expenditure squared coefficient for rice was -0.039, suggesting that the average budget allocation for rice consumption will decrease if household income doubles. Lastly, the price coefficient on rice consumption was positive (0.371) and significant at the 1% level. This means that any price changes will impact an increase in the share of spending on rice consumption. The price coefficients for maize and potatoes for expenditure share for rice with price coefficients of 0.007 and 0.021, respectively. Meanwhile, the price coefficients for wheat, instant noodles, and processed food on the expenditure share for rice with price coefficients are -0.036, -0.147, and -0.218, respectively.

Demographic factors such as residential location and household expenditure level significantly estimate rice demand in East Kalimantan. It has been observed that urban areas have a higher demand for rice than their rural counterparts, and households with moderate to high incomes tend to consume more rice than those with lower incomes. This is in line with the research at the Indonesian national level, which shows that demographic factors, including age, education, place of residence, and household expenditure, have an impact on rice consumption behaviour [12]. The upcoming discussion on income and price elasticity will delve deeper into the influence of such demographic differences.

3.2 Impact of income changes

The influence of income fluctuations on rice demand can be analysed by studying the elasticity of spending on rice goods. In East Kalimantan, QUAIDS calculated the elasticity of demand for rice by including goods considered substitutes for rice as additional variables and demographic variables, outlined in Table 3. Generally, the income elasticity of rice consumption in East Kalimantan is 0.949, suggesting that a 1% increase in household spending results in a 0.949% increase in rice consumption. An increase in household expenditure in East Kalimantan caused a decrease in rice consumption [7]. Rural regions show that a 1% increase in household income leads to a 1.097% increase in rice consumption, while in urban areas, consumption only increases by 0.811%. Rice is elastic in rural areas and inelastic in urban areas based on income changes. For low-income households working in agriculture and living in rural areas, rice is a fundamental necessity, and every income increase leads to a rise in rice consumption. Demographic characteristics suggest that the proportion of expenditure on consumption varies among various goods.

Based on the data presented in Table 3, it's clear that household income plays a major role in determining the demand for food, especially rice. According to the income elasticity figure of 0.949, if a household's income increases by 1%, their demand for rice consumption will increase by 0.949%. However, different social demographics have varying preferences for rice consumption. Urban residents, heads of households with advanced education and non-agricultural employment, and middle to high-income households tend to consume less rice than rural residents, those with lower education, agricultural employment, and lower incomes.

Furthermore, an increase in income tends to correlate with an increase in consumption of processed foods, which are often seen as luxury items. Conversely, items such as maize,

wheat, cassava, sweet potatoes, potatoes, and instant noodles are considered income inelastic, meaning their demand remains relatively constant regardless of changes in income.

Table 3. Expenditure elasticities of food groups in East Kalimantan, 2021.

Parameter	Rice	Maize	Wheat	Cassava & sweet potato	Potatoes	Instant noodle	Processed food
All	0.949	0.688	0.504	0.615	0.838	0.280	1.439
Urban	0.811	0.788	0.715	0.652	0.824	0.371	1.433
Rural	1.097	0.563	0.372	0.585	0.881	0.282	1.467
College	0.765	0.840	0.823	0.633	0.809	0.383	1.371
Non-college	0.967	0.671	0.482	0.616	0.845	0.279	1.453
Agri job	1.143	0.517	0.393	0.554	0.887	0.297	1.433
Non agri job	0.837	0.772	0.664	0.652	0.829	0.344	1.447
Lowest income	1.106	0.485	0.248	0.568	0.866	0.268	1.657
Middle-high income	0.917	0.718	0.552	0.623	0.836	0.286	1.420

Based on SUSENAS 2021 data, of the seven food groups in this study, households mainly spend their money on rice (44%), processed foods (34%), and instant noodles (14%). This option is widely available and commonly consumed. Meanwhile, cassava and sweet potatoes, potatoes, and corn only account for around 1-2% of this food group's expenditure.

3.3 Impact of price changes

Table 4 shows that with an increase in rice prices of 1%, the quantity demanded of rice falls to 0.597%. With this price increase, the decline in rice consumption was higher in households in the agricultural sector, living in villages, with low education and with low incomes than in households working in non-agriculture, living in cities, with high education, and with high incomes. In addition, each food group has a unique and compensated price elasticity. Cassava and sweet potato have the lowest own price elasticity value of -0.442, while corn has the highest value of -2.667. Rice, processed foods, and instant noodles are inelastic goods, while wheat and potatoes are elastic goods. Compensation can help mitigate the impact of rising commodity prices on consumption, because compensated price elasticity is lower than uncompensated price elasticity, as shown in Table 5.

Table 4. Compensated own price elasticities of food groups in East Kalimantan, 2021.

Parameter	Rice	Maize	Wheat	Cassava & sweet potato	Potatoes	Instant noodle	Processed food
All	-0.597	-2.667	-1.079	-0.442	-1.188	-0.826	-0.501
Urban	-0.496	-2.539	-1.063	-0.464	-1.156	-0.623	-0.466
Rural	-0.738	-2.914	-1.096	-0.403	-1.265	-0.995	-0.539
College	-0.473	-2.597	-1.084	-0.336	-1.118	-0.560	-0.390
Non-college	-0.610	-2.677	-1.078	-0.454	-1.202	-0.850	-0.516
Agri job	-0.811	-3.057	-1.082	-0.335	-1.304	-1.032	-0.520
Non agri job	-0.507	-2.544	-1.075	-0.476	-1.160	-0.661	-0.484
Lowest income	-0.807	-2.896	-1.153	-0.426	-1.436	-1.085	-0.653
Middle-high income	-0.563	-2.636	-1.069	-0.444	-1.170	-0.772	-0.477

Tables 4 and 5 in East Kalimantan show negative elasticity for all food commodities, indicating that a price increase would decrease the quantity demanded. Rural households and those in agriculture have higher price elasticity. Rice price hikes reduce welfare and increase

poverty [13]. The study's results contradict another research that found middle and upper-income groups experience the largest decrease in rice consumption with a price increase [14]. Table 5 shows that maize is the most price-sensitive commodity. An increase in its price would impact agriculture workers the most. Instant noodles affect rural areas and agricultural households the most. Education level affects instant noodle consumption, with highly educated heads of households having the lowest price elasticity. Lastly, processed food positively correlates with consumption for urban, college-educated, and non-agricultural job households. The agricultural job is an important demographic variable that affects the demand for staple foods [6,14].

Table 5. Uncompensated own price elasticity (Marshallian) in East Kalimantan, 2021.

Own price elasticity	Rice	Maize	Wheat	Cassava & sweet potato	Potatoes	Instant noodle	Processed food
All	-1.016	-2.675	-1.092	-0.453	-1.202	-0.866	-0.996
Urban	-0.843	-2.549	-1.079	-0.476	-1.172	-0.663	-1.023
Rural	-1.244	-2.920	-1.108	-0.413	-1.276	-1.050	-0.939
College	-0.766	-2.608	-1.099	-0.345	-1.138	-0.598	-1.004
Non-college	-1.045	-2.685	-1.091	-0.465	-1.216	-0.891	-0.994
Agri job	-1.317	-3.062	-1.097	-0.343	-1.314	-1.093	-0.913
Non agri job	-0.876	-2.555	-1.089	-0.488	-1.176	-0.700	-1.022
Lowest income	-1.390	-2.901	-1.160	-0.436	-1.443	-1.140	-0.985
Middle-high income	-0.956	-2.645	-1.083	-0.455	-1.186	-0.810	-0.997

Cross-price elasticity determines whether a product is complementary (negative) or substitute (positive). Based on Table 6, when the price of rice increases by 1%, demand for other food groups also increases (positive). Rice is a substitute for other food groups, but maize and potatoes can also act as substitutes for rice. In contrast, rice is an independent good that is not affected by increases in the prices of other products.

Table 6. Cross-price elasticities compensated (Hicksian) in East Kalimantan, 2021.

Quantity demanded	Price change						
	Rice	Maize	Wheat	Cassava & sweet potato	Potatoes	Instant noodle	Processed food
Rice		0.047	0.020	0.029	0.062	0.125	0.314
Maize	1.681		0.522	-0.276	0.223	0.302	0.215
Wheat	0.369	0.248		0.030	-0.114	0.513	0.033
Cassava & sweet potato	0.750	-0.193	0.041		-0.541	0.282	0.102
Potatoes	1.602	0.162	-0.177	-0.565		0.217	-0.052
Instant noodle	0.434	0.027	0.094	0.037	0.028		0.207
Processed food	0.381	0.008	0.006	0.006	-0.003	0.103	

The information presented in Table 7 displays the uncompensated cross-price elasticity results. It indicates that when the cost of rice increases, the consumption demand for all other food groups generally rises, except for processed food, which has a negative value (-0.254). Since no income compensation is provided, the increase in rice prices reduces the demand for processed food. This reveals that processed food is a complementary item to rice. Income, prices, and demographic characteristics significantly influence household consumption behaviour [7].

Table 7. Cross-price elasticities uncompensated (Marshallian) in East Kalimantan, 2021.

Quantity demanded	Price change						
	Rice	Maize	Wheat	Cassava & sweet potato	Potatoes	Instant noodle	Processed food
Rice		0.035	-0.005	0.013	0.046	-0.009	-0.012
Maize	1.377		0.504	-0.288	0.211	0.205	-0.022
Wheat	0.147	0.242		0.021	-0.122	0.441	-0.140
Cassava & sweet potato	0.478	-0.201	0.025		-0.552	0.196	-0.109
Potatoes	1.232	0.152	-0.199	-0.580		0.099	-0.340
Instant noodle	0.311	0.023	0.086	0.032	0.023		0.111
Processed food	-0.254	-0.010	-0.032	-0.020	-0.028	-0.100	

This research shows that rice still dominates the demand for the carbohydrate-source food group, which is in line with previous findings. Due to its status as a staple food for most households, rice has income and price-low elasticity values, which means that a simultaneous increase in income and rice prices is unlikely to impact the amount of consumption significantly demanded [15].

4 Conclusions and policy recommendations

Our study examined rice consumption patterns in households in East Kalimantan by analysing the SUSENAS 2021 data and employing the QUAIDS methodology. Our research findings indicate that household income and rice prices significantly influence the budget allocation for rice consumption. Based on the QUAIDS model, the rice demand function equation has a negative expenditure squared coefficient for rice, which is -0.039. This suggests that the average budget allocation for rice consumption will decrease if household income doubles. The price coefficient on rice consumption was positive (0.371) and significant at the 1% level. This implies that any changes in the price of rice will increase the share of spending on rice consumption.

Household income plays a crucial role in determining the demand for food, particularly rice. Rice is elastic in rural areas and inelastic in urban areas based on income changes. Low-income households working in agriculture and living in rural areas consider rice a fundamental necessity, and every income increase leads to a rise in rice consumption. Urban residents, heads of households with advanced education and non-agricultural employment, and middle to high-income households tend to consume less rice than rural residents, those with lower education, agricultural employment, and lower incomes.

Based on its price elasticity, if the price of rice increases by 1%, the quantity demanded of rice falls to 0.597%. With this price increase, rice consumption decreased more in households in the agricultural sector, living in rural areas with low education and incomes, than in non-agriculture households living in urban areas, with high education and incomes.

Marshallian and Hicksian price elasticity calculations show negative elasticity for all food groups, indicating that a price increase would reduce the quantity demanded. Rural households and those in agriculture have higher price elasticity. An increase in rice prices would impact agricultural workers the most.

According to cross-price elasticity, rice substitutes other food groups, but maize and potatoes can also act as substitutes for rice. In contrast, rice is an independent good that is not affected by increases in the prices of other products.

The government can address the decline in rice consumption by improving welfare programs, stabilising prices, and prioritising village development. Education and promoting the maize and potato industry can also help encourage food diversification.

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Appendix

Summary of share equation estimated coefficients from QUAIDS in East Kalimantan

Parameter	Expenditure Share						
	Rice	Maize	Wheat	Cassava & Sweet Potato	Potatoes	Instant Noodle	Processed Food
α (Constant)	-0.667***	0.024***	0.112***	0.027***	0.007	0.371***	1.125***
β (Expenditure)	-0.434***	0.008***	0.039***	0.003	-0.001	0.163***	0.222***
λ (Expenditure^2)	-0.039***	0.001***	0.005***	0.001***	0.000	0.025***	0.007***
γ (Price)							
1. Rice	0.370***	0.007*	-0.036***	0.003	0.021***	-0.147***	-0.218***
2. Maize		-0.020***	0.007**	-0.003	0.002	0.005	0.001
3. Wheat			0.001	0.001	-0.003	0.025***	0.006**
4. Cassava&Sweet Potato				0.009***	-0.009***	0.005	-0.005**
5. Potatoes					-0.003	0.002	-0.008***
6. Instant Noodle						0.082***	0.027***
7. Processed Food							0.196***
η (Demography)							
Z1: Residence	0.004*	-0.001***	-0.002***	-0.002***	-0.002***	-0.008***	0.011***
Z2: College	0.003	0.000	0.002**	0.001	-0.002***	-0.001	-0.003
Z3: Agrijob	0.001	0.001***	0.000	0.003***	0.002***	0.012***	-0.019***
Z4: Low_exp	-0.026***	0.001**	0.004***	0.002***	0.002***	0.014***	0.004
Rho	Z1=-0.534***	Z2=-0.159***	Z3=0.644***				

Note: The symbols *, **, and *** signify significance at 10, 5, and 1%, respectively. Due to symmetrical restrictions, the empty cells are not stated.