Geospatial Analysis of Average Rice Consumption in South Kalimantan and Central Kalimantan

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ABSTRACT— *This study aims to analyze the per capita rice consumption pattern and the factors that affect it at the regency/city level in South Kalimantan and Central Kalimantan. This study uses per capita rice consumption data, rice prices, and per capita income data by regency/city in South Kalimantan and Central Kalimantan in 2023. The data used is sourced from the Central Statistics Agency for National Socio-Economic Survey activities in March 2023 as well as data on food price developments by the National Food Agency. Regression analysis was used to identify the relationship between rice consumption per capita and rice prices and per capita income. Furthermore, a geospatial approach is applied to understand the variation of rice consumption and the factors that affect it in each regency/city. The results showed that there was a significant relationship between per capita rice consumption and rice price and per capita income with a determinant coefficient, R2 = 0.49 (higher than the determination coefficient in the usual regression analysis (R2 = 0.35)) The rice price elasticity of -0.40 showed that the increase in rice prices could reduce per capita rice consumption but did not have a major impact. Meanwhile, from the estimated results, the amount of income elasticity of -0.33 indicates that the increase in income will reduce rice consumption. But in fact, rice must be a normal commodity with a positive income elasticity. But it does not apply to all income levels. At a relatively high incomes level and food needs through rice have been met in good quantity, the increase in income no longer has a positive influence which is reflected in the increasing quantity of demand for rice. Even at a higher income level, it is possible that the quantity of demand for rice will decrease. The need for food is no longer met by rice but, by using the potential income, people have other alternatives through noodles, bread, and ready-to-eat foods such as fried rice, ketupat, lontong, satay, and others.*

Keywords— geospatial analysis, geographically weighted regression, rice consumption, rice price, per capita income

1. INTRODUCTION

Rice commodities in the provinces of South Kalimantan (South Kalimantan) and Central Kalimantan (Central Kalimantan) show diversity in trade distribution patterns. Although South Kalimantan has a surplus of rice production supplied to Central Kalimantan and neighboring regions, it also purchases rice from other provinces such as East Java and Central Kalimantan. In addition, data shows that South Kalimantan sells rice to West Kalimantan, Central Kalimantan, and East Kalimantan. Rice production in South Kalimantan in 2021 reached 1.02 million tons, almost three times the rice production in Central Kalimantan. That way, the needs of household consumption in South Kalimantan can be met by a surplus of production in the province. Per capita rice consumption in the two provinces shows differences in regency/city, with consumption patterns that may be related to rice prices and people's income levels.

The analysis of the average rice consumption by regency/city in South Kalimantan and Central Kalimantan is an interesting research subject to analyze the factors that affect it. For example, people's rice consumption patterns can be associated with income levels. Low-income people tend to allocate most of their expenses to meet basic needs such as rice. However, the constraints in obtaining accurate revenue data encourage the use of expense data in lieu of income, which is often referred to as a proxy for revenue.

However, when the observation unit is a territory, it is necessary to take into accounts spatial or geospatial aspects, including location and geographical location. Each region has different geographical characteristics, which can affect the results of the analysis. Therefore, in this study, geospatial analysis was adopted as the main tool to understand the patterns and factors affecting rice consumption in each region. It is hoped that with this approach, the results of the analysis will be more accurate and comprehensive, providing a deeper understanding of the dynamics of rice consumption at the local level.

The analysis of rice consumption per capita in South Kalimantan and Central Kalimantan attracted attention. Variations in consumption in regency/city are the focus, influenced by rice prices and people's incomes. Geospatial analysis helps map rice consumption patterns, providing in-depth insights into the factors that influence it. Therefore, the objectives of this study are to (1) analyze the average per capita rice consumption and rice prices and per capita income

in South Kalimantan and Central Kalimantan by regency/city; (2) analyze the relationship between average rice consumption per capita and rice prices and per capita income in South Kalimantan and Central Kalimantan by regency/city; (3) to analyze the effect of per capita income and rice prices on the average per capita rice consumption in South Kalimantan and Central Kalimantan using geospatial analysis.

This research is expected to provide a deeper understanding of the factors that affect rice consumption. The results of this study are expected to be useful for designing more effective food policies. In addition, the results of this research are also expected to support the development of the local agricultural sector and become the basis for further research in the field of food and agriculture.

2. RESEARCH METHODS

2.1 Place and Time of Research

The research was carried out in South Kalimantan Province, starting from the proposal making stage in April 2022 and continuing with data processing until the completion of the research results report in May 2024.

2.2 Types and Data Sources

The type of data collected in this study consists of secondary data obtained from published data. The average per capita rice consumption in 2023 is data from the Central Statistics Agency (BPS) as a result of the March 2023 National Socio-Economic Survey (Susenas). The 2023 per capita income is adjusted per capita expenditure data which is also sourced from the 2023 Susenas by BPS. Meanwhile, rice price data in 2023 is data processed from food price development data by the National Food Agency and Susenas 2023 data by BPS.

Then, the coordinate points (longitude and latitude) of each regency/city in South Kalimantan and Central Kalimantan Provinces were obtained from the map from the BPS mapping results in 2020. The coordinate point of each regency/city is the centroid of each regency/city. Centroid is a point that represents the geometric center of a regency/city to describe the center of the area.

2.3 Data Analysis Methods

The data analysis method applied consists of descriptive analysis and inferential analysis. First, to evaluate the average per capita rice consumption and per capita income in South Kalimantan and Central Kalimantan by regency/city, a descriptive analysis was used. The descriptive analysis presents data on average rice consumption per capita and per capita income by regency/city in South Kalimantan and Central Kalimantan Provinces. Data for descriptive analysis are presented in tabular, graph, and map formats.

Second, inferential analysis was used to explore the relationship between per capita income and rice prices with the average per capita rice consumption in South Kalimantan and Central Kalimantan using geospatial analysis using the Geographically Weighted Regression (GWR) method. The GWR method is a technique that modifies a global regression model into a regression model that is tailored based on geographical location. The GWR model can be described as follows.

$$y_i = \beta_0(u_i, v_i) + \sum_{k=1}^{p} \beta_k(u_i, v_i) x_{ik} + \varepsilon_i$$

where (u_i, v_i) is the coordinate point (longitude, latitude) of the i observation and the independent variable of the kth with $k = 1, 2, ..., p$.

Because there are 2 independent variables, the GWR model in this study can be written as follows:

$$y_i = \beta_0(u_i, v_i) + \beta_1(u_i, v_i) x_{i1} + \beta_2(u_i, v_i) x_{i2} + \varepsilon_i$$

with:

y = average rice consumption per capita
$x1$ = per capita income
$x2$ = rice Prices
u = longitude
v = latitude
i = a total of 24 regency/city.

Then if the equation is reduced to a log equation, then the parameters β_1 and β_2 generated by the GWR model are matrices that show the elasticity of income and price elasticity for each regency/city in South Kalimantan and Central Kalimantan. The model that has been serialized into a natural log equation is as follows:

$$\ln y_i = \beta_0(u_i, v_i) + \beta_1(u_i, v_i) \ln x_{i1} + \beta_2(u_i, v_i) \ln x_{i2} + \ln \varepsilon_i$$

The GWR model is a spatial regression approach that takes into accounts spatial variability in data. When applied to data for 27 regency/city in South Kalimantan and Central Kalimantan, the GWR model provides different parameter estimates for each spatial location. This variation reflects the difference in the relationship between rice consumption per capita and rice prices and per capita income in each region. So that this study will produce 27 GWR models.

3. RESULTS AND DISCUSSION

3.1 Rice Consumption Patterns

Average consumption rice per capita in regency/city in South Kalimantan and Central Kalimantan shows quite significant variations as seen in **Figure 1**. Barito Selatan Regency recorded the highest figure with a consumption of 1,976 kg. This figure shows that people in the area have high needs and perhaps access to rice. Followed by Pulang Pisau Regency with 1,820 kg, and Kapuas Regency with 1,752 kg. These figures show a fairly high consumption pattern in several regency. Murung Raya Regency and Hulu Sungai Tengah Regency also have relatively high consumption, amounting to 1,721 kg and 1,714 kg, respectively.

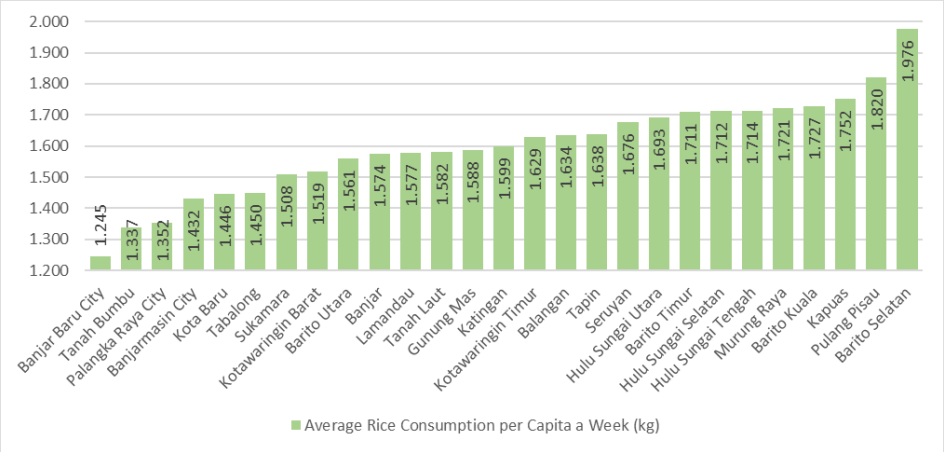

Figure 1: Average rice consumption per capita

On the other hand, the lowest rice consumption was recorded in Banjarbaru City with 1,245 kg, Tanah Bumbu Regency with 1,337 kg and Palangka Raya City with 1,352 kg. The lower consumption of rice in these urban areas may be due to a more diverse diet and greater access to various other types of food. Most regency/city have rice consumption per capita above 1.5 kg which indicates that rice is a very important staple for the community. These variations in consumption can be influenced by various factors, rice prices, income, including culture, rice availability, and local preferences for other staple foods.

3.2 Rice Prices

Rice prices in various regency/city show quite striking differences. The highest rice price was recorded in Kotabaru Regency with Rp 16,958 per kilogram, followed by Tanah Bumbu (Rp 16,508) and Balangan (Rp 16,217). In contrast, the lowest price was found in Kotawaringin Timur Regency with Rp 11,933 per kilogram, followed by Barito Kuala (Rp 12,041) and Gunung Mas (Rp 12,909). The average price of rice is in the range of Rp 13,000 to Rp 15,000 per kilogram.

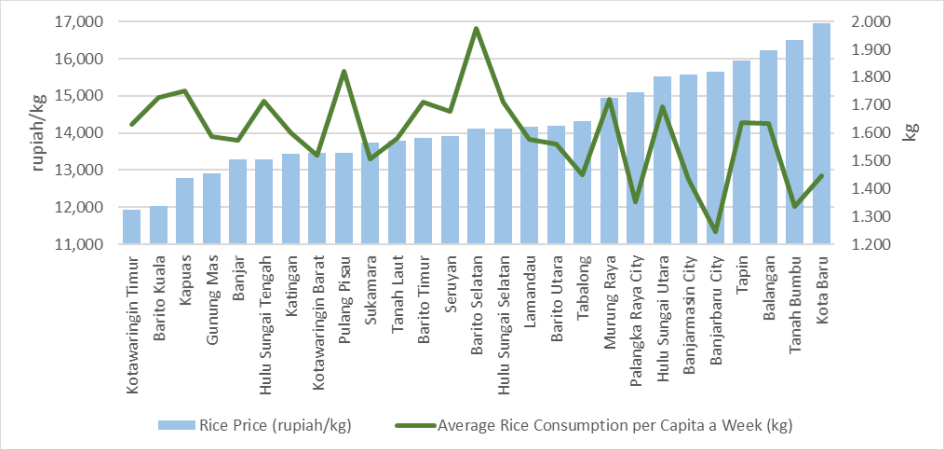

Figure 2: Rice price

This price difference can be caused by variations in distribution costs, supply availability, and local market conditions in each region. For example, areas with high rice prices may experience distribution constraints that increase costs, or high local demand that makes prices more expensive. Meanwhile, lower-priced regions may have better access to rice production sources or have stricter pricing policies. Factors such as the distance to production centers, transportation infrastructure, and local government policies also play an important role in determining the price of rice in each region.

3.3 Income

Meanwhile, per capita income in various regency/city also showed striking variations, reflecting differences in economic levels and people's welfare. Banjarmasin City has the highest per capita income of Rp 15,280,000 per year. The high income in this city may be due to factors such as higher urbanization, more diversified economic activities, as well as better infrastructure and supporting economic growth.

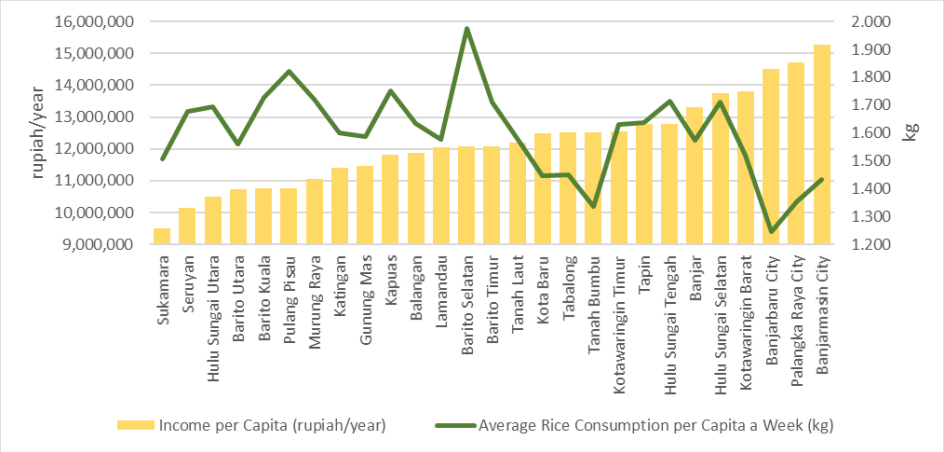

Figure 3: Income per capita

Palangka Raya City and Banjarbaru City also recorded high incomes, amounting to Rp 14,727,000 and Rp 14,524,000 per year, respectively, indicating that these cities have a more developed economy compared to other regency. In contrast, Sukamara Regency recorded the lowest per capita income of Rp 9,494,000 per year, followed by Hulu Sungai Utara Regency with Rp 10,491,000 per year. This income disparity indicates a significant economic inequality in the region, with city tending to have higher incomes compared to regency.

3.4 Regression Analysis

Regression analysis is used to determine the direction of the relationship between average rice consumption per capita and rice prices and per capita income, whether there is a positive or negative relationship and to predict the average per capita rice consumption if rice prices or per capita income increase or decrease. From the regression results obtained a coefficient of determination/R-Square (R2) of 0.35 with the following equation model:

$\ln Y = 9.6464 - 0.3986 \ln X_1 - 0.3293 \ln X_2$

With:

Y : Average rice consumption
X_1 : Rice price
X_2 : Per capita income

Then, by looking at the Significance value of F= 0.006147 which is smaller than the significance level of α=0.05, it shows significant evidence that simultaneously, the rice price and per capita income variables have a significant influence on the average per capita rice consumption in the regency/city studied. Therefore, the regression model as a whole was able to explain the variation in the data better than expected randomly, and showed a significant relationship simultaneously between the independent variable (rice price and per capita income) and the dependent variable (rice consumption per capita).

In the rice price variable, by looking at the value of P-value=0.045797 smaller than the significance level of α=0.05, it shows strong evidence that partially the rice price variable has a significant influence on rice consumption per capita in the regency/city studied. Then, the coefficient for the rice price variable of -0.398598 shows a negative relationship between rice price and rice consumption per capita. This means that when the price of rice rises by one percent, per capita rice consumption tends to decrease by around 0.40 percent. This confirms that the increase in rice prices is likely to reduce the per capita rice consumption rate.

The per capita income variable, with P-value of 0.037146, which is smaller than the significance level of α=0.05, shows strong evidence that the per capita income variable significantly affects rice consumption per capita. Furthermore, the regression coefficient associated with this variable of -0.329272 shows a negative relationship between per capita income and per capita rice consumption. In other words, when per capita income increases by one percent, per capita rice consumption tends to decline by about 0.33 percent, ignoring the influence of other independent variables in the regression model.

Price Elasticity

The rice price elasticity of -0.398598 shows that there is a negative relationship between rice prices and rice consumption per capita. This value means that every 1% increase in rice prices will lead to a decrease in rice consumption per capita by 0.40%. Conversely, a 1% reduction in rice prices will increase rice consumption per capita by 0.40%. Since the absolute value of elasticity is less than 1, this indicates that the demand for rice is relatively inelastic to price changes. This means that consumers are not too sensitive to changes in rice prices; They tend to continue consuming rice even though the price changes. This may be due to the role of rice as a staple that is difficult to replace by other foods, so the tendency to switch to other alternatives is relatively low among consumers.

An elasticity of -0.398598 indicates that per capita rice consumption is not too sensitive to price changes, confirming the stability of rice consumption despite price fluctuations. This reflects the importance of rice as a staple commodity of the community. The change in price does not cause a significant change in the amount of rice consumed. People tend to adjust other expenses before reducing rice consumption, showing a high priority to these basic needs in daily consumption behavior.

Revenue Elasticity

The elasticity of income against rice commodity of -0.329272 is an important parameter in analyzing the relationship between per capita income and per capita rice consumption. A negative number indicates an inverse relationship between the two. Any increase in per capita income of 1% will lead to a decrease in per capita rice consumption by 0.33%, while a decrease in per capita income of 1% will result in an increase in per capita rice consumption of 0.33%. Elasticity less than 1 indicates that rice demand tends to be inelastic to changes in income, that is, changes in income do not result in a proportional change in rice consumption. Although there was a decrease in rice consumption along with the increase in income, the decrease was not significant. This reflects the importance of rice as a basic and stable commodity, despite rising consumer incomes. Consumers still prioritize the need for rice even when they have higher incomes, affirming its position as an essential need in people's consumption patterns.

The elasticity of rice income, which should be positive for normal goods, implies that the increase in income will increase consumption. However, in the context of rice consumption, the pattern varies depending on income level. At low income levels, an increase in income will result in an increase in rice consumption, but at middle income level, rice consumption levels tend to be stable even if income rises. Meanwhile, at high income levels, rice consumption may decrease due to the tendency to choose alternative foods such as noodles, bread, and ready-to-eat dishes such as fried rice, ketupat, lontong, satay, and others.

The decline in rice consumption along with the increase in income can be triggered by food diversification. As incomes increase, consumers tend to reduce rice consumption and switch to foods that are considered more varied or of higher quality such as meat, vegetables, and processed products. Lifestyle changes and increased access to various types of food are also contributing factors to this shift in consumption patterns. While rice remains considered important, negative income elasticity suggests that consumers are more likely to explore other food options as their income increases, reflecting changing preferences and purchasing power.

3.5 Geospatial Analysis

Geospatial analysis of rice consumption using the Geographically Weighted Regression (GWR) obtained a coefficient of determination/R-Square (R2) of 0.49. The value of the determination coefficient is better when compared to the usual regression analysis which is only 0.35. The GWR model obtained can be seen in **Table 1**.

Table 1: Geographically Weighted Regression (GWR) Model

No.	Regency/City	GWR Model
1	Tanah Laut	$\ln Y = 12{,}918391 - 0{,}476380 \ln X_1 - 0{,}483455 \ln X_2$
2	Kotabaru	$\ln Y = 12{,}752207 - 0{,}494759 \ln X_1 - 0{,}462005 \ln X_2$
3	Banjar	$\ln Y = 12{,}695841 - 0{,}459574 \ln X_1 - 0{,}479469 \ln X_2$
4	Barito Kuala	$\ln Y = 12{,}321073 - 0{,}426458 \ln X_1 - 0{,}475958 \ln X_2$
5	Tapin	$\ln Y = 12{,}435575 - 0{,}442931 \ln X_1 - 0{,}473177 \ln X_2$
6	Hulu Sungai Selatan	$\ln Y = 12{,}419016 - 0{,}448192 \ln X_1 - 0{,}469008 \ln X_2$
7	Hulu Sungai Tengah	$\ln Y = 12{,}488320 - 0{,}466589 \ln X_1 - 0{,}462375 \ln X_2$
8	Hulu Sungai Utara	$\ln Y = 12{,}191311 - 0{,}437062 \ln X_1 - 0{,}461532 \ln X_2$

9	Tabalong	ln Y = 11,751165 - 0,438064 ln X_1 - 0,433842 ln X_2
10	Tanah Bumbu	ln Y = 13,077495 - 0,505767 ln X_1 - 0,475694 ln X_2
11	Balangan	ln Y = 12,250955 - 0,462914 ln X_1 - 0,449911 ln X_2
12	Banjarmasin City	ln Y = 12,428484 - 0,433023 ln X_1 - 0,478798 ln X_2
13	Banjarbaru City	ln Y = 12,638754 - 0,450573 ln X_1 - 0,481376 ln X_2
14	Kotawaringin Barat	ln Y = 7,315828 - 0,389119 ln X_1 - 0,193519 ln X_2
15	Kotawaringin Timur	ln Y = 9,279383 - 0,337229 ln X_1 - 0,343106 ln X_2
16	Kapuas	ln Y = 11,261828 - 0,356426 ln X_1 - 0,452109 ln X_2
17	Barito Selatan	ln Y = 11,570379 - 0,389914 ln X_1 - 0,451196 ln X_2
18	Barito Utara	ln Y = 10,241886 - 0,346277 ln X_1 - 0,395337 ln X_2
19	Sukamara	ln Y = 6,468857 - 0,387224 ln X_1 - 0,143019 ln X_2
20	Lamandau	ln Y = 6,726200 - 0,352356 ln X_1 - 0,178883 ln X_2
21	Seruyan	ln Y = 8,118007 - 0,354760 ln X_1 - 0,262275 ln X_2
22	Katingan	ln Y = 10,053063 - 0,309481 ln X_1 - 0,406209 ln X_2
23	Pulang Pisau	ln Y = 11,394772 - 0,364865 ln X_1 - 0,455513 ln X_2
24	Gunung Mas	ln Y = 9,764501 - 0,256834 ln X_1 - 0,419187 ln X_2
25	Barito Timur	ln Y = 11,822578 - 0,422119 ln X_1 - 0,447651 ln X_2
26	Murung Raya	ln Y = 9,206191 - 0,210363 ln X_1 - 0,411920 ln X_2
27	Palangka Raya City	ln Y = 10,678060 - 0,325834 ln X_1 - 0,434632 ln X_2

The GWR model shows the elasticity of rice demand in each regency/city with the following discussion.

Price Elasticity of GWR Results

From the model, it can be seen that the elasticity of rice prices in various regency/city in South Kalimantan and Central Kalimantan Provinces is mostly negative, indicating an inelastic nature in the response of demand or supply to price changes. Most elasticity values range from around -0.3 to -0.5 although there are some lower values around -0.2.

From the results of the study, it can be observed that Tanah Bumbu, Kotabaru, and Tanah Laut Regencies are the three regions that show the highest rice price elasticity. Tanah Bumbu Regency leads with a price elasticity of -0.505767 followed by Kotabaru with a value of -0.494759 and Tanah Laut with a value of -0.47638. This means that changes in rice prices in these regions have a significant impact on the amount of rice demand or supply. This sensitive response to price changes illustrates the importance of rice prices in the dynamics of the local food market.

Katingan, Gunung Mas, and Murung Raya regencies emerged as the three regions with the smallest rice price elasticity. Katingan Regency has an elasticity value of -0.309481; Gunung Mas is -0.256834; and Murung Raya by -0.210363. Low price elasticity in these three regency shows that changes in rice prices have a mild impact on the amount of rice demand or supply in these regions. The implication is that the rice market in the three regency tends to be less responsive to fluctuations in rice prices compared to other regions. The causes of this low elasticity may vary, including limited consumption alternatives, strong consumer habits towards rice, or a stable local market structure.

In the context of food policy and market regulation, stakeholders at the local level must pay attention to this condition. Rice price stability is key in ensuring adequate food access for the population. Effective market surveillance and policies that support increased local rice production can help address price fluctuations and improve food security in these regions.

Revenue Elasticity of GWR Results

The elasticity of income towards rice commodities in regency/city in South Kalimantan Province and Central Kalimantan Province shows that all regions have negative income elasticity towards rice, with values ranging from -0.143 to -0.483. This indicates that rice tends to have inelastic demand, where the increase in income does not significantly lead to a change in demand for rice. However, there was variation in the level of elasticity among regency/city, suggesting the influence of local factors that may differ on consumption patterns. The implications of these findings highlight the importance of policy considerations tailored to the local context to improve community well-being and advance the agricultural sector effectively.

Tanah Laut Regency, Banjarbaru City, and Banjar Regency are the three regions with the largest income elasticity to rice consumption compared to other regions. Tanah Laut Regency has an income elasticity value of -0.483455; Banjarbaru City by -0.481376; and Banjar Regency of -0.479469. This means that in these areas, the increase in income has a greater impact on rice consumption compared to other regions. This shows that an increase in income in these areas will lead to a decrease in rice consumption in a larger proportion compared to other regions.

The three regency with the smallest income elasticity value on rice consumption, namely Kotawaringin Barat (-0.193519), Lamandau (-0.178883), and Sukamara (-0.143019), show that in these areas, income increases have a relatively small impact on rice consumption compared to other regions. Near-zero numbers indicate that changes in income have little impact on rice consumption in these areas. This shows that there is a more stable consumption pattern for rice in these areas.

4. CONCLUSIONS AND SUGGESTIONS

4.1 Conclusion

Based on the results of the analysis and discussion described earlier, the following can be concluded.

1. Rice consumption per capita showed significant variation in various regions, the highest in Barito Selatan Regency at 1,976 kg per capita and the lowest in Banjarbaru City at 1,245 kg per capita.
2. Regression analysis shows that simultaneously, both rice prices and per capita income have a significant influence on per capita rice consumption in the regency/city studied.The elasticity of rice prices of -0.398598 indicates that an increase or decrease in rice prices will have a proportionate impact on rice consumption, but the impact is relatively small. The income elasticity of -0.329272 indicates that an increase in income will reduce rice consumption. In theory, the elasticity of income with a positive value means that income increases, so rice consumption increases. However, for rice consumption, at low income levels, rice consumption increases; at an intermediate level, stable due to staple foods; and at a high level, it declined due to alternative food choices.
3. With the Geographically Weighted Regression (GWR) method, the determination coefficient (R^2) of 0.49 was obtained which is better than the usual regression analysis which is only 0.35. This shows that the GWR model provides a better explanation for the variation in rice consumption in different regency/city. GWR analysis shows that the elasticity of rice prices in South Kalimantan and Central Kalimantan is negative and inelastic, ranging from -0.210 to -0.506. Tanah Bumbu shows the highest elasticity, while Murung Raya shows the lowest elasticity. GWR analysis shows that the elasticity of income towards rice in South Kalimantan and Central Kalimantan is between -0.143 to -0.483. The Tanah Bumbu has the highest elasticity, while Sukamara shows the lowest elasticity.

4.2 Suggestion

Several things can be suggested from the findings of this study, namely.

1. In areas with high price elasticity, rice price stability is very important. The government can consider price subsidies or assistance to farmers to increase production and reduce price fluctuations.
2. In areas with a high level of income elasticity, it is necessary to increase food diversification programs to reduce dependence on rice. This can be done by promoting alternative foods that are more nutritious and in accordance with the tastes of the local community.
3. In areas with low price and income elasticity, market monitoring remains important to ensure adequate food availability and price stability, although not a top priority.
4. For future research, it is recommended to expand the scope by considering additional factors that affect rice consumption patterns and conducting a more in-depth spatial analysis and comparison with other regions in order to provide more insights.

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