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Strategies for Strengthening Sustainable Food Security in the Islands Province: Analysis of the Influence of Rice Production Factors and Distribution Accessibility

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Abstrak

- **Tujuan:** Penelitian ini bertujuan menganalisis bagaimana indeks ketahanan pangan di Kabupaten/Kota Provinsi Kepulauan Bangka Belitung dan di Provinsi Kepulauan Riau, dimana indeks Ketahanan Pangan Ini akan di pengaruhi oleh Luas Panen Padi, Produktivitas Padi dan Aksesibilitas Distribusi di daerah tersebut.
- **Desain/metodologi/pendekatan:** Penelitian menggunakan metode Kuantitatif, yaitu penelitian ini mencoba menggambarkan kondisi ketahanan pangan di Provinsi Kepulauan Bangka Belitung dan Provinsi Kepulauan Riau yang dapat di jabarkan dalam bentuk angka dan data sebenarnya kemudian data ini di oleh menggunakan analisis regresi data panel sehingga dapat menggambarkan pengaruh dari Variabel Luas Panen Padi, Produktivitas Padi dan Aksesibilitas Distribusi di kedua daerah tersebut dan dapat membandingkan apa yang paling mempengaruhi kedua daerah ini menjadi rentan terhadap ketahanan pangan
- **Temuan:** Hasil penelitian menunjukkan bahwa terdapat perbedaan struktural ketahanan pangan antara Provinsi Kepulauan Riau dan Provinsi Kepulauan Bangka Belitung dimana Provinsi Riau Sangat Bergantung kepada Akses dari luar (Ekspor) sedangkan Provinsi Kepulauan Bangka Belitung masih bergantung kepada Produksi Lokal. Ketahanan pangan di Kepulauan Riau lebih ditentukan oleh faktor eksternal, seperti pasokan antar pulau dan perdagangan, sedangkan ketahanan pangan di Bangka Belitung lebih dipengaruhi oleh faktor internal, terutama produksi pertanian lokal.
- **Batasan penelitian/dampak:** Penelitian selanjutnya disarankan untuk memperluas populasi penelitian pada wilayah-wilayah kepulauan di Indonesia dengan analisis spasial sehingga dapat memperdalam pemahaman serta karakteristik antar pulau.
- **Implikasi praktis:** Hasil penelitian menunjukkan bahwa setiap daerah memiliki karakteristik yang berbeda dimana di daerah Provinsi Kepulauan Riau memiliki luas wilayah pulau yang kecil dibandingkan dengan wilayah Provinsi Kepulauan Bangka Belitung, sehingga Provinsi Kepulauan Riau sangat terbatas berkaitan dengan Produksi padi serta luas panen padi dalam menompang



ketahanan pangan namun untuk akses jalan mempunyai hubungan yang positif namun tidak signifikan sehingga pemerintah harus dapat menjamin akses impor dari luar daerah untuk dapat memenuhi kebutuhan daerahnya, sedangkan di Provinsi Kepulauan Bangka Belitung Produksi Padi dan Aksesibilitas jalan mempunyai hubungan yang positif artinya pemerintah harus menguatkan produksi dalam daerah serta meningkatkan akses jalan demi menjaga ketahanan pangan di daerah tersebut.

- **Jenis makalah:** jenis artikel ini adalah penelitian untuk meneliti bagaimana indeks ketahanan pangan di Kabupaten/Kota Provinsi Kepulauan Bangka Belitung dan di Provinsi Kepulauan Riau, dimana indeks Ketahanan Pangan Ini akan di pengaruhi oleh Luas Panen Padi, Produktivitas Padi dan Aksesibilitas Distribusi di daerah tersebut

Kata Kunci: *Ketahanan Pangan; Luas Panen; Produktivitas Padi; Aksesibilitas Distribusi;*

Abstract

- **Purpose:** *This study examines the Food Security Index at the regency/municipal level in the Bangka Belitung Islands Province and the Riau Islands Province, focusing on the effects of harvested rice area, rice productivity, and food distribution accessibility.*
- **Design/methodology/approach:** *This study employs a quantitative research method, aiming to describe the food security conditions in the Bangka Belitung Islands Province and the Riau Islands Province using numerical indicators and empirical data. The data are analyzed using panel data regression analysis to examine the effects of harvested rice area, rice productivity, and distribution accessibility in both regions. Furthermore, this analysis allows for a comparison of the factors that most significantly contribute to food security vulnerability in these two provinces.*
- **Findings:** *The results indicate the existence of structural differences in food security between the Riau Islands Province and the Bangka Belitung Islands Province. The Riau Islands Province is highly dependent on external access, particularly inter-regional supplies and trade, whereas the Bangka Belitung Islands Province remains reliant on local production. Overall, food security in the Riau Islands is primarily determined by external factors, such as inter-island supply chains and trade, whereas food security in Bangka Belitung is more strongly influenced by internal factors, particularly local agricultural production.*
- **Research limitations/implications:** *Further research is recommended to expand the study population to include archipelagic regions across Indonesia by employing spatial analysis, thereby enhancing the understanding of food security dynamics and inter-island linkages.*
- **Practical implications:** *The results of the study show that each region has different characteristics, whereby the Riau Islands Province has a smaller island area compared to the Bangka Belitung Islands Province. so that the Riau Islands Province is very limited in terms of rice production and rice harvest area in supporting food security. However, road access has a positive but insignificant*

relationship, so the government must be able to guarantee access to imports from outside the region to meet the needs of the region. Meanwhile, in the Bangka Belitung Islands Province, rice production and road accessibility have a positive correlation, meaning that the government must strengthen local production and improve road access in order to maintain food security in the region.

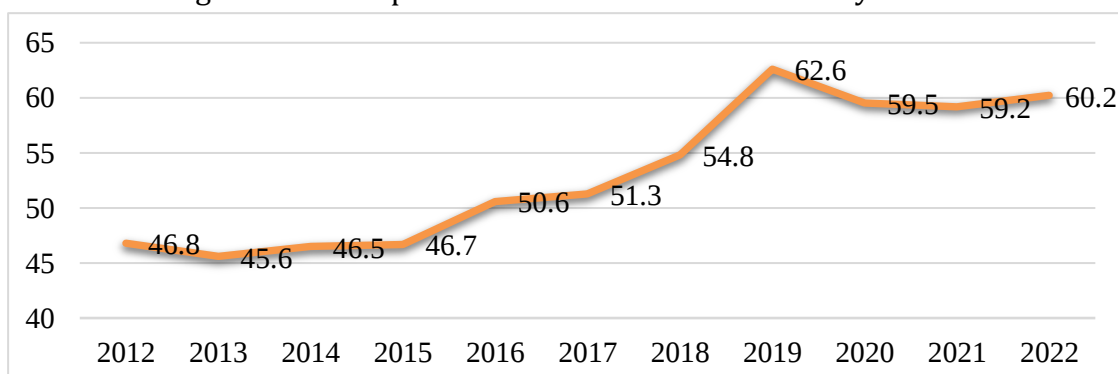
- **Originality/value:** this study compares two provinces, namely the Province of Bangka Belitung Islands and the Province of Riau Islands, both of which are island regions that are equally vulnerable to food price volatility, making it important to examine food security in these two regions. It also examines whether rice production, rice harvest area, and distribution accessibility can affect food security in these regions.
- **Paper type:** This article is a study to examine how the food security index in the regencies/cities of the Bangka Belitung Islands Province and the Riau Islands Province is influenced by rice harvest area, rice productivity, and distribution accessibility in these regions.

Keywords: Food Security; Harvest Area; Rice Productivity; Distribution Accessibility;

Introduction

As an agrarian country, a large proportion of the Indonesian population fulfills its livelihood needs through farming. This condition is supported by Indonesia's tropical climate and its extensive and fertile green open spaces (Djanggal & Patta Rapanna, 2023). These favorable conditions are utilized by the Indonesian population for cultivation activities, particularly in the agricultural sector (Purwanto & Alam, 2020). Fertile land has strong potential for food crop cultivation, and food crops are essential as staple foods for the entire population. Therefore, their availability must be ensured to sustainably meet staple food needs and to fulfill nutritional requirements (Tian et al., 2021).

Figure 1. Development of Indonesia's Food Security Indeks



Source: Global Security Indeks (2023)

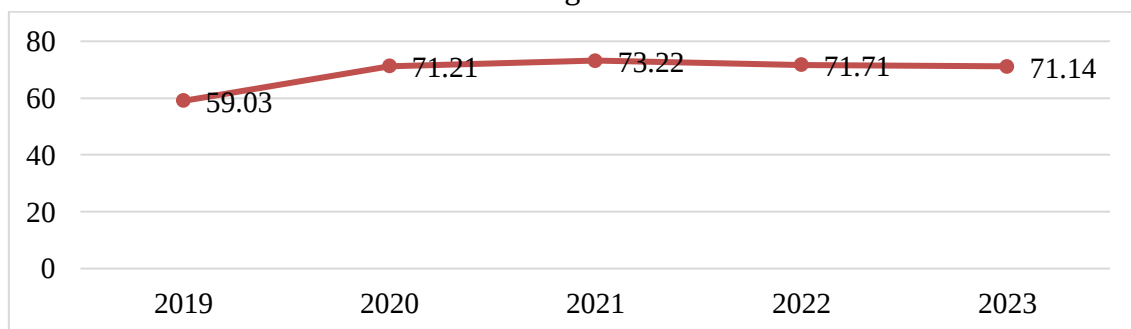
Based on data from the Global Food Security Index (GFSI), Indonesia's food security index has shown a consistently upward trend over the years. This trend

reflects the government's commitment to addressing food security challenges in Indonesia. In 2022, Indonesia's food security index reached 60.2, an increase compared to the 2020–2021 period; however, this figure remains below the global average of 62.2 and the Asian average of 63.4 (Adi Ahdiat, 2022).

The relatively low level of Indonesia's food security index is driven by multiple factors that directly influence food security, one of which is the limited extent of agricultural land and low food production. Agricultural land degradation has become a major contributor to the decline in food production. Food security is a critical pillar of sustainable development, particularly in archipelagic regions such as the Bangka Belitung Islands Province and the Riau Islands Province. These two provinces possess unique geographical characteristics, consisting of numerous islands and diverse natural resources. However, challenges such as limited agricultural land, dependence on food imports, and fluctuations in food commodity prices remain critical issues that must be addressed. In this context, strategies to strengthen sustainable food security are highly relevant to ensuring the availability, accessibility, and stability of food supply for the population.

Figure 2 shows that the Food Security Index in Bangka Belitung Province in 2019 was 56.03 percent, increasing to 71.21 percent in 2020 and 73.22 percent in 2021, before declining to 71.71 percent, and fell again in 2023 to 71.14 percent. This indicates that the food security index in Bangka Belitung Province has an increasing trend, although in the last 3 years there has been a downward trend, indicating that there is a decline in food security that must be addressed immediately. In addition, the need for basic commodities continues to increase every year, accompanied by a growing population, causing the need for food to increase. Population growth can affect food availability in a region (Putra & Rahmani, 2025). The availability of food commodities must be balanced with rice consumption needs. The population of a region also greatly affects food availability in order to achieve food balance in that region.

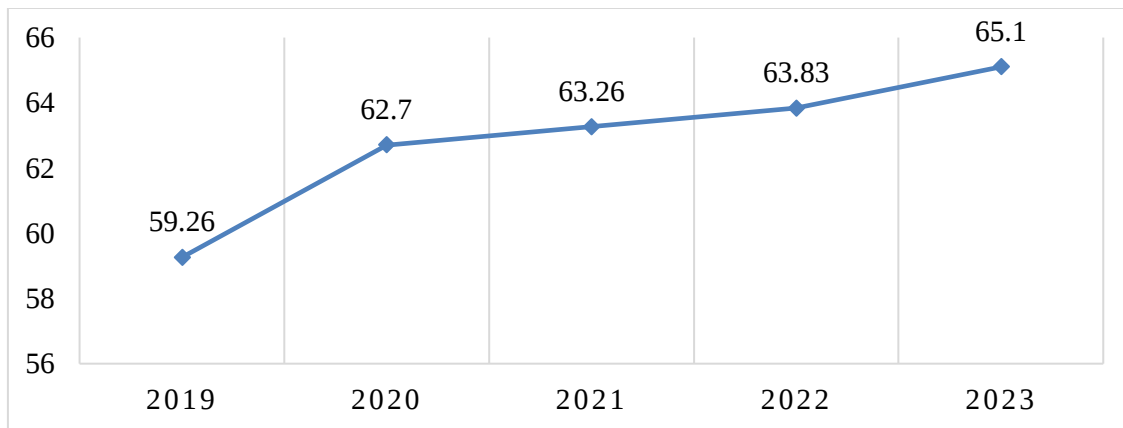
Figure 2. Development of the Food Security Index in the Province of Bangka Belitung Islands



Source: National Food Agency, Indonesia (2023)

The Riau Islands Province is an archipelagic province with characteristics similar to those of the Bangka Belitung Islands Province, which is also an archipelagic region. Figure 3 shows that the Food Security Index in the Riau Islands Province in 2019 was 59.26 percent, increasing in 2020 to 62.70 percent, reaching 63.26 percent in 2021, decreasing to 63.83 percent in 2022, and falling again to 65.10 percent in 2023. The Food Security Index in the Riau Islands Province has increased every year, indicating an improvement in food security in the Riau Islands Province, which is getting better every year. Limited access and the scarcity of agricultural land in the Riau Islands region are problems that prevent the food security index from reaching a good level. Therefore, special attention from the government is needed to address these issues so that the food security index can improve and meet the needs of the community, which are increasing over time.

Figure 3. Development of the Food Security Index in the Riau Islands Province



Source: National Food Agency, Indonesia (2023)

In general, food security does not only depend on local food production, but is also influenced by various factors such as the availability of production factors (land, labor, capital, and technology), government policies, and economic conditions such as the availability of good distribution infrastructure such as roads. This will have an impact on food inflation, which can have a significant impact on people's purchasing power and food price stability. BPS data shows that food inflation in these two provinces is often higher than national inflation, especially for staple commodities such as rice, which poses a serious threat to food security (Badan Pusat Statistik Indonesia, 2024a).

Therefore, understanding the relationship between rice productivity factors, rice harvest area and distribution access within the context of food security is essential for formulating effective strategies. In particular, the Bangka Belitung Islands Province and the Riau Islands Province possess potential for agricultural sector development, especially in rice as a primary staple food commodity.

However, rice productivity in these two provinces remains relatively low compared to other regions in Indonesia (Darman, 2018; Nurhemi et al., 2014)

Data from the Ministry of Agriculture indicate that rice productivity in Bangka Belitung reaches only 4.2 tons per hectare (Badan Pusat Statistik Indonesia, 2024b; Kartiasih & Setiawan, 2019), while in the Riau Islands it is only 3.8 tons per hectare (Badan Pusat Statistik Indonesia, 2024b), which is far below the national average of 5.2 tons per hectare (Badan Pusat Statistik Indonesia, 2024b). This condition is attributed to various factors, including limited fertile land, minimal adoption of modern agricultural technologies, and insufficient incentives for farmers. In addition, high inflation particularly in food commodities can further exacerbate food security conditions by increasing production costs and reducing the competitiveness of local products.

Rice Productivity factors, such as land availability, seed quality, fertilizer use, and irrigation, play a crucial role in enhancing productivity. However, available data show that agricultural land in both provinces has tended to decline due to land-use conversion for non-agricultural activities, such as mining and tourism. In Bangka Belitung, for example, agricultural land area has decreased by approximately 2.5% per year over the past five years. Meanwhile, farmers' access to technology and capital remains limited, constraining efforts to increase production. On the other hand, difficult and costly access to these regions has led to significant price disparities in archipelagic areas, which in turn reduces purchasing power and increases agricultural production costs (Adhitya et al., 2013).

Accordingly, this study aims to analyze the effects of rice production factors and road accessibility on sustainable food security in the Bangka Belitung Islands Province and the Riau Islands Province. This research examines the relationships among these variables using a quantitative approach in order to formulate appropriate strategies to strengthen food security, whether through improving agricultural productivity, stabilizing food prices, or strengthening food-related institutions at the local level. The findings of this study are expected to contribute to more targeted and sustainable policymaking efforts to achieve food security in both provinces.

Literature review and hypothesis development

Food Security Theory – FAO Framework

The concept of global food security refers to a framework developed by the Food and Agriculture Organization (FAO, 1996), which states that food security is achieved when all people have physical, social, and economic access to sufficient, safe, and nutritious food to meet their active and healthy needs. The FAO identifies

four main dimensions of food security, namely availability, access, utilization, and stability.

Food security is a condition in which food needs are fulfilled from the national to the individual level, as reflected in the availability of sufficient food in terms of quantity and quality that is safe, diverse, nutritious, equitably distributed, and affordable, and that does not conflict with religious beliefs and cultural values, thereby enabling people to live healthy, active, and productive lives in a sustainable manner.

The development of food and nutrition security is implemented through a systematic and cross-sectoral approach. This strategy seeks to ensure sufficient food availability through domestic production and trade, maintain stable food supply and access across macro, meso, and micro levels, and guarantee adequate food quality and quantity, including diversity and safety, supported by improvements in supporting infrastructure (WIDIYANI, 2023). Achieving these conditions requires strong macroeconomic policy support to promote economic stability and to secure stable food supplies and price stability.

The Indonesian National Food Agency identifies a set of key indicators used to measure the Food Security Index in Indonesia. These indicators encompass the balance between normative per capita consumption and net food production, the proportion of the population living below the poverty line, the share of households allocating more than 65 percent of their total expenditure to food, and the proportion of households lacking access to electricity. Additional indicators include the average years of schooling among females aged 15 and above, the percentage of households without access to clean water, the ratio of population to health workers relative to population density, the prevalence of stunting among children under five, and life expectancy at birth (badan ketahanan pangan, 2022a). .

Harvest Area

Harvested area refers to the total land area cultivated by farmers for rice production within a single planting season and is measured in hectares (ha) (Moonik et al., 2020). Environmental factors, particularly soil characteristics and climatic conditions, play a critical role in influencing crop growth and production systems. Harvested area represents an important determinant of rice output, as expansions in cultivated land are generally associated with higher levels of production. Rice production is also highly dependent on favorable natural conditions during the growing season, as the absence of extreme events such as flooding or drought supports optimal crop performance. Under such conditions, an expansion in harvested area is expected to contribute to increased production yields (Wardani et al., 2019).

Productivity

Productivity refers to the capacity of a production factor, such as land area, to generate output per hectare (Andrias et al., 2018). It is defined as the ratio between the volume of output produced and the volume of inputs utilized. Both productivity and production are influenced by multiple factors, including soil fertility, seed quality, adequate fertilizer application, sufficient water availability, appropriate cultivation techniques, the use of suitable agricultural equipment, and the availability of effective labor (Sari, 2021). Although closely related, production and productivity represent distinct concepts. Production emphasizes output volume, whereas productivity reflects the efficiency with which resources are utilized (Pristiana et al., 2015).

Productivity is shaped by two key dimensions: efficiency and effectiveness. Efficiency relates to the optimal use of resources to achieve high output quality within a shorter time frame and at minimal cost. Effectiveness, on the other hand, refers to the extent to which intended outcomes are achieved. Together, efficiency and effectiveness are interdependent and play a crucial role in enhancing overall productivity.

Food Distribution Accessibility

Distribution accessibility refers to the degree to which a region can efficiently channel goods, including food, from production centers to consumption areas (World Bank, 2020). Factors such as the availability of transportation facilities, road networks, market access, and logistics systems play a crucial role in determining the effectiveness of distribution flows. Uneven food distribution or distribution systems constrained by geographical conditions such as archipelagic or remote inland areas can lead to price disparities and reduce households' ability to access adequate food (Bahri, 2020). Consequently, distribution accessibility constitutes a key determinant of the "access" dimension of food security.

Numerous studies have demonstrated a strong relationship between food security and distribution accessibility. Higher levels of distribution accessibility are associated with stronger food security at the regional level (Rahayu et al., 2025). Well-developed distribution infrastructure enhances logistical efficiency, lowers transportation costs, and helps maintain the stability of food supply and prices. Conversely, limited distribution access is often a primary driver of food vulnerability, particularly in remote areas. For instance, a study by Amrullah et al., (2019) in Indonesia found that regions with limited road access experience higher levels of food insecurity, as elevated distribution costs increase food prices and reduce household purchasing power.

Factors such as spatial inequality, high logistics costs, and disparities in infrastructure across regions further reinforce this relationship (Amin et al., 2024). Within the context of regional development, strengthening distribution accessibility represents a critical strategy for enhancing national food security.

Hipotesis

Based on the Food Security Framework developed by FAO and supported by prior empirical studies, this research hypothesizes that harvested area, rice productivity, and food distribution accessibility significantly influence the Food Security Index in two archipelagic provinces Riau Islands Province and Bangka Belitung Islands Province. Within the agricultural context, harvested area represents the land input capacity utilized in the production process. According to agricultural production theory, an expansion of cultivated land is expected to increase food output, thereby strengthening regional food availability. In addition, productivity plays a crucial role, as higher yields per hectare contribute to greater total domestic food production. Regions characterized by higher agricultural productivity generally exhibit more stable food supplies and stronger resilience to supply shocks. Transportation and distribution accessibility also constitute an important determinant of food security. Improved infrastructure reduces logistics costs, enhances distribution efficiency, and helps stabilize food prices. Areas with well-developed road networks tend to have more efficient distribution systems, enabling them to maintain stable food supply flows.

Therefore, this study empirically compares the effects of harvested area, rice productivity, and distribution accessibility on the Food Security Index in the two archipelagic provinces of the Riau Islands and Bangka Belitung Islands.

- **H1:** Harvested rice area has a significant effect on the Food Security Index in the Riau Islands Province and the Bangka Belitung Islands Province.
- **H2:** Rice productivity has a significant effect on the Food Security Index in the Riau Islands Province and the Bangka Belitung Islands Province.
- **H3:** Food distribution accessibility has a significant effect on the Food Security Index in the Riau Islands Province and the Bangka Belitung Islands Province.

Research Method

This study employs a quantitative research approach using secondary data. Secondary data analysis refers to the use of existing datasets that have previously been collected and represent original data derived from prior studies and other relevant and credible sources. These data are analyzed to generate valid conclusions based on the information provided by the original sources.

Types and Sources of Data

The data types in this study are secondary data in the form of time series from 2018 to 2024 and cross-sectional data from five regencies in Bangka Belitung Province. Then, there is time series data from 2018 to 2024 and cross-sectional data from five regencies in Riau Islands Province.

The data used in this study include Harvested Area data, calculated in hectares (Ha). Rice Productivity data, which measures the average rice yield per unit of land area harvested during a specific period, is measured in tons (ton). Food Distribution data, which uses road length data, is measured in kilometers (km). The data sources for this study are the Food Security Agency, the Central Statistics Agency of Bangka Belitung Islands Province and Riau Islands Province, Bank Indonesia, and data from the Ministry of Agriculture.

Data Analysis Methods

This study adopts a correlational research design, which aims to examine the relationships between two or more variables (Agustina & Priambodo, 2017). Using a panel data analytical framework, Three regression models were used: Pooled Least Squares (PLS), Fixed Effects Model (FEM), and Random Effects Model (REM). To determine the best model, a Chow test (PLS vs. FEM) and a Hausman test (FEM vs. REM) were performed. The test results indicated that the FEM model was more appropriate than the other two models. The selection of the Fixed Effects Model (FEM) was based on the characteristics of the data and the research objectives. The study analyzes the relationships between harvested rice area, rice productivity, and food distribution data in relation to the Food Security Indeks. This research only took 5 districts in the Bangka Belitung Islands Province, including Bangka, Bangka Barat, Bangka Tengah, Bangka Selatan, and Belitung Timur. It also includes only took 5 districts in the Riau Islands Province, namely Bintan, Karimun, Kepulauan Anambas, Lingga and Natuna. The analytical technique employed in this study is panel data regression analysis, which is used to identify the effects of harvested rice area, rice productivity, and road accessibility on the Food Security Index in the Bangka Belitung Islands Province and the Riau Islands Province.

Analysis Technique

The analysis technique used in this research is the Panel Data Regression Analysis method. Panel data is a combination of time series and cross section data. This study uses the EViews 9 program as a tool in analyzing data. The model equation in this study is as follows:

$$FSI_t^i = \alpha_i + \beta_{1i} RHA_t^i + \beta_{2i} RP_t^i + \beta_{3i} RA_t^i + e_t^i \quad (1)$$

Figure. 4. Panel Data Regression Equation

Information :

FSI : Food Security Index
 RHA : Rice Harvest Area
 RP : Rice Productivity
 RA : Road Accessibility
 E : *error term*
 i : region II (i = 1, 2, 3, ..., 10)
 t : time

Classical Assumption Tests

Classical assumption tests are conducted to evaluate whether the regression model employed in this study is statistically appropriate and reliable (Akbar et al., 2022). When these assumptions are satisfied, the model can be considered suitable for generating valid insights and policy-relevant recommendations.

Multicollinearity Test

The multicollinearity test is used to assess the presence of strong correlations among the independent variables included in the regression model. Multicollinearity can be detected by examining the Variance Inflation Factor (VIF) for each explanatory variable. A VIF value below the commonly accepted threshold of 4 or 5 indicates the absence of multicollinearity, suggesting that the independent variables do not exhibit excessive interdependence (Akbar et al., 2022; Pulungan et al., 2023).

Heteroskedasticity Test

The heteroskedasticity test is applied to determine whether the variance of the residuals remains constant across observations. If the residual variance is constant, the model is said to exhibit homoskedasticity; conversely, varying residual variances indicate the presence of heteroskedasticity (Pulungan et al., 2023).

Coefficient of Determination (R^2)

The coefficient of determination (R^2) measures the extent to which variations in the dependent variable can be explained by the independent variables included in the model. A higher R^2 value indicates greater explanatory power of the regression model (Sugiyono, 2019).

$$D = R^2 \times 100\% \quad (2)$$

Figure. 5. Coefficient of determination

Information :

D = Coefficient of Determination

R = Variable correlation coefficient

Result and discussion

Descriptive Analysis

Food security is a crucial indicator for safeguarding fundamental aspects of societal welfare and national stability. The level of food security provides insights into potential food vulnerability and food crises, while also assisting governments in formulating appropriate policies and effective programs for regional food management (Putra & Rahmani, 2025). One of the primary crops supporting food security and serving as a staple food in Indonesia is rice. Rice is a crop that is well adapted to local conditions and has long been cultivated across various regions of Indonesia, including the Riau Islands and the Bangka Belitung Islands

The Riau Islands Province and the Bangka Belitung Islands Province are two archipelagic provinces located in western Indonesia. These regions are relatively vulnerable to food insecurity due to the challenges associated with archipelagic accessibility and the limited availability of agricultural land for cultivation

Table 1. Rice Harvested Area, Rice Productivity, and Total Road Length by Regency/Municipality in the Riau Islands Province, 2023

Regency	Rice Harvest Area (Ha)	Rice Productivity (ton)	Total Road Length (Km)	Food Security Index
Bintan	5,37	21,27	874	59,58
Karimun	1.41	21,35	791	62,97
Kepulauan Anambas	20,48	26,91	370	55,72
Lingga	62,32	33,47	1.117	52,41
Natuna	62,32	29,97	722	59,15

Source: BPS Provinsi Kepulauan Riau (2023)

Based on Table 1, it can be observed that the harvested rice area in the Riau Islands Province has consistently declined over time. The largest harvested rice areas are found in Natuna Regency and Lingga Regency, amounting to 62.32 hectares, while the smallest harvested area is recorded in Karimun Regency at only

1.41 hectares. This decline is primarily attributed to land degradation resulting from population growth and the conversion of agricultural land into oil palm plantations. In addition, inadequate irrigation infrastructure has further accelerated the conversion of paddy fields to non-agricultural uses (Suryadi, 2024).

In terms of rice productivity, the highest level is observed in Lingga Regency at 33.47 percent, whereas the lowest productivity is recorded in Bintan Regency at only 21.27 percent. Compared to previous years, rice productivity in the Riau Islands Province has experienced a slight, though not statistically significant, decline. This trend is largely associated with the reduction in paddy cultivation area, which has negatively affected rice productivity across the region.

Strengthening food security also requires an efficient food distribution network across all regions within the Riau Islands Province, which can be proxied by the total length of road infrastructure. Lingga Regency has the longest total road network at approximately 1,117 km, reflecting its status as the largest regency in the province. In contrast, the Anambas Islands Regency records the shortest total road length at around 370 km, due to its relatively small territorial size, second only to Tanjungpinang City.

With respect to food security conditions, five regencies in the Riau Islands Province are still classified as food-vulnerable areas, with an average Food Security Index score of only 55 points (badan ketahanan pangan, 2022a)

The Bangka Belitung Islands Province shares similar archipelagic characteristics with the Riau Islands Province.

Table 2. Rice Harvested Area, Rice Productivity, and Total Road Length by Regency/Municipality in the Bangka Belitung Islands Province, 2023

Regency	Rice Harvest Area (Ha)	Rice Productivity (ton)	Total Road Length (Km)	Food Security Index
Bangka	1.270	32	859,50	81,31
Bangka Barat	929,52	30	920	63,76
Bangka Tengah	112	35,38	609	58,62
Bangka Selatan	12.322	35	737	82,94
Belitung Timur	629,02	28	918,37	62,09

Source : BPS Provinsi Kepulauan Riau (2023)

Based on Table 2, the largest harvested rice area is recorded in South Bangka Regency at 12,322 hectares, while the smallest harvested area is found in Central Bangka Regency at only 112 hectares. This variation reflects differences in regional

land availability, as Bangka Island constitutes a relatively large archipelagic area with more extensive agricultural land.

Regarding rice productivity, Central Bangka Regency exhibits the highest productivity level at 35.38 tons, whereas East Belitung Regency records the lowest productivity. This condition can be attributed to the limited number of households engaged in rice cultivation in the Bangka Belitung Islands Province, as many residents prefer oil palm plantations or are involved in tin mining activities.

Food distribution infrastructure, measured by total road length, also varies across regencies. West Bangka Regency has the longest road network at approximately 920 km, while South Bangka Regency records the shortest at around 737 km. In assessing food security in the Bangka Belitung Islands Province, road length plays an important role, as a more extensive road network indicates wider distribution coverage, which in turn supports food accessibility and overall food security.

According to Table 2, the food security condition in the Bangka Belitung Islands Province can be classified as relatively strong, with an average Food Security Index score of 69.70 points (badan ketahanan pangan, 2022b)

Discussion

The analysis used in this study employed panel data regression analysis, in which the best model selection test was conducted. Based on the model selection test, the following data was obtained::

Table 3. Panel Data Regression Model Selection Test

Province		Model Selection Test		Data results	Decision
				(Prob)	
Riau Island		Chow Test		0,0000 < 0,05	FEM
		Hausman Test		0,0000 < 0,05	FEM
		Legrange Test	Multiplier	-	FEM
Bangka Island	Belitung	Chow Test		0,0000 < 0,05	FEM
		Hausman Test		0,0000 < 0,05	FEM
		Legrange Test	Multiplier	-	FEM

Source: Processed Data (2026)

Based on Table 3, the Fixed Effects Model (FEM) is identified as the most appropriate specification for both the Riau Islands Province and the Bangka Belitung Islands Province. To ensure the robustness and validity of the estimation results, classical assumption tests were conducted so that the Fixed Effects Model

satisfies the required conditions for producing unbiased, consistent, and efficient (BLUE) estimates (Fitrah, 2024).

Table 4. Testing Classical Assumptions of FEM Regression Models for Riau Islands Province and Bangka Belitung Islands Province

Province	Multicolinerity test	Desc.	Heteroscedasticity test	Desc
Riau Island	Data coefficient LLP, PP and AJ < 0,85	Passed	Prob LPP, PP dan AJ > 0,05	Passed
Bangka Belitung Island	Data coefficient LLP, PP and AJ < 0,85	Passed	Data coefficient LLP, PP and AJ < 0,85	Passed

Source: Processed Data (2026)

Based on the classical assumption tests conducted—namely the multicollinearity and heteroskedasticity tests—the estimated model satisfies the BLUE criteria, indicating that it is unbiased, consistent, and efficient. The Fixed Effects Model (FEM) can therefore be specified as follows:

Table 5. Analysis of the Impact of Food Security Index, Rice Harvest Area, Rice Productivity, and Road Accessibility in Riau Islands Province

Dependent Variable: FSI

Method: Panel Least Squares

Sample: 2018 2024

Total panel (balanced) observations: 35

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	63.26533	2.644161	23.92643	0.0000
RHA	-0.050925	0.014257	-3.571867	0.0014
RP	-0.165441	0.075972	-2.177661	0.0383
RA	0.000598	0.001106	0.540838	0.5931
R-squared	0.775044	Mean dependent var		55.86720
Adjusted R-squared	0.716722	S.D. dependent var		3.919808
S.E. of regression	2.086273	Akaike info criterion		4.506267
Sum squared resid	117.5184	Schwarz criterion		4.861775
Log likelihood	-70.85968	Hannan-Quinn criter.		4.628989
F-statistic	13.28907	Durbin-Watson stat		2.583975
Prob(F-statistic)	0.000000			

Source: Processed Data (2026)

Panel Data Regression Equation

$$\text{FSI} = 63.2653 - 0.0509 \cdot \text{RHA} - 0.1654 \cdot \text{RP} + 0.0006 \cdot \text{RA} + e$$

The regression results can be interpreted as follows:

1. The regression constant for the Food Security Index (FSI) is estimated at 63.26, indicating that when all independent variables in the model are held constant or assume a value of zero, the Food Security Index increases by 63.26 percent.
2. The coefficient of rice harvested area (RHA) is -0.0509 , suggesting that a 1 percent increase in harvested rice area is associated with a 0.0509 percent decrease in the Food Security Index, holding other variables constant.
3. The coefficient of rice productivity (RP) is -0.165 , implying that a 1 percent increase in rice production leads to a 0.165 percent decline in the Food Security Index, *ceteris paribus*.
4. The coefficient of road accessibility (RA) is 0.0006, indicating that a 1 percent improvement in road accessibility contributes to a 0.0006 percent increase in the Food Security Index, all else being equal.

Table 5 presents the basis for significance testing in the regression analysis. The probability value for the harvested rice area variable (HRA) is 0.00, which is below the 0.05 significance level, indicating that harvested rice area has a statistically significant effect on the Food Security Index (FSI). Similarly, the rice productivity variable (RP) has a probability value of 0.03, also below 0.05, suggesting a significant influence on the Food Security Index. In contrast, the road accessibility variable (RA) records a probability value of 0.59, which exceeds the 0.05 threshold, implying that road accessibility does not have a statistically significant effect on the Food Security Index.

The adjusted R-squared value of 0.71 indicates that approximately 71 percent of the variation in the Food Security Index can be explained by harvested rice area, rice production, and road accessibility, while the remaining 29 percent is attributable to other factors not included in this study

Table 6. Analysis of the Impact of Food Security Index, Rice Harvest Area, Rice Productivity, and Road Accessibility in the Province of Bangka Belitung Islands

Dependent Variable: FSI

Method: Panel Least Squares

Sample: 2018 2024

Total panel (balanced) observations: 35

Variable	Coefficient	Std. Error	t-Statistic	Prob.
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C	47.18281	4.686380	10.06807	0.0000
RHA	-0.006772	0.003047	-2.222628	0.0348
RP	0.598904	0.119409	5.015580	0.0000
RA	0.008062	0.004482	1.798818	0.0832
R-squared	0.875298	Mean dependent var	69.70120	
Adjusted R-squared	0.842967	S.D. dependent var	9.864802	
S.E. of regression	3.909157	Akaike info criterion	5.762152	
Sum squared resid	412.6008	Schwarz criterion	6.117661	
Log likelihood	-92.83767	Hannan-Quinn criter.	5.884874	
F-statistic	27.07366	Durbin-Watson stat	1.785154	
Prob(F-statistic)	0.000000			

Source: Processed Data (2026)

$$\text{FSI} = 47.1828 - 0.0067 \cdot \text{RHA} + 0.5989 \cdot \text{RP} + 0.0080 \cdot \text{RA} + e$$

The regression results can be interpreted as follows:

1. The estimated constant of the Food Security Index (FSI) is 47.18, indicating that when all independent variables in the model are held constant or take a value of zero, the Food Security Index increases by 47.18 percent
2. The coefficient of harvested rice area (HRA) is -0.0067 , suggesting that a 1 percent increase in harvested rice area is associated with a 0.0067 percent decrease in the Food Security Index, *ceteris paribus*
3. The coefficient of rice productivity (RP) is 0.59, implying that a 1 percent increase in rice production leads to a 0.59 percent increase in the Food Security Index, holding other variables constant
4. The coefficient of road accessibility (RA) is 0.008, indicating that a 1 percent improvement in road accessibility contributes to a 0.008 percent increase in the Food Security Index, all else being equal

Table 6 provides the basis for determining statistical significance in the regression analysis. The probability value for the rice harvested area variable (RHA) is 0.00, which is below the 0.05 significance threshold, indicating that harvested rice area has a statistically significant effect on the Food Security Index (FSI). Similarly, the rice productivity variable (RP) records a probability value of 0.03, also below 0.05, suggesting a significant influence on the Food Security Index. In contrast, the road accessibility variable (RA) shows a probability value of 0.59, exceeding the 0.05 level, which implies that road accessibility does not have a statistically significant effect on the Food Security Index. The adjusted R-squared value of 0.71 indicates that approximately 71 percent of the variation in the Food Security Index is explained by harvested rice area, rice production, and road accessibility, while the remaining 29 percent is attributed to other factors not captured in this study.

Based on the panel data regression results, it can be concluded that the Riau Islands Province exhibits a higher baseline coefficient of food security at 63.2 percent compared to the Bangka Belitung Islands Province, which records a value of 47.18 percent. This difference may be attributed to the relatively higher income levels in the Riau Islands, smoother inter-island food distribution networks, and more effective food import mechanisms. The geographical proximity of the Riau Islands Province to Singapore a highly developed economy with a high gross domestic product also contributes positively to regional economic performance and food security. In contrast, food security in the Bangka Belitung Islands Province is more heavily dependent on internal factors such as local agricultural production and road accessibility, resulting in a lower baseline Food Security Indeks (Putra & Rahmani, 2025).

1. The Effect of Rice Harvested Area on the Food Security Index

The estimation results indicate that harvested rice area has a negative and statistically significant effect on the Food Security Index (FSI) in the Riau Islands Province, with a coefficient of -0.0509 and a probability value of 0.0014 ($p < 0.05$). This implies that an increase in harvested area is associated with a decline in food security levels in the region.

From a theoretical perspective, this finding appears to contradict conventional agricultural production theory, which posits that an expansion of cultivated land should increase total output and strengthen food availability. However, the result can be explained within the framework of the FAO Food Security Framework, which emphasizes that food security is determined not only by availability but also by access, utilization, and stability. In this context, increasing harvested area without corresponding improvements in productivity and efficiency does not necessarily enhance food security outcomes.

This phenomenon suggests that the expansion of rice cultivation in the Riau Islands has not been accompanied by gains in productivity, thereby limiting its contribution to food security. Moreover, this finding is consistent with the food systems approach, which highlights that regions with service- and trade-oriented economic structures tend to rely more on external supply chains rather than local agricultural production. As such, the Riau Islands Province depends more heavily on inter-regional food inflows than on domestic production (Suryadi, 2024). Therefore, the negative relationship observed in this study can be considered conditionally consistent with theory, particularly when viewed from a broader food systems and multi-dimensional food security perspective.

In contrast, in the Bangka Belitung Islands Province, harvested rice area also exhibits a negative and significant effect on the Food Security Index, with a coefficient of -0.0067 and a probability value of 0.0348 ($p < 0.05$). Although the

effect remains negative, its magnitude is smaller compared to that of the Riau Islands. This finding further indicates that land expansion alone is insufficient to improve food security outcomes.

According to agricultural productivity and efficiency theory, the effectiveness of land use depends not only on its size but also on factors such as soil quality, technology adoption, and input efficiency. Thus, this result is consistent with modern agricultural theory, which emphasizes that improvements in productivity and efficiency are more critical determinants of food security than mere increases in cultivated land area.

2. The Effect of Rice Productivity on the Food Security Index

Rice productivity is found to have a negative and statistically significant effect on the Food Security Index (FSI) in the Riau Islands Province, with a coefficient of -0.1654 and a probability value of 0.0383 ($p < 0.05$). This finding suggests that improvements in rice productivity do not necessarily translate into enhanced food security outcomes. From a theoretical perspective, the FAO Food Security Framework highlights that food security is not solely determined by food availability, but also by access, utilization, and stability. Therefore, even when productivity increases, its contribution to food security remains limited in regions that are highly dependent on external food supply. In addition, several structural constraints such as inefficient farming practices and the conversion of agricultural land into plantation areas further reduce the effectiveness of productivity gains in archipelagic regions (Putra & Rahmani, 2025).

These results are consistent with the food systems approach, which posits that regions characterized by service- and trade-oriented economic structures tend to rely more on market integration and inter-regional distribution than on local agricultural productivity. As a result, increases in rice productivity do not significantly affect overall food security, given their relatively small contribution to total food demand. This also indicates that rice agriculture has not been prioritized in regional development and continues to be overshadowed by industrial and commercial sectors (Azhar et al., 2023).

In contrast, rice productivity in the Bangka Belitung Islands Province shows a positive and highly significant effect on the Food Security Index, with a coefficient of 0.5989 and a probability value of 0.0000 ($p < 0.01$). This finding aligns with agricultural productivity theory, which emphasizes that higher yields per hectare are a key driver of food availability, particularly in regions that depend on local production systems.

Furthermore, within the FAO framework, the availability dimension plays a dominant role in areas with limited reliance on external markets. In Bangka

Belitung, where local communities still depend heavily on domestically produced food, improvements in rice productivity directly enhance food availability and contribute to supply stability. This underscores that the efficiency and performance of the local agricultural sector are critical determinants in strengthening food security in the region (Azhar et al., 2023).

3. The Effect of Road Accessibility on the Food Security Indeks

The estimation results indicate that the road accessibility variable has a positive coefficient of 0.0006, but it is not statistically significant, with a probability value of 0.5931 ($p > 0.05$) in the Riau Islands Province. This finding suggests that land-based road infrastructure does not have a substantial impact on food security in the region.

According to the FAO Food Security Framework and distribution/logistics system theory, transportation infrastructure accessibility plays a crucial role in enhancing food security, particularly in terms of access and stability. Well-developed infrastructure is expected to reduce distribution costs, facilitate the movement of goods, and maintain price stability. However, in the context of the Riau Islands, this result can be explained using the spatial economics perspective and the food systems approach, where geographical characteristics strongly determine the effectiveness of specific types of infrastructure.

The Riau Islands Province is an archipelagic region, with approximately 98% of its area consisting of sea and only 2% land (Badan Pusat Statistik Kepulauan Riau, 2012; Harefa, 2013), meaning that food distribution systems rely predominantly on inter-island maritime transport rather than road networks. Therefore, although road accessibility is theoretically important, its impact becomes insignificant in this case due to the region's geographical conditions, which favor sea-based transportation. Consequently, this finding may be considered inconsistent with general theoretical expectations, but remains theoretically valid within a context-specific framework that accounts for geographic characteristics and archipelagic food systems.

In contrast, in the Bangka Belitung Islands Province, road accessibility has a positive coefficient of 0.0080, although it is also not statistically significant at the 5% level ($p\text{-value} = 0.0832$). Nevertheless, the positive relationship indicates that improvements in road accessibility have the potential to enhance the efficiency of food distribution across regions.

This finding is consistent with infrastructure and economic development theory, which suggests that improvements in road quality and network coverage can increase distribution efficiency, reduce logistics costs, and expand market access. In Bangka Belitung, food distribution occurs primarily within land-based areas (main

islands), making road infrastructure relatively more important than in the Riau Islands. Thus, although the effect is not statistically significant, the result is consistent with theoretical expectations, as it demonstrates the expected positive relationship between infrastructure accessibility and food security (Rachman, 2010).

Conclusions

Based on the results of the panel data regression analysis conducted in two archipelagic provinces in Indonesia, several key conclusions can be drawn:

1. Structural differences in food security exist between the Riau Islands Province and the Bangka Belitung Islands Province. Food security in the Riau Islands is not primarily dependent on local rice production, whereas Bangka Belitung exhibits a strong reliance on domestic agricultural output.
2. Harvested rice area has a negative effect in both provinces. This finding indicates that expanding cultivated land does not directly enhance food security unless it is accompanied by improvements in agricultural productivity.
3. Rice Productivity exerts markedly different effects across provinces. In the Riau Islands Province, rice production has a negative and statistically significant impact on food security. In contrast, in the Bangka Belitung Islands Province, rice production shows a positive and significant effect, highlighting a fundamental divergence in food security dynamics between the two regions.
4. Road accessibility does not have a statistically significant effect in either province; however, its role is relatively more pronounced in Bangka Belitung than in the Riau Islands.
5. The regression model demonstrates stronger explanatory power in Bangka Belitung, with an R-squared value of 87.53%, compared to 77.50% in the Riau Islands.
6. Food security in the Riau Islands is largely influenced by external factors, such as inter-island food supply chains and trade flows. Conversely, food security in Bangka Belitung is predominantly driven by internal factors, particularly local agricultural production.

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