



The Impact of The Central Kalimantan Food Production Centre Area (Food Estate) Policy on Rice Production in Kalimantan

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ABSTRACT

The Central Kalimantan Food Production Centre Area (Food Estate) Program is one of the strategic policies aimed at increasing production and maintaining national food security. This study examines the impact of the national strategic policy to develop food production centre areas in Central Kalimantan on rice production, using the difference-in-difference method with panel data from cities and districts in the Kalimantan region. Analysis of the regression results indicates that the policy of developing the Food Production Centre Area program in Central Kalimantan does not have a statistically significant impact on rice production, at least until 2023. The results of the parallel trend and placebo effect tests show a parallel trend and no placebo effect. This condition suggests that the government's policy strategy for developing food production centre areas in Central Kalimantan is less effective in increasing rice production in designated food estate areas in the short term.

INTRODUCTION

Concerns about a global food crisis are growing due to various factors that threaten the stability of food supplies. One major factor is climate change and global warming, which are causing extreme weather events, disrupted weather patterns, and decreased agricultural productivity (Ray et al., 2019; Rosenzweig & Perry, 1994; Wheeler & von Braun, 2013). Rising temperatures accelerate water evaporation, reduce soil moisture, and increase the frequency of disasters such as droughts, floods, and storms. Consequently, agricultural infrastructure is damaged, farmland is affected, and crop yields are declining, especially in developing countries. Climate change also affects ecosystems that support agriculture, such as the availability of natural pollinators and clean water, and alters climate zones, thereby reducing the suitability of land for agriculture. This makes it difficult for farmers to plan planting and harvesting seasons.

Furthermore, geopolitical instability exacerbates the food crisis. Armed conflict, economic sanctions, and political tensions disrupt food production, distribution, and trade (Tiwari et al., 2021; Micallef et al., 2023). This uncertainty is pushing countries to reduce exports and prioritise the security of domestic food stocks.

Indonesia was unable to avoid the shock of the food crisis and continues to face internal food security issues that are not improving. The total score of the Indonesian Food Security Index (Global Food Security Index - Indonesia) declined between 2018 and 2022. The average total score was 61.3. In 2022, Indonesia scored 60.2, a 5.35% decrease compared to 2018, which recorded its highest total score of 63.6. This condition is an improvement compared to the previous year. Although Indonesia is an agricultural and maritime country, it has not been able to ensure that food is both available and affordable to meet the community's overall demand in terms of both quantity and quality.

A closer look reveals that Indonesia's greatest weakness in food security lies in the aspects of sustainability and adaptation, with an average score of 46.4. Meanwhile, the average scores for the availability, quality and safety aspects were 55.7 and 57.3, respectively. This indicates that the national food supply chain system remains insufficient to meet domestic demand for high-quality food, leaving the public vulnerable to consuming low-quality and unsuitable food. However, the affordability aspect scored quite high, with an average score of 80.4, indicating that food supplies are generally quite accessible to the public.

Table 1. Details of Indonesia's Food Security Index Score, 2018-2022

Aspect	2018	2019	2020	2021	2022	Mean
Availability	56.5	56.9	57.2	57.0	50.9	55.7
Affordability	80.8	78.2	83.3	78.1	81.4	80.4
Quality and Safety	62.8	60.5	53.9	52.9	56.2	57.3
Sustainability and Adaptation	49.5	45.2	45.5	45.5	46.3	46.4

Source: Ministry of Agriculture, 2023

The food problems experienced by Indonesia are compounded by the country's inability to anticipate a population growth rate that outpaces the rate of self-sufficient food production. Food production often fails to keep up with population growth, especially in developing countries, thus increasing the risk of food scarcity (Kousar et al., 2021). Indonesia is still experiencing population growth and is projected to continue growing. The reality faced by Indonesia is that the production of strategic food commodities cannot keep pace with its growing population. The pace of Indonesia's population growth is faster than that of its food production, a condition that persists to this day. While the population of Indonesia increases over time, so does the production of rice and other food commodities; however, the proportion of food crops available for consumption per person is decreasing.

Table 2. Production and Proportion of Rice per Person in Indonesia, 2020-2023

Indicator	2020	2021	2022	2023
Mid-year Indonesian population (million people)	270.20	272.68	275.77	278.70
Rice production (million tonnes)	54.65	53.78	54.34	53.96
Rice per person (tonnes)	2.02	1.97	1.97	1.94

Source: Statistics Indonesia, 2023

Not all regions in Indonesia serve as a national food reserve. The island of Java is the country's primary rice-producing region, with major provinces such as East Java, Central Java, and West Java recording the highest yields. This high productivity is attributed to factors such as fertile soil, the use of high-yielding rice varieties, and advanced cultivation techniques (Manning,

1988; Rachman et al., 2022; Sumaryanto et al., 2023). In contrast, Sumatra shows relatively even production, while South Sulawesi leads in its respective region. Kalimantan's average production remains low, except for South Kalimantan, and the eastern parts of Indonesia report the lowest yields. This regional disparity in production capacity highlights a critical area for national food policy attention.

These indicators reveal that Indonesia is facing significant challenges to its food security, prompting the government to enhance its national food management. Therefore, the government established integrated food production centres, known as food estates, to serve as new food granaries and address these issues by increasing quality production. Based on this situation, this research aims to examine whether the food estate development policy in Central Kalimantan has an impact on rice production.

Several quantitative studies on food estates in Indonesia have shown that farming in some locations has good financial feasibility and can increase agricultural commodity production (Fahmid et al., 2022; Mulyono et al., 2023; Rina et al., 2023; Setyo & Elly, 2018; Taena et al., 2023; Yusup & Sonia, 2024). Other research, based on literature reviews, indicates that the implementation of food estates by previous administrations was unsuccessful due to factors such as agrarian governance, farmers' expertise, and institutional issues, as well as environmental impacts (Izzati et al., 2023; Rasman et al., 2023). Furthermore, Hikmat et al. (2022) argue that peatlands have the potential for agricultural use, and Surahman et al. (2018) support this by showing that peatlands have a high sustainability score for rice commodities. However, no literature has yet been found that quantitatively examines the impact of the food estate policy on agricultural production, particularly rice.

LITERATURE REVIEW

One of the regions designated as a development locus for the Food Production Centre Area (Food Estate) is Central Kalimantan Province. The program in this region focuses on land intensification and extensification to create food production hubs in areas with agricultural land potential. The planning for this food production centre area is regulated in a master plan established by the Minister of National Development Planning/Head of the National Development Planning Agency, as per Decree Number KEP.18/M.PPN/HK/03/2023 concerning the Master Plan for the Development of the Food Estate/Food Production Centre Area in Central Kalimantan Province. The project's development timeline spans from 2020 to 2024. This area encompasses the development of agricultural production, encompassing the sub-sectors of food crops, horticulture, plantations, and livestock. Although various agricultural commodities are included, the government's strategic focus in this area is primarily on rice, meaning that government interventions are mainly aimed at increasing rice production.

The development of the Central Kalimantan Food Estate, in accordance with its master plan, is located in the southeastern part of Central Kalimantan Province, near the border with South Kalimantan Province. The functional area designated as the Area of Interest (AoI) for the development of this production centre covers 2,310,457 hectares, including the area of the former Peatland Development Project (Proyek Lahan Gambut/PLG). This former PLG area comprises Blocks A, B, C, D, and E, which encompass both irrigated and non-irrigated zones. Administratively, this entire functional land spans four administrative regions: Palangkaraya City, Kapuas Regency, Pulang Pisau Regency, and South Barito Regency. The government is utilising the former PLG land for this project due to its potential for increasing agricultural productivity, the existing infrastructure, and previous management efforts. Another rationale is to avoid deforestation from opening new forest land and to utilise the available peatlands as potential agricultural areas.

The food estate policy is a top-down mandate strategy originating from the highest authority of the central government, which is implemented by lower-level government officials,

distinguishing it from general production enhancement policies. Institutionally, this policy is the execution of a mandate from the central government, which designates a specific region to be developed into an integrated agricultural area that supports national food security. Central Kalimantan was chosen by the central government as a strategic location due to its vast potential agricultural land, deemed suitable for large-scale agricultural development, especially in the 743,793.55-hectare former PLG area. In terms of implementation, this policy differs from previous agricultural policies in that it involves large-scale intervention carried out through synergy between the central and local governments to boost agricultural commodity production. Several central government institutions were mandated to execute this policy, including the Ministry of Agriculture; the Ministry of Public Works and Public Housing; the Ministry of Agrarian Affairs and Spatial Planning/National Land Agency, the Ministry of Villages, Development of Disadvantaged Regions, and Transmigration; and the Ministry of Environment and Forestry. Furthermore, there is the involvement of a non-conventional actor, which is the National Armed Forces, which participates in farmer assistance and land preparation to ensure the policy's implementation.

The implementation of the food estate policy in Central Kalimantan shows a fundamental difference compared to conventional agricultural production enhancement policies previously run by the government through the Ministry of Agriculture. Conventional agricultural policies were generally implemented partially by individual work units under the Ministry of Agriculture according to their respective duties and functions. These policy programs were implemented by specific sectoral units responsible for aspects such as cultivation, livestock, land management, irrigation management, or farmer extension services, without involving comprehensive cross-institutional synergy.

The food estate program advocates for an integrated approach that involves cross-institutional coordination at both central and regional levels. This approach is reflected in the significant budget allocation of IDR 2.03 trillion in 2021, sourced from a combination of central and local government funds (Bappenas, 2022). This large allocation reflects an intervention scale that is not only substantial in nominal terms but also indicates a paradigm shift in the implementation of food policy from a sectoral to a collaborative model. The policy began to demonstrate synergy between agencies in managing a priority area in a focused manner. Therefore, the food estate program can be understood as a central government policy with great ambition to form a modern agricultural ecosystem through an integrated approach between central and regional government institutions, which fundamentally distinguishes it from previous conventional agricultural production enhancement programs.

The food estate program is implemented through three main aspects: geospatial, on-farm, and off-farm. The geospatial aspect includes land use planning, connectivity infrastructure development, water resource management, and the conservation of forest and peatland ecosystems. The on-farm aspect focuses on land development, the provision of production inputs, farmer training, pest control, and the strengthening of farmer institutions. Expansion is carried out on farmer-owned land that was previously unutilized. The off-farm aspect covers post-harvest improvements, product processing, marketing, and corporate-based institutional training to strengthen the linkage between the production and distribution sectors of agricultural products.

METHODS

This study utilises secondary data, which are compiled into a panel dataset for analysis and processing. The secondary data consist of information on production, production factors, climate, agricultural characteristics, and government food-related interventions at the city and regency levels, with a geographical focus on the island of Kalimantan. These data are sourced from various government agencies, including Statistics Indonesia (BPS), the Ministry of

Agriculture, the Ministry of Finance, and the National Development Planning Agency (Bappenas). The data from the Ministry of Agriculture used in this study originate from BPS and have been confirmed to be identical. Rainfall data were obtained from the data portal of the Centre of Hydrometeorology and Remote Sensing (CHRS). Information regarding the areas affected by the Central Kalimantan food estate policy was sourced from its development master plan document. The data period spans from 2010 to 2023 to observe changes by comparing the periods before the treatment was introduced in 2020 and after the policy was implemented.

The ideal research design for testing causality is a randomised controlled trial (RCT). However, in situations where an RCT is not feasible, the Difference-in-Differences (DiD) method can be employed for causal inference. DiD is used to evaluate the impact of an intervention or policy by comparing the outcomes of a treatment group (those affected by the intervention) with those of a control group (those unaffected) in the periods before and after the intervention is implemented.

Before testing the policy's impact, this study first selects observations for the control group using the Propensity Score Matching (PSM) method. This approach ensures that the chosen control group has characteristics comparable to the treatment group, thereby increasing the validity of the impact estimation. Kane et al. (2020) state that the PSM method is beneficial for forming a more representative control group by eliminating outlier control units, reducing the influence of irrelevant covariates, and improving the measurement precision of the variables under study.

Based on this approach, the model used in this study is as follows:

$$\text{paddyprod}_{it} = \beta_0 + \beta_1 \text{treat}_{it} + \beta_2 \text{timeafter}_{it} + \beta_3 \text{treatxafter}_{it} + \beta_4 \text{luaspanen}_{it} + \beta_5 \text{tkhani}_{it} + \beta_6 \text{rls}_{it} + \beta_7 \text{ratacurahhujan}_{it} + \varepsilon_{it}$$

Where:

paddyprod	:	Total rice production (tonnes).
treatxafter	:	The interaction term between the 'treat' dummy and the 'timeafter' dummy. This is the main coefficient of interest for the DiD analysis.
treat	:	Dummy variable for the treatment group. 1 = city/regency is a food estate location; 0 = non-food estate location.
timeafter	:	Dummy variable for the post-treatment period 1 = the year 2021 and after (≥ 2021); 0 = the year before 2021 (< 2021).
luaspanen	:	Rice harvested area (hectares)
tkhani	:	Number of workers in the agricultural sector (persons).
rls	:	The mean years of schooling of the population (years).
ratacurahhujan	:	The average rainfall (millimetres).
ε_{it}	:	The error terms.

The variables used in this study are transformed using the natural logarithm (ln) for data processing with the Difference-in-Differences (DiD). The purpose of this transformation is to mitigate issues arising from differences in units and scale across variables, which allows for a more straightforward interpretation of the results (Cole & Altman, 2017). This logarithmic transformation was not applied to the mean years of schooling variable because its relatively small range of values could risk complicating the interpretation.

The selection of the treatment group was based on formal planning documents and program reports released by the government. This approach was taken due to limitations in the

data and information available from the ministries and agencies that delivered the program's interventions. The treatment group consists of two regencies through which the Central Kalimantan food estate administratively runs: Kapuas Regency and Pulang Pisau Regency. These two regencies were selected because the government's actual interventions for the food estate's development were focused on them. Meanwhile, all other cities and regencies on the island were included in the control group to serve as a comparison for the observations that did not receive the treatment. Cities and regencies in the Kalimantan region were selected as a control group because they share characteristics similar to those of the food estate locations in Central Kalimantan than other regions. Although there is also a food estate program intervention in Gunung Mas Regency, this regency is not included in the AoI of the Central Kalimantan Food Production Centre Area Program because it is an authority outside the intended master plan, and the commodity focused on is cassava plants, so it is included in the control group.

RESULTS

The food estate program in Central Kalimantan was initiated in 2020, with two regencies designated as intervention locations. Therefore, it is essential to understand the extent of this program's impact on rice production, the primary food commodity and the policy's main target in the region. To evaluate the program's impact objectively and measurably, a comparative approach is necessary between the designated food estate locations and other areas that did not receive a similar intervention. This comparison must consider conditions both before and after the program's implementation to distinguish the effects of the policy intervention from other changes that may have occurred over time.

Table 3. Comparison of Indicators in Cities/Districts in the Kalimantan Region that are Used as Food Estate Locations with Non-Food Estate Locations in the Period Before and After the Implementation of the Food Estate Program

	2010 (before intervention)		2019 (before intervention)		2022 (after intervention)	
	Non-Food Estate Area	Food Estate Area	Non-Food Estate Area	Food Estate Area	Non-Food Estate Area	Food Estate Area
Mean Rice Production (thousand tonnes)	75.76	204.77	49.24	131.23	26.85	119.49
Mean Harvested Area (thousand ha)	21.77	71.60	14.65	40.64	10.48	36.03
Mean Agricultural Sector Labour (thousand people)	54.29	80.48	49.06	65.01	51.89	58.28
Mean Years of Schooling (years)	7.12	6.96	8.25	7.80	8.51	7.95
Mean Rainfall (mm)	3,824.05	4,368.30	2,809.17	3,074.96	3,539.96	3,575.59

Source: Data Processed, 2025

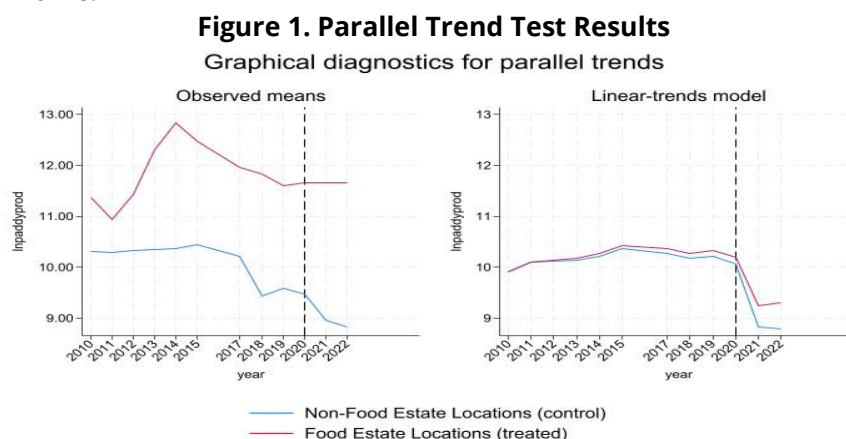
Table 3 presented above illustrates the dynamics of agricultural indicators in food estate and non-food estate locations in Central Kalimantan by comparing three crucial time periods: 2010, 2019, and 2022. The comparison between the 2010 and 2019 periods reveals a significant shift in the methodology for collecting rice production data, as Statistics Indonesia (BPS) transitioned from a tile-based household survey method (ubinan) to the Area Sample Frame (ASF) method. This methodological transition, which began around 2018, affected the figures for rice production and harvested area. Therefore, direct comparisons of data from before and after this transition must be interpreted with great caution. Meanwhile, the year 2019 represents the

baseline condition before the food estate intervention, and the 2022 data reflect the condition after the intervention, which officially began in 2020.

In general, both food estate and non-food estate locations experienced a decline in average rice production and harvested area between 2010 and 2022. In the food estate locations, production decreased from 204.77 tonnes in 2010 to 119.49 thousand tonnes in 2022, while the harvested area shrank from 71.60 thousand hectares to 36.03 thousand hectares. The decline between 2010 and 2019 was partly influenced by the change in the calculation method from the tile-based survey to the Area Sample Frame (ASF), which tends to produce lower estimates. Let's compare the average rice production at the food estate location before and after the change in the method of calculating rice production, following the intervention of the food estate program. It can also be observed that there has been a decrease in rice production, from 131.23 thousand tonnes in 2019 to 119.49 thousand tonnes in 2022, as well as a decline in the area harvested for rice, from 40.46 thousand hectares in 2019 to 36.03 thousand hectares in 2022. However, the fact that this decline continued after the intervention raises questions about the effectiveness of the food estate program. Agricultural labour data, available only through 2019, also indicate a decrease, which limits the analysis of employment after intervention. In contrast, the mean years of schooling increased across all regions, indicating an improvement in human capital. Meanwhile, rainfall fluctuated, decreasing from 2010 to 2019 and slightly rising in 2022. This change in rainfall is a potential external factor that could influence agricultural outcomes. Overall, the data indicate a consistent downward trend in production, regardless of the intervention.

Testing the Parallel Trend Assumption

Once the control group, selected via propensity score matching, has been balanced against the treatment group, a test can be performed to verify the parallel movement of rice production between the two groups over time. Based on the "Graphical Diagnostics for Parallel Trends" plot, it can be concluded that the parallel trends assumption for the pre-intervention period is reasonably satisfied, particularly when referring to the right-hand panel (the linear-trends model graph). In Figure 1, the trend lines for the treatment group (red line) and the control group (blue line) show a similar direction and slope during the period from 2010 until the intervention year of 2020. This indicates that, before the policy's implementation, both groups exhibited parallel patterns of change in the logarithm of rice production ($\ln\text{paddyprod}$), a fundamental requirement for applying the Difference-in-Differences method. The year 2016 does not appear in the graph because a missing value for the agricultural sector labour prevented its estimation for that point in time.



Source: Data Processed, 2025

However, in the left-hand panel (the "observed means" graph), a persistent difference in production levels is still visible. The red line, representing the treatment group, shows higher production values than the control group, particularly after 2012. This difference can be attributed to a previous government policy: The Special Effort Program for Rice, Corn, and Soybeans (UPSUS PAJALE), which began in 2013. This program aimed to increase food self-sufficiency, including rice production, by enhancing agricultural production and productivity. It was implemented through the provision of superior seeds, fertilisers, and pesticides; the utilization of fallow land as productive land; the construction of tertiary irrigation canals; and farmer assistance and extension services. The implementation of the UPSUS program in various regions contributed to an increase in agricultural output, especially in the groups that received greater attention under the program.

Furthermore, since 2018, the effects of climate change, including La Niña and El Niño events, have become more pronounced. This has led to droughts and high rainfall, causing crop failures, as well as shifts in planting seasons, which have delayed and reduced rice production. These impacts contributed to the general decline in rice production, which is clearly visible in the downward trend for both groups after 2019. These climate disruptions could be an external factor that weakened overall rice production, including in regions that did not receive direct intervention. Following the intervention in 2020, a divergence in trends is observable between the control and treatment groups. The control group experienced a sharp decline in rice production, whereas the treatment group's production tended to stabilise.

To test the validity of the Difference-in-Differences model and ensure that no systematic differences existed between the treatment and control groups before the start of the food estate program, a placebo test was conducted by restricting the estimation to the period before 2021. The year 2020 was omitted from the estimation as the reference year. The treat variable, which defines the difference between food estate and non-food estate locations, was not included as it is time-invariant during the pre-intervention period. The number of observations in this model was 550, with 56 city/regency observational units, which is lower than the main model due to the shorter time period covering only the pre-intervention years.

Table 4. Placebo Effect Test Results

	(1) Without controls	(2) With controls
VARIABLES	Inpaddyprod	Inpaddyprod
treatxtimerescale	0.0484*	0.0124
	(0.0246)	(0.0132)
treat	-	-
timerescale	-0.0893***	-0.000867
	(0.0138)	(0.0115)
lnluaspanen		0.846***
		(0.0910)
Intktani		0.0377
		(0.0907)
rls		-0.0933
		(0.0796)
lnratacrhujan		0.256
		(0.230)
Constant	9.593***	0.703
	(0.0815)	(2.275)

Observations	550	550
R-squared	0.224	0.814
Number of id	56	56

Robust standard errors in parentheses

***** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$**

Source: Data Processed, 2025

The first model (1) only includes the interaction between the treatment (treat) and time (timerscale) variables, without considering other control variables. The interaction coefficient for treat $\times$ timerscale is 0.0484 and is statistically significant at the 10% level, suggesting a potential difference in the growth trend of the logarithm of rice production between the treatment and control regions before the intervention. However, given that this model does not yet control for other variables, this result does not fully reflect the net effect of the trend difference. The timerscale variable has a negative coefficient of -0.0893 and is significant at the 1% level, indicating a general downward trend in the logarithm of rice production over time during the pre-program period.

The second model (2) adds several control variables representing production factors and regional characteristics that can influence rice production. After controlling for these factors, the interaction coefficient for treat $\times$ timerscale drops substantially to 0.0124 and is no longer statistically significant. This indicates that the difference in rice production trends between food estate and non-food estate locations before the intervention becomes statistically insignificant once the influence of the control variables is taken into account. The insignificance of this interaction variable validates that there is no placebo effect before 2021, thus satisfying the key parallel trends assumption.

The R-squared value increases sharply from 0.224 in model (1) to 0.814 in model (2), indicating that the model with controls explains the variability in the data far better. The results of this placebo test provide support for the validity of applying the Difference-in-Differences approach. The absence of a significant trend difference between the treatment and control groups before the implementation of the food estate program, after controlling for relevant variables, demonstrates that the parallel trends assumption is met. Consequently, the subsequent analysis evaluating the program's impact can be conducted with a higher degree of confidence in the resulting causal estimates. Therefore, these results support the validity of the DiD method.

DiD Regression Analysis Results

To evaluate the impact of the Central Kalimantan food estate program on rice production, a Difference-in-Differences (DiD) approach was employed using a panel regression model. The estimation was conducted in two specifications: the first model (1) without controls, and the second model (2) with controls. The dependent variable in this model is $\ln\text{paddyprod}$, the logarithm of total rice production. The observation period encompasses years preceding and following the implementation of the food estate program, with the year 2020 excluded as the reference year. The treat variable was not included as it is time-invariant.

The $\text{treat} \times \text{timeafter}$ variable is the interaction term between treat and timeafter. This variable serves as the indicator for the Average Treatment Effect on the Treated (ATET), which is the average effect of the food estate program on the regions where it was implemented. In model (1), without controls, the $\text{treat} \times \text{timeafter}$ coefficient is 0.748 and is statistically significant at the 5% level ($p < 0.05$). This suggests that, without controlling for other factors, the food estate program is associated with a 0.748-unit increase in the logarithm of rice production. This corresponds to an average increase in rice production of approximately 74.8% in the program's intervention locations compared to non-intervention locations after the policy was implemented in 2021, *ceteris paribus*.

However, when control variables are introduced in model (2), the *treatafter* coefficient decreases to 0.393 and is significant at the 10% level. This suggests that, after accounting for differences in production factors and regional characteristics, the food estate program continues to have a weak, yet positive, impact on rice production in the treatment regions. The magnitude of this impact is smaller, corresponding to an average increase of approximately 39.3% in intervention locations compared to non-intervention locations after 2021, *ceteris paribus*. These results indicate a positive influence of the program on rice production; however, due to the statistically weak effect, it can be concluded that the program did not have a significant impact on rice production up to 2023.

Table 5. DiD Regression Results

	(1) Without controls	(2) With controls
VARIABLES	Inpaddyprod	Inpaddyprod
treatafter	0.748**	0.393*
	(0.286)	(0.226)
treat	-	-
timeafter	-1.441***	-0.194
	(0.207)	(0.363)
lnluaspanen		0.873***
		(0.0822)
lnlktani		0.0479
		(0.144)
rls		-0.198
		(0.224)
lnratacrhujan		0.462
		(0.316)
Constant	10.34***	-0.597
	(0.0591)	(3.126)
Observations	662	662
R-squared	0.385	0.632
Number of id	56	56

Robust standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Source: Data Processed, 2025

The *timeafter* variable is a time dummy that distinguishes between the pre- and post-program implementation periods. In the model without controls, its coefficient is negative and significant at -1.441 ($p < 0.01$), indicating a general decline in rice production across all regions after 2021. However, in the model with controls, this coefficient becomes insignificant with a value of -0.194, suggesting that variations in the control variables can explain the decline. The *lnluaspanen* variable (log of harvested area) shows a very strong and positive relationship with rice production, with a coefficient of 0.873, significant at the 1% level. This is consistent with production theory, which posits that an increase in harvested area will lead to an increase in total rice production. The regression model indicates that the variables for the log of agricultural labour (*lnlktani*), log of average rainfall (*lnratacrhujan*), and mean years of schooling (*rls*) are not statistically significant in their effect on rice production. Although their coefficients are positive, labour and rainfall show only a weak association with increased production. Conversely, the mean years of schooling have a negative coefficient, indicating a potential inverse relationship between education level and rice production; however, this effect is also not

significant. Several year dummies, particularly for the period 2011–2015 in the model with controls, show a significant positive impact on rice production compared to the reference year (2021). Meanwhile, the negative effects observed for the years 2018–2020 become insignificant after controls are added. The R-squared value increases from 0.385 to 0.632 after including controls, which indicates a substantial improvement in the model's ability to explain the variation in rice production across regions. It is essential to acknowledge that the interpretation of the estimation results in this study is limited by changes in the calculation methodology for several key variables, particularly in the period preceding 2021 (pre-intervention). The variables that underwent methodological adjustments include rice production, harvested area, and mean years of schooling. In several official publications, particularly before the reformulation of the statistical reporting system by the relevant agencies, data collection and processing methods were altered, whether in terms of technical classification, observational scope, or calculation approaches. Rice production and harvested area data were revised starting in 2018 due to improvements in the sampling frame method and the use of remote sensing technology. Meanwhile, the mean years of schooling variable underwent an adjustment in its calculation approach beginning in 2015, which subsequently affected the consistency of the data across years. These changes impact the uniformity of the data throughout the analysis period and may potentially affect the accuracy of the policy effect measurement in the estimation phase. Therefore, the findings and interpretations generated from the analytical model must be read proportionally, taking into account the technical dynamics within the statistical system used as the data source. This situation highlights the challenges of conducting regional-level studies and underscores the importance of data transparency as a foundation for supporting the validity of scientific findings.

DISCUSSION

The primary objective of this research is to evaluate the impact and effectiveness of the Central Kalimantan Food Production Centre Area (Food Estate) policy in increasing rice production and to measure the magnitude of that impact. The significance of this study lies in its contribution to bridging the literature gap concerning the quantitative evaluation of food estate policies, providing strategic insights for stakeholders in formulating and evaluating national food security policies. Based on the analysis using both the Difference-in-Differences (DiD), it can be concluded that the development programme for the food estate in Central Kalimantan has provided a positive impact with weak statistical significance, or essentially no significant impact on rice production up to 2023 in the intervention areas in Kalimantan.

These findings are consistent with literature by Rasman et al. (2023), which argues that food estate projects in Central Kalimantan have been hindered by suboptimal implementation of extensification and irrigation, as well as a failure to involve the community comprehensively. Furthermore, the results align with Fuglie (2018), suggesting that intensification can maintain production levels even when input growth slows, as observed in locations that have not yet faced extreme production pressures. A plausible explanation for the non-significant findings is the "time lag effect," particularly regarding idle swamplands that have only recently been utilised for agriculture and require significant time for natural composting to decompose soil reconstruction residues. Additionally, external factors such as climate change, specifically El Nino and La Nina phenomena, have caused shifts in the planting season and increased the risk of crop failure.

This study implies that the government should focus on more mature planning that considers regional characteristics, ensuring the availability of productive land ecosystems and a sufficient supply of skilled labour. Specifically, there is a need for high-quality water management infrastructure, such as tertiary irrigation networks, to mitigate the risks of flooding and high tides. The internal and external validity of this research is influenced by primary limitations, including the transition in rice production and harvest area calculation methods by BPS in 2018,

missing data for agricultural labour variables in 2016 and 2023, and a post-intervention observation period that remains relatively short-term. For future research, insightful opportunities include extending the post-treatment observation period to capture long-term dynamic impacts and incorporating specific control variables.

CONCLUSION

Based on the analysis, it can be concluded that the Central Kalimantan Food Production Centre Area (Food Estate) Program had a positive but statistically weak impact on rice production in the intervention areas in the short term, at least up to 2023. This is likely because the government's interventions were insufficient to significantly boost output through key factors of production, namely land and labour. Furthermore, there is a potential time lag effect; the significant impacts of the food estate program's interventions on increasing rice production may only materialise after a longer period, necessitating further research to estimate its long-term effects. However, the policy was reasonably effective in helping to maintain production levels in the intervention locations during shifts in planting seasons caused by climate change, especially when compared to non-intervention regions. This finding is consistent with studies by Shete & Rutten (2015) and Howlader (2023), which suggests that large-scale agricultural development projects often show significant impacts only after several years of implementation. Moreover, the challenge of climate change adaptation has not been fully addressed within the food estate program, which has limited the potential for significant production increases under the current intervention strategy. Therefore, a follow-up study is needed to dynamically estimate the program's long-term impact using a longer post-treatment observation period.

To address the limitations of this study, several recommendations are proposed for future research. First, the post-treatment observation period could be extended to allow for the estimation of the program's long-term impacts. Second, future studies should incorporate additional control variables to capture greater variation and obtain more accurate coefficient estimates. These variables could include soil nutrients, farmer technology adoption, total paddy field area, government assistance with production inputs, pest outbreaks, and El Niño-Southern Oscillation (ENSO) climate indicators. Finally, to more accurately represent the labour factor that directly affects rice production, subsequent research could utilise more specific data, such as data on farmer labour or labour specifically within the food crop sub-sector.

LIMITATION

This study is subject to several limitations that warrant consideration when interpreting the findings. A primary challenge stems from data inconsistencies, particularly the shift in calculation methodologies by Statistics Indonesia (BPS) for key variables such as rice production and harvested area (starting in 2018) and mean years of schooling (starting in 2015), which could potentially influence the estimated coefficients. Compounding this, the agricultural labour data utilized was an aggregate measure for the entire sector—including farming, fisheries, and forestry—due to the unavailability of more specific data at the city/regency level. The presence of missing values in this variable further complicated the implementation of the PSM technique, the parallel trends test, and the final DiD estimation.

Furthermore, the analysis is limited to a short-term impact, as the post-intervention period spans only three years. The model's robustness is also constrained by the unavailability of several crucial variables due to data limitations. Data on soil nutrients, farmer technology adoption, fertiliser and seed type usage, specific paddy field area, the area and depth of peatlands, subsidised fertiliser distribution, pest outbreaks, production figures exclusively from within the food estate, the realised area dedicated to rice, and El Niño-Southern Oscillation (ENSO) indicators could not be obtained. The absence of these variables introduces a risk of omitted variable bias, highlighting the challenges inherent in regional-level studies.

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DS: Conceptualization, Methodology, Data Collection, Data Analysis, Writing – Original Draft, Visualization, Review and Editing

WS:Supervision.

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3. Conflict of Interest:

No conflict of interest: The authors declare that they have no conflict of interest related to the research and publication of this article.

4. Research Ethics:

The study did not involve any intervention, biological specimens, vulnerable groups, or sensitive personal data. Participation was voluntary, and the confidentiality of the respondents was maintained.

5. Use of Artificial Intelligence (AI):

No Use of AI. The authors declare that generative AI was not used in the preparation of this article.

REFERENCES

- Atallah, O., & Rajib, R. K. (2024). Implementasi Food Estate Sebagai Tantangan Menjaga Ketahanan Pangan dan Melestarikan Lingkungan. *Jurnal Ilmiah Penelitian Mahasiswa*, 2(3), 72–80. <https://doi.org/10.61722/jipm.v2i3.57>
- Barbier, E. B. (2004). Explaining Agricultural Land Expansion and Deforestation in Developing Countries. *American Journal of Agricultural Economics*, 86(5), 1374–1353. <https://doi.org/10.1111/J.0002-9092.2004.00688.X>
- Cole, T. J., & Altman, D. G. (2017). Statistics Notes: Percentage Differences, Symmetry, and Natural Logarithms. In *BMJ* (Online) (Vol. 358). *BMJ Publishing Group*. <https://doi.org/10.1136/bmj.j3683>
- Fahmid, I. M., Wahyudi, Agustian, A., Aldillah, R., & Gunawan, E. (2022). The Potential Swamp Land Development to Support Food Estates Programmes in Central Kalimantan, Indonesia. *Environment and Urbanization ASIA*, 13(1), 44–55. <https://doi.org/10.1177/09754253221078178>
- Hikmat, M., Yatno, E., & Heryanto, B. (2022). Potentials of peatlands for agriculture in Tanjung Jabung Barat Regency, Jambi Province. *IOP Conference Series: Earth and Environmental Science*, 1025(1). <https://doi.org/10.1088/1755-1315/1025/1/012035>
- Izzati, A. N., Gustiawati, B. L., & Saputra, R. Y. (2023). Proyek Food Estate Pada Lahan Eks Pengembangan Lahan Gambut di Kalimantan Tengah: Perlu atau Tidak? *ECOPROFIT*, 1(1), 59–76. <https://doi.org/10.61511/ecoprofit>
- Kane, L., Fang, T., Galetta, M., Goyal, D., Nicholson, K., Kepler, C., Vaccaro, A., & Schroeder, G. (2020). Propensity Score Matching: A Statistical Method. *Clinical Spine Surgery*. <https://doi.org/10.1097/BSD.0000000000000932>
- Kousar, S., Ahmed, F., Pervaiz, A., & Bojnec, Š. (2021). Food Insecurity, Population Growth, Urbanization and Water Availability: The Role of Government Stability. *Sustainability (Switzerland)*, 13(22). <https://doi.org/10.3390/su132212336>
- Manning, C. (1988). Rural Employment Creation in Java: Lessons from the Green Revolution and Oil Boom. *Population and Development Review*, 14(47), 47–80. <https://doi.org/10.2307/1972500>

- Micallef, J., Grima, S., Spiteri, J., & Rupeika-Apoga, R. (2023). Assessing the Causality Relationship between the Geopolitical Risk Index and the Agricultural Commodity Markets. *Risks*, 11(5). <https://doi.org/10.3390/risks11050084>
- Mulyono, J., Syahyuti, & Gunawan, E. (2023). The Performance of Existing Rice Farming on Peatlands in Central Kalimantan Food Estate Area. *SOCA: Jurnal Sosial Ekonomi Pertanian*, 17(3), 164–175. <https://doi.org/10.24843/SOCA.2023.v17.i03.p02>
- Rachman, B., Ariningsih, E., Sudaryanto, T., Ariani, M., Septanti, K. S., Adawiyah, C. R., Ashari, Agustian, A., Saliem, H. P., Tarigan, H., Syahyuti, & Yuniarti, E. (2022). Sustainability status, sensitive and key factors for increasing rice production: A case study in West Java, Indonesia. *PLoS ONE*, 17(12 December). <https://doi.org/10.1371/journal.pone.0274689>
- Rasman, A., Sinta Theresia, E., & Fadel Aginda, dan M. (2023). Analisis Implementasi Program Food Estate Sebagai Solusi Ketahanan Pangan Indonesia. *Holistic: Journal of Tropical Agriculture Sciences Riset*, 1(1), 36–68. <https://doi.org/10.61511/hjtas.v>
- Ray, D. K., West, P. C., Clark, M., Gerber, J. S., Prishchepov, A. V., & Chatterjee, S. (2019). Climate change is likely to have already impacted global food production. *PLoS ONE*, 14(5). <https://doi.org/10.1371/journal.pone.0217148>
- Rina, Y. D., Hairani, A., Sulaeman, Y., & Annisa, W. (2023). Financial Feasibility of Introduced Rice Cultivation Technology on Tidal Type B (Case of Belanti Siam Village, Pandih Batu District, Pulang Pisau Regency). *IOP Conference Series: Earth and Environmental Science*, 1230(1). <https://doi.org/10.1088/1755-1315/1230/1/012196>
- Rosenzweig, C., & Perry, M. L. (1994). Potential impact of climate change on world food supply. *Nature*, 367, 133–138. <https://doi.org/10.1038/367133A0>
- Setyo, P., & Elly, J. (2018). Problems Analysis on Increasing Rice Production Through Food Estate Program in Bulungan Regency, North Kalimantan. *IOP Conference Series: Earth and Environmental Science*, 147(1). <https://doi.org/10.1088/1755-1315/147/1/012043>
- Sumaryanto, S., Susilowati, S. H., Saptana, S., Sayaka, B., Suryani, E., Agustian, A., Ashari, A., Purba, H. J., Sumedi, S., Dermoredjo, S. K., Purwantini, T. B., Yofa, R. D., & Pasaribu, S. M. (2023). Technical efficiency changes of rice farming in the favorable irrigated areas of Indonesia. *Open Agriculture*, 8(1). <https://doi.org/10.1515/opag-2022-0207>
- Surahman, A., Soni, P., & Shivakoti, G. P. (2018). Are Peatland Farming Systems Sustainable? Case Study on Assessing Existing Farming Systems in The Peatland of Central Kalimantan, Indonesia. *Journal of Integrative Environmental Sciences*, 15(1), 1–19. <https://doi.org/10.1080/1943815X.2017.1412326>
- Taena, W., Sipayung, B. P., Blegur, F. A., & Klau, A. D. (2023). Comparative Advantages and Factors Affecting Agriculture Production and Income in The Food Estate Area on The Indonesia–Timor-Leste Border. *Asian Journal of Agriculture and Rural Development*, 13(1), 56–65. <https://doi.org/10.55493/5005.v13i1.4762>
- Tiwari, A. K., Boachie, M. K., Suleman, M. T., & Gupta, R. (2021). Structure dependence between oil and agricultural commodities returns: The role of geopolitical risks. *Energy*, 219. <https://doi.org/10.1016/j.energy.2020.119584>
- Wheeler, T., & von Braun, J. (2013). Climate Change Impacts on Global Food Security. *Science*, 341(6145), 508–513. <https://doi.org/10.1126/science.1237190>
- Yusup, S., & Sonia, Y. (2024). Can Rice Farming through the National Strategy Food Estate Increase Regional Production? *Jurnal Lahan Suboptimal: Journal of Suboptimal Lands*, 13(2). <https://doi.org/10.36706/jlso.13.2.2024.675>