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Impact of Rice Field Conversion Effectiveness on the Availability of Rice in Jakarta Province From 1981 to 2023

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ABSTRACT

This study examines the impact of rice field conversion on the availability of rice in Jakarta Province from 1981 to 2023. Over this period, Jakarta experienced rapid urbanization, transforming agricultural land especially rice field area into urban infrastructure. The rice field area shrank from 7,720 hectares in 1981 to only 341 hectares in 2023, with rice production declining from 70,387 tons to 2,674 tons. Meanwhile, rice demand surged from 474 million kilograms in 1981 to 874 million kilograms in 2023 due to population growth. The study employs secondary data analysis, utilizing regression models to assess the influence of population density and productivity on rice field area. The results indicate that population density is the primary driver, with every unit increase leading to a loss of 104 hectares of rice field area. Conversely, productivity improvements had no significant impact on land size. The findings of current study highlight a growing dependency on external food sources, exposing Jakarta to food security risks. This research underscores the urgency of sustainable land management policies to balance urbanization and agricultural preservation. Recommendations include integrating land-use planning with food security strategies to ensure a stable and sufficient food supply for Jakarta's growing population.

Keywords: rice field conversion, urbanization, food security, Jakarta, agricultural land

1. INTRODUCTION

Jakarta, as the capital city and economic hub of Indonesia, has experienced a profound transformation in its agricultural landscape. Historically, Jakarta played a significant role as one of the country's major rice producers. However, over the decades, it has transitioned into a predominantly urban area reliant on food supplies from external regions. This shift is closely tied to the conversion of agricultural land, particularly rice fields, into urban and commercial areas, which has significantly impacted rice availability in the province.

According to data from Indonesia's Central Bureau of Statistics (BPS), in 1981, Jakarta had extensive rice fields covering thousands of hectares. By 2023, this had drastically reduced to approximately 542.93 hectares of harvested area, yielding only 2,674.28 tons of milled dry grain. This sharp decline underscores the pressure on productive land due to urban development and infrastructure expansion. The loss of arable land is primarily driven by the increasing demand for

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residential, industrial, and transportation infrastructure in response to rapid population growth and urbanization.

One of the main contributors to this trend is the repurposing of agricultural land for urban use. Projects such as toll road construction and large-scale national infrastructure initiatives have converted fertile rice fields into non-agricultural areas. This trend aligns with Ricardo's Land Rent Theory, which states that agricultural land in regions with high economic value is often repurposed for more profitable uses. In Jakarta, the result has been a decline in local rice production, heightening the province's dependency on supplies from regions such as West Java and Lampung.

Population growth in Jakarta has further exacerbated the strain on agricural land patrticulary on rice field area. Data from BPS indicates that Jakarta's population grew from approximately 6.5 million in the 1980s to over 10.5 million in 2020. This increase in population has led to greater demand for urban infrastructure, resulting in the conversion of remaining rice field area. The limited space for rice cultivation has directly impacted local rice availability, making the province heavily reliant on food imports from surrounding areas.

The decreasing of rice fields has not only reduced local production but also poses challenges to Jakarta's food security. While theories such as Malthusian and Boserup's Agricultural Intensification suggest different outcomes of population pressure on food production, Jakarta's case illustrates a scenario where urbanization has led to a decline in agricultural capacity. The loss of productive farmland has shifted Jakarta from being a producer of rice to a consumer, dependent on interregional distribution networks to meet its food needs.

The ongoing reduction in agricultural land highlights the urgent need for sustainable land management policies. While the Indonesian government has introduced measures, such as Government Regulation No. 41 of 2009, to safeguard agricultural land, enforcement in Jakarta remains a challenge. Studies, including those by Saputro (2019), show that population growth and development demands continue to drive agricultural land conversion. For Jakarta, this situation underscores the importance of balancing urban growth with strategies to protect and optimize the use of rice field area.

This study focuses on analyzing the impacts of rice field conversion on rice availability in Jakarta from 1981 to 2023. It aims to provide insights into the factors driving land use changes and their consequences on local food security, ultimately offering recommendations for policies that can mitigate the challenges posed by declining rice production in the province.

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2. RESEARCH METHOD

Description Of Study Area

Jakarta is the capital city of Indonesia, located on the northwest coast of Java Island, at approximately 6°12′ South Latitude and 106°49′ East Longitude. The city covers a land area of around 661.5 km², with an additional sea area of 6,977 km² that includes the Thousand Islands, an archipelago of over 100 small islands in Jakarta Bay.

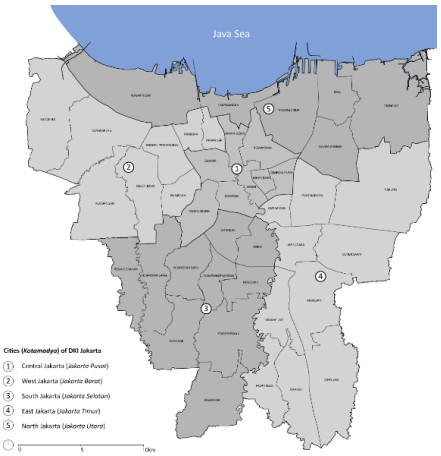

Figure 1. Map of Jakarta Province

Jakarta province is bordered by the Java Sea to the north, providing access to trade and port activities. To the east, it shares a boundary with Bekasi Regency, an industrial area. To the south, Jakarta is bordered by Depok City and Bogor Regency, while to the west, it is adjacent to Tangerang City and Tangerang Regency. Since the late 1970s, Jabotabek has been designated as a metropolitan area encompassing Jakarta Province, which has been one of the biggest factors driving population growth in Jakarta.

Data Sources

This study relies on secondary data sourced from various publications and reports related to Jakarta Province, covering the years 1981 to 2023. The data used includes information about the area of rice fields, rice demand, rice production, and population figures.

Data collection and interpretations

The secondary data were gathered from available publications, specifically from government reports, and were organized into time series format to identify trends for each variable over the years. These data were then presented using tables, graphs, and maps to clearly depict the changes in land use, population density, and production over time.

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Data analysis and calculation

To calculate the conversion rate of rice fields, we employed a formula based on previous research (Astuti, 2011). The conversion rate of rice fields is calculated as follows:

$$V = (L_t - L_{t-1})/L_{t-1} \text{ x } 100\% \quad (1)$$

Description:

V = Land conversion rate (%)

L_t = Land area in year t (ha)

L_{t-1} = Land area in the previous year (ha)

For rice availability, we used the standard equations for grain shrinkage, following the guidelines outlined by the Indonesian Ministry of Agriculture's regulation. The calculation accounts for losses due to seed usage, animal feed, and milling processes:

$$s = P \text{ x } 0.9\% \quad (2)$$

$$f = P \text{ x } 0.44\% \quad (3)$$

$$w = P \text{ x } 5.4\% \quad (4)$$

Description:

s = seed (%)

f = animal feed (%)

w = scattered (%)

P = Paddy production (kg)

The net paddy production (P_{net}) is calculated by substracting the grain shrinkage from the total paddy production:

$$P_{net} = P - (s + f + w) \quad (5)$$

The net rice production (R_{net}) is then determined using a conversion factor:

$$R_{net} = C \text{ x } P_{net} \quad (6)$$

Description :

P_{net} = Net paddy production (kg)

R_{net} = Net rice production (kg)

C = 0.632 kg

Rice demand is calculated using the following equation, based on the population of Jakarta and the average rice consumption per person per week:

$$KB = JP \text{ x } C \text{ x } M \quad (7)$$

Description:

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KB = Rice demand (kg)

JP = Total population (people)

C = Average consumption per person per week (1.571 kg/capita)

M = Number of weeks in a year (52.143 weeks)

After the rice demand and production have been calculated, the next step is to compare the two results to determine whether the demand and production indicate a deficit or a surplus. For the analysis of factors affecting the conversion of rice fields, a multiple linear regression model was applied. The independent variables used in this study are population density (POP) and rice productivity (PROD), while the dependent variable is the rice fields area (RFA). The equation for this analysis is as follows:

$$RFA = \alpha + \beta_1 POP \text{ x } \beta_2 PROD + \varepsilon \quad (8)$$

Description:

RFA = Area of rice field (ha)

α = Constant

POP = Population Density (people/km^2)

$PROD$ = rice productivity (km^2)

β_1, β_2 = Parameter coefficients

ε = Standard error

The model also includes hypothesis testing, such as the determination test, which calculates the coefficient of determination (R^2):

$$Kd = R^2 \text{x } 100\% \quad (9)$$

Description:

Kd = Coefficient of determination

R^2 = Correlation coefficient

The simultaneous (F) test is used to determine the joint effect of the independent variables:

$$F = (\frac{R^2}{k})/(1 - R^2) \text{ x } (n - k - 1) \quad (10)$$

Description:

R^2 = Coefficient of determination

k = Number of independent variables

n = Sample size

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The partial (t) test assesses the individual effect of each independent variable:

$$t = r\sqrt{n-2}/\sqrt{(1-r^2)} \quad (11)$$

Description:

t = t-distribution

r = Partial correlation coefficient

r^2 = Coefficient of determination

n = Sample size

This methodology allows for a thorough examination of how population density and productivity affect the rice fields area in Jakarta over the period from 1981 to 2023.

3. RESULTS AND DISCUSSION

Conversion Rate

The availability of food supplies, such as rice, is heavily influenced by the availability of agricultural land. The larger the area of agricultural land, the greater the production capacity. The following graph illustrates the development of rice field area in Jakarta Province, which has experienced negative growth.

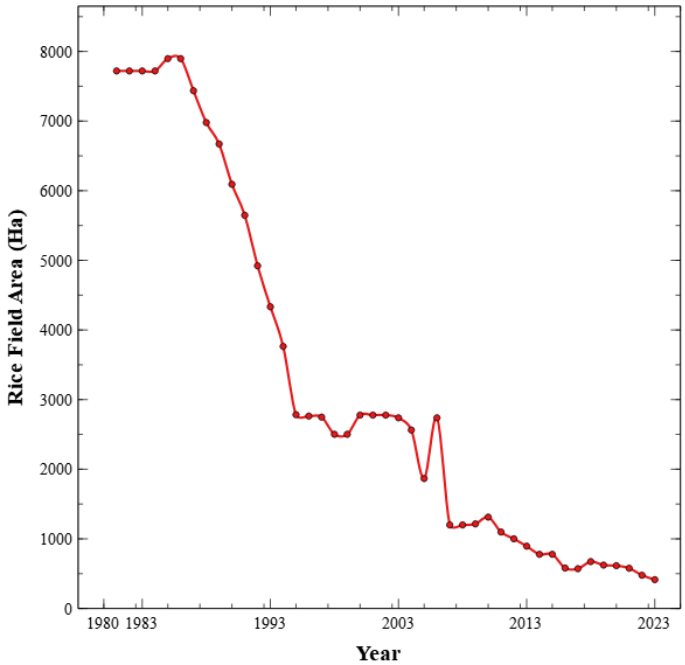

Figure 2. Growth of Rice Field Area in Jakarta, 1981-2023

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The development of agricultural land from 1981 to 2023 reveals significant changes, with fluctuating land areas year by year. Overall, a consistent downward trend can be observed, where in 1981, the land area still reached 7,720 hectares, followed by a drastic decline to only 341 hectares by 2023. This decrease is largely attributed to land-use conversion, which frequently occurs in tandem with rapid economic development and urbanization. Overall, this pattern of declining rice field area highlights serious challenges in agricultural land management.

Land-use conversion, which is the primary cause of this decline, is closely linked to non-agricultural economic development, such as housing, commercialization, and infrastructure construction. This aligns with Saptana's (2020) research, which explains that urbanization and industrialization are the main drivers of agricultural land reduction in many regions of Indonesia. This phenomenon is also consistent with data from the Central Statistics Agency (BPS, 2021), which indicates that areas near development hubs are often the primary targets for land conversion, especially in zones with strategic infrastructure access, such as major roadways or industrial zones.

With the increasing demand for land for non-agricultural purposes, many agricultural areas are inevitably sacrificed to meet these needs. This trend of declining agricultural land has serious implications, particularly for local food security. The reduction in agricultural land area directly impacts agricultural production capacity, which in turn affects the availability of food for the population.

Table 1. Rice Field Conversion Rate in Jakarta Province

Year	Conversion Rate (%)
2023	54
2013	67
2003	37
1993	44
1983	0

The rate of rice field area conversion in Jakarta is alarming, with a rapidly increasing trend. From 1981 to 1983, there was no significant land conversion affecting agriculture. However, within a decade, the conversion rate surged by 44%, marking the beginning of urbanization and industrialization. In the subsequent decades, the decline consistently exceeded 30%, peaking in 2013 when the conversion rate reached 67%. By 2023, only about 314 hectares of rice field area remained.

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This high conversion rate is driven by non-agricultural activities, particularly urbanization. In 1981, the population of Jakarta was only 5,788,630. However, the urbanization trend accelerated as Jakarta became a metropolitan city, attracting more people to fulfill various needs. By 2023, the population had grown significantly to 10,672,100, resulting in increased demand for land to accommodate housing and other residential needs.

Food Sufficiency

a. Rice availability

Rice production is intrinsically tied to the extent of available rice fields. A reduction in the size of these fields inevitably leads to a decline in production capacity. This relationship underscores the critical importance of preserving rice field area to maintain consistent output. As farmland diminishes, regions face significant challenges in meeting production demands, ultimately impacting food security and local economic stability. Thus, the extent of arable land directly shapes the rice yield and the ability to sustain growing populations.

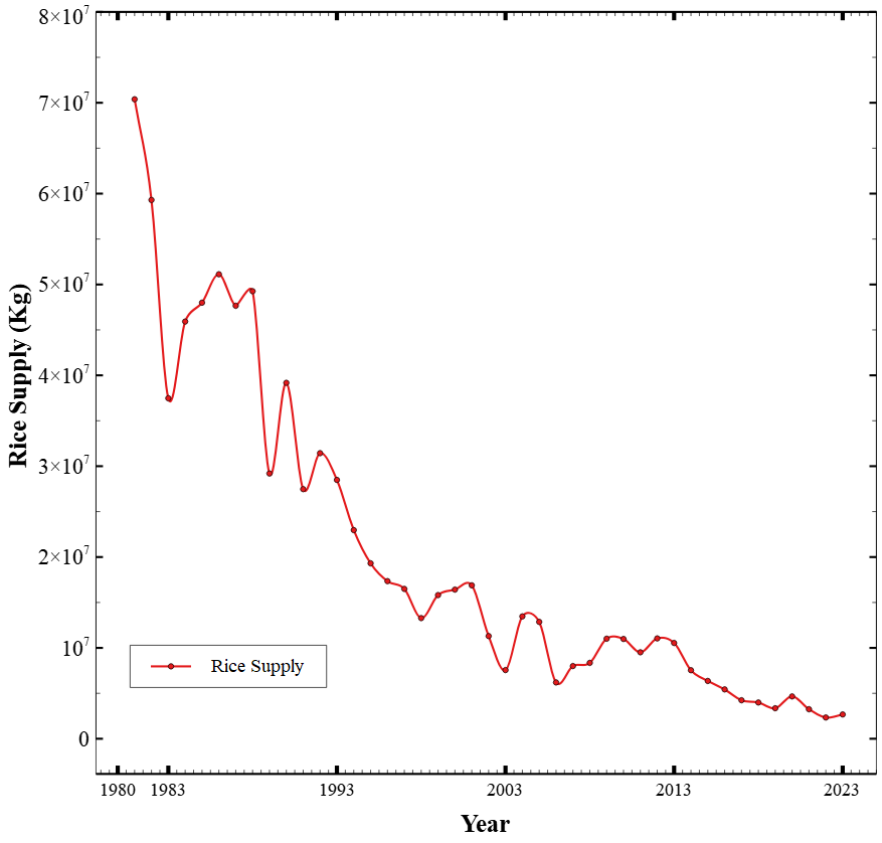

Figure 3. Rice Production in Jakarta Province 1981-2023

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The graph above illustrates rice production in Jakarta Province from 1981 to 2023. It shows that rice production in Jakarta has consistently fluctuated, with declining output becoming a significant issue. The downward trend in rice production aligns directly with thein creasing trend of non-rice field land area in Jakarta. Since 1981, the expansion of non-agricultural land has driven the transformation of rice fields into non-agricultural uses. In 1981, Jakarta was capable of producing 70,387 tons of rice, a stark contrast to the data from 2023, where rice production dropped drastically to only 2,674 tons. This significant decline has made Jakarta increasingly dependent on other provinces for its food supply, underscoring the challenges of maintaining agricultural productivity amidst rapid urbanization and land-use conversion.

b. Rice demand

The graph below illustrates rice demand in Jakarta Province from 1981 to 2023. It shows a sharp increase in demand over this period, starting at 474,184,195 kg in 1981 and rising to 874,222,712 kg in 2023. This indicates a 400,037,517 kg increase in rice demand over 43 years. However, there was a temporary decline between 1999 and 2001, with a reduction of 33,433,545

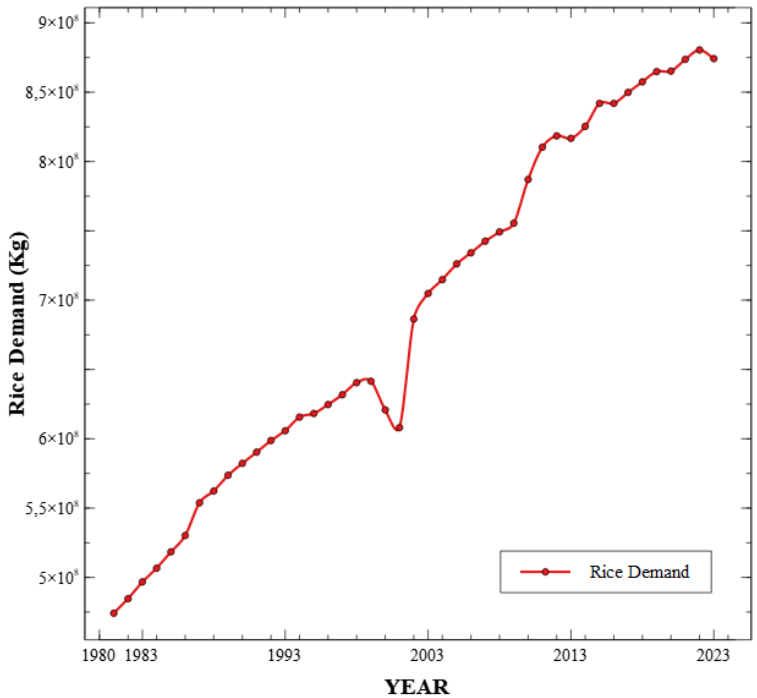

Figure **4**. Rice Demand in Jakarta Province 1981-2023

The rising rice demand in a city is correlates directly with the region's growing population (Fauzi, 2019). As Jakarta's population increases, the demand for rice also escalates, reflecting the critical link between demographic growth and food requirements in the metropolitan area.

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c. Rice supply and demand balance

Food security can be assessed by comparing the rice production levels in Jakarta with the demand from its population. When there is a surplus, where the production line is above the demand line, the region can maintain its food security. Conversely, when the production line falls below the demand line, the region experiences a shortage of food—in this case, rice—requiring external food support from other areas (Rahmawati, 2020). This situation indicates food insufficiency or regional food insecurity.

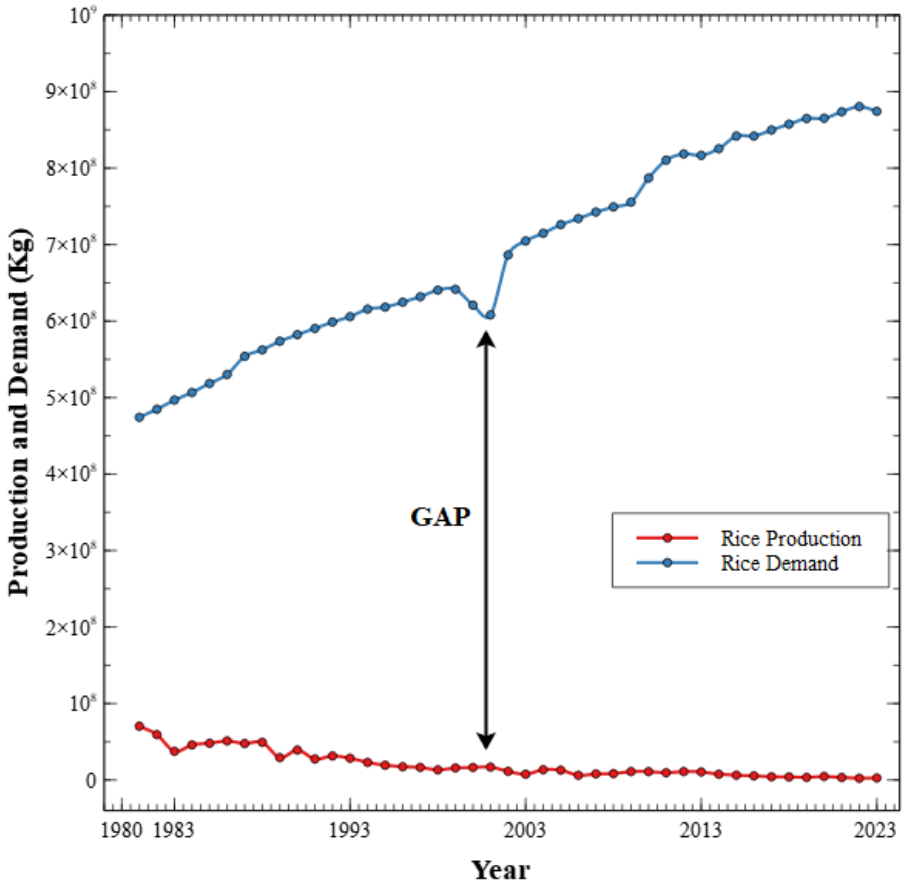

Figure 4. Rice Production and Demand Balance of Jakarta province, 1981-2023

Jakarta is a clear example of food insufficiency when looking at rice production and demand, with significant consequences for its population and food security. Over the past 42 years, from 1981 to 2023, the city has faced a growing gap between the rice it produces and the amount its residents require. In 1981, Jakarta produced approximately 70,387,000 Kg of rice while demand was 474,000,000 Kg. By 2023, production had dropped sharply to just 2,674,000 Kg, while demand surged to 874,000,000 Kg. This persistent imbalance highlights the severe impact of urban development, as rice field area has been converted to infrastructure at an alarming rate. As a result,

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Jakarta now relies heavily on external rice supplies, exposing the city to risks such as price volatility, supply chain disruptions, and economic shocks. These vulnerabilities threaten food security for millions of residents. Research emphasizes that sustainable food systems require effective integration of urban planning with agricultural policies to address these challenges (Smith & Brown, 2020; FAO, 2019; Dewi et al., 2023). Without such efforts, Jakarta's reliance on external food sources will continue to escalate, putting its future food stability at serious risk.

Factors Affecting Land Conversion

The coefficient of determination (R^2) is used to measure how well a model explains the variation in the dependent variable. Based on the table above, the Adjusted R-square value is 0.843. This indicates that 84.3% of the profitability level, as measured by rice field area, is influenced by the variables Population Density (X_1) and Productivity (X_2). The remaining 15.7% is influenced by other factors outside the scope of this study.

Table 1. The Coefficient of Determination

Model	R	R^2	Adj. R^2	Std.Error of the Estimate
1	0.922	0.850	0.843	1039.259

Source: Secondary Data (Processed, 2024)

The simultaneous hypothesis testing using time series data from 1981 to 2023 yielded statistically significant results. The analysis revealed an F-statistic of 113.530, which far exceeds the critical F-table value of 2.78 at a 0.05 significance level with the corresponding degrees of freedom. Furthermore, the probability value (p-value) was extremely low, at <0.001, well below the 0.05 threshold for significance. These findings statistically confirm a significant simultaneous effect of the predictor variables—Productivity and Population Density—on the dependent variable, Rice Field Area.

Table 2. Model Significance Table

Information	Value
F_{stat}	113.530
Sig.	<0.001

Source: Secondary Data (Processed, 2024)

The significance of the F-test demonstrates that the regression model effectively explains the relationships among the variables. The explained variation in the model is substantially greater than the unexplained variation, as reflected in the high F-statistic. Specifically, the Productivity variable indicates the efficiency of Rice field area use, while Population Density reflects

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demographic pressures, such as urbanization and land conversion. The interplay of these variables provides a deeper understanding of the changes in rice field area over the given time period.

Theoretically, these findings align with previous literature, which suggests that increasing population pressure in urban areas tends to drive land-use changes, significantly reducing agricultural land (Chaudhry & Sharma, 2020). Furthermore, while enhanced agricultural productivity can maintain output on smaller areas, careful management is essential to prevent soil degradation and ensure environmental sustainability in the long term (FAO, 2021). The detection of simultaneous significance underscores the necessity for development policies to balance increased agricultural productivity with effective management of demographic pressures.

Table 3. Regression Analysis of Factore Affecting Land Conversion in Jakarta Province, 1981-2023

Variables	Coefficients	t_{stat}	Prob.
Constant	16336.006	14.570	<0.001
Population Density (POP)	-104.211	-12.698	<0.001*
Rice Productivity (PROD)	1.384	0.055	0.956

Source: Secondary Data (Processed, 2024)

Based on the t-test analysis, the variable Population Density has a t-value of -12.698, which is smaller than the critical t-value of 2.021. The significance level for this variable is <0.001, which is well below the 0.05 threshold. Thus, H_0 is rejected, indicating that Population Density has a negative and significant effect on Rice Field Area. This result implies that higher population density in a region increases the pressure to reduce rice field area due to urbanization and land-use conversion to non-agricultural purposes. These findings highlight the critical role of demographic factors in determining changes in Rice field area use.

In contrast, the variable Productivity has a t-value of 0.055, which is smaller than the critical t-value of 2.021, and a significance level of 0.956, which is much higher than the 0.05 threshold. As a result, H_0 is accepted, indicating that Productivity does not have a significant individual effect on Rice Field Area. This suggests that increases in productivity per unit area are more related to harvest efficiency on existing land rather than directly affecting changes in the size of rice field area.

The multiple linear regression equation derived from the analysis is as follows:

$$RFA = 16{,}336.006 - 104.211\ POP + 1.384 PROD$$

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The constant value of 16,336.006 indicates that if population density and productivity are both zero, the predicted rice field area would remain at 16,336.006 hectares. This constant has a very high level of significance, with a t-value of 14.570 and a p-value <0.001, indicating its critical role in the model.

The coefficient for the variable population density is -104.211, suggesting that every one-unit increase in population density (e.g., persons per square kilometer) results in a decrease of 104.211 hectares in rice field area, assuming other variables remain constant. This influence is statistically significant, as reflected by a t-value of -12.698 and a p-value <0.001. These findings illustrate the impact of urbanization pressures that lead to the conversion of rice field area to housing or infrastructure.

The coefficient for the variable productivity is 1.384, implying that every one-unit increase in productivity (e.g., quintals per hectare) would increase rice field area by 1.384 hectares, assuming other variables remain constant. However, this influence is not statistically significant, as evidenced by a t-value of 0.055 and a p-value of 0.956. This result indicates that while productivity improvements can enhance harvest yields per hectare, they do not directly affect the size of rice field area.

Impact of Land Conversion On Rice Availability

The reduction in rice field area in Jakarta Province has significantly impacted various aspects, particularly food security. According to data, the rice field area in Jakarta Province has drastically decreased from 7,720 hectares in 1981 to only 341 hectares in 2023. This change is attributed to land conversion for urbanization, infrastructure development, and other non-agricultural activities, as illustrated by the following image depicting land transformation in Jakarta Province from 1981 to 2023.

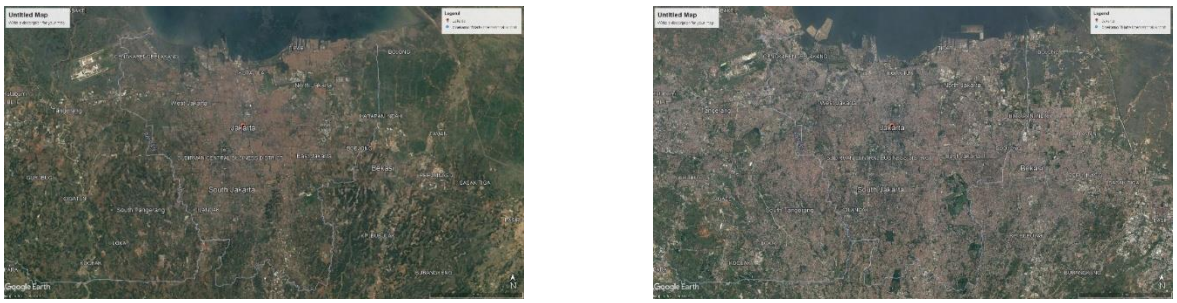

Figure 5. Map of Land use in Jakarta Province; 1981(a), 2020 (b)

This land conversion has led to reduction of rice field area and also a decline in rice production capacity from 70,387 tons in 1981 to just 2,674 tons in 2023, while rice demand continues to rise due to significant population growth, from 5.7 million people in 1981 to 10.6

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million people in 2023. A similar trend has been observed in Banyumas Regency, as highlighted in the study by Acintya et al. (2023). Eventhough smaller in scale, Banyumas is also grappling with the effects of land conversion for urban and industrial development. Population growth has further exacerbated the situation, with a 10% spike in rice demand between 2018 and 2019 due to demographic expansion.

Although Banyumas faces a similar trend of rice field conversion, the scale of its impact is smaller compared to Jakarta. According to the study by Acintya et al. (2023), Banyumas recorded an average land conversion rate of -0.14 over the past decade, resulting in a 1.31% reduction in rice availability, equivalent to 2,952.7 tons. However, despite the decline in rice field area and the increasing demand for rice due to population growth, Banyumas has still managed to maintain its local food security. This contrasts with Jakarta, where the significant imbalance between rice production and demand necessitates reliance on external food supplies.

The comparison between Jakarta and Banyumas highlights that the scale and intensity of land conversion have different impacts on food security. In Jakarta's case, the high dependency on external food supplies underscores the urgent need for stronger policy interventions to manage urbanization and protect the remaining agricultural land to ensure the sustainability of food supply.

4. CONCLUSIONS

The reduction on Rice fields area in DKI Jakarta province is very significant every year, reaching up to 95 percent from 1981 to 2023. As a result, rice production is no longer a priority due to the very minimal availability of land. However, the increase in population is the cause of the reduction in rice field area in DKI Jakarta based on the results of multiple linear regression analysis, while rice production has no significant effect.

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