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Governing the Conversion of Paddy Fields in Peri-Urban Areas for Food Security: The Role of Farmers' Decisions and Land Conservation Incentives in Indonesia

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Abstract

Paddy fields conversion poses a threat to achieving food security. Therefore, this study aims to project the impact of paddy field conversion on economic value and local food availability in peri-urban areas; analyze the driving factors behind paddy field conversion; and examine strategic policy recommendations to anticipate paddy field conversion based on compensation values for farmers to prevent them from converting their land. The study used a descriptive quantitative approach. Data analysis in this study utilised four analytical methods integrated within a single research framework. Firstly, a farm enterprise analysis was conducted to determine the economic value of paddy field production within the context of paddy fields conversion. Secondly, an analysis of the local food availability index was carried out to assess the capacity of paddy fields to produce food, particularly rice to meet the community's food needs amidst paddy fields conversion. Thirdly, Structural Equation Modelling–Partial Least Squares (SEM-PLS) analysis to examine the factors influencing paddy fields conversion. Fourth, a Contingent Valuation Method (CVM) analysis to assess farmers' Willingness to Pay (WTP) and Willingness to Accept (WTA) as a policy recommendations for mitigating paddy field conversion. Results show that conversion eliminates an economic value of IDR59,925,200 ha⁻¹ yr⁻¹. The local food availability index was 1.67 (surplus), yet a deficit of 45,033,045.45 kg of rice is projected by 2040. Driving factors positively and significantly influenced land conversion, explaining 63.9% of the variance ($R^2 = 0.639$). The average willingness to pay (WTP) among farmers was IDR360,000 yr⁻¹, and the average willingness to accept (WTA) was IDR500,000 month⁻¹. These values serve as the recommended foundation for a policy instrument to regulate the paddy fields conversion, one that provides compensation to farmers while supporting Sustainable Development Goals (SDGs) 1 and 2, as well as food self-sufficiency, in order to realize the vision of “Golden Indonesia 2045.”

Keywords: Paddy field conversion, paddy field production, food security, Golden Indonesia, Sustainable Development Goals

1. Introduction

Food security is one of the main pillars of sustainable development, the sustainability of which depends heavily on the availability of productive agricultural land, particularly paddy fields as the basis for rice production in Asian countries (Makhtar et al., 2022; Viana et al., 2022). The massive pressure of urbanization in various developing countries has driven the large-scale conversion of agricultural land into residential, industrial, and infrastructure areas, particularly in peri-urban areas (Bren d'Amour et al., 2017; Seto et al., 2011). Peri-urban areas are the most vulnerable because they lie in the transition zone between urban and rural areas (Woltjer, 2014). This phenomenon presents a development dilemma: on the one hand,

peri-urban areas are needed to accommodate population growth and urban economic activity; on the other hand, these areas generally still contain fertile paddy field that play a vital role in supporting regional food security (Giyarsih et al., 2026; Rizqi & Manessa, 2025).

Global food security is facing increasing pressure as the world's population is projected to reach 9.7 billion by 2050 (Kumar et al., 2025; Oluwole et al., 2023). Amidst this rising demand for food, the availability of productive agricultural land is, in fact, shrinking at an accelerating rate due to land conversion for non-agricultural purposes, particularly in peri-urban areas affected by urban expansion (Abdulai, 2022; Rai et al., 2025). Paddy field, as the mainstay of paddy and staple food production for communities, are among the land types most vulnerable to land conversion (Suliman et al., 2022). Phenomenon land-use conversion not only threatens food production capacity but also erodes the livelihoods of millions of farmers who rely on rice farming as their primary source of income (Pranata, 2026). These conditions make the paddy fields conversion an issue that directly intersects with two key Sustainable Development Goals (SDGs), namely SDG 1 on poverty eradication and SDG 2 on ending hunger and achieving food security (Madhavedi et al., 2025).

Indonesia, as an agrarian country with a population of over 280 million, faces a serious dilemma between meeting food needs and developing infrastructure and settlements (Mukaddas et al., 2025). National rate of paddy field conversion for the 2015–2019 period averaged 5.68% per year, resulting in a loss of rice production equivalent to Rp35.1 trillion due to the loss of this productive land (Yafi & Rondhi, 2024). The rate of paddy field conversion in Indonesia averages 96,512 hectares per year (Kurniawan, 2024; Mulyani et al., 2020). That matter becoming increasingly important to study as Indonesia is on the path towards realising the 'Indonesia Emas 2045' vision, which aims for high-income country status with near-zero poverty and national food self-sufficiency as one of its key pillars (Bappenas, 2025). Achieving this vision will be difficult if the national food production base continues to erode, whilst the peak of the demographic dividend will actually increase food demand. The island of Java is experiencing significant pressure from paddy field conversion, particularly in peri-urban areas (Mardiansjah et al., 2021). These findings confirm that threats to food security are no longer merely reactive issues, but rather something that should be anticipated early on through a predictive approach.

Peri-urban areas are a critical focal point for paddy field conversion due to their proximity to urban growth centers, making them particularly vulnerable to urbanization and land-use conversion. Research conducted by (Giyarsih et al., 2026) shows that urban sprawl in peri-urban areas has placed significant pressure on local food security through massive paddy field conversion. Similar findings were also observed in the peri-urban areas of Malang, revealing that 12.8% of legally protected sustainable food agricultural land (LP2B) was converted during the 2019-2025 period (Maulana & Hermawan, 2026). One of the most dynamic peri-urban areas in Indonesia, and one facing the greatest threat from paddy field conversion, is Sidoarjo Regency (Firmansyah et al., 2021). Sidoarjo Regency has experienced rapid economic growth in the industrial, manufacturing, residential and commercial sectors, which has directly fuelled pressure to convert agricultural land (Mardiansjah et al., 2021). The regency's geographical location, bordering directly on the city of Surabaya, makes it a key buffer for the Gerbangkertosusila conurbation and, at the same time, the area with the highest rate of land conversion in East Java (Firmansyah et al., 2021). Data show that the area of paddy fields in Sidoarjo Regency has shrunk from 34,321.14 hectares in 2020 to 29,004 hectares in 2025, representing an average annual reduction of more than 1,000 hectares over a five-year period (Statistics of Sidoarjo Regency, 2020; Statistics Sidoarjo Regency, 2026). This rate of conversion exceeds the national average proportionally and has the potential to threaten food self-sufficiency, particularly at the local level, as well as erode the income base of farming households that have long relied on farming as their primary source of livelihood.

The conversion of paddy fields is influenced by various factors that affect farmers' decisions to convert their paddy fields. These factors include land price and location (Harini et al., 2012), educational level, age, and number of family members (Tsani et al., 2018), economic pressures and proximity to highway infrastructure (Makbul et al., 2019; Wijayanto et al., 2025), as well as the increasing economic value of

land due to urbanization (Rondhi et al., 2018). Research by (Prayitno et al., 2021) shows that psychological factors such as “place attachment” that is, farmers’ emotional attachment to their land contribute to 31.6% of the variance in the decision to retain land. This indicates that land conversion decisions are not solely influenced by rational-economic factors but are also shaped by complex social-psychological dimensions. In response to this threat, the Indonesian government has enacted Law No. 41 of 2009 on the Sustainable Protection of Agricultural Land for Food Production (LP2B), which mandates the provision of incentives and disincentives as tools to control land conversion. However, the effectiveness of these incentives remains questionable. This situation stands in contrast to developments in the international literature on the design of farmer-preference-based land conservation incentives, such as the willingness-to-accept (WTA) approach implemented in Spain for agricultural land rewilding schemes (Granado-Díaz et al., 2022).

Various existing studies have thoroughly documented the scale and socioeconomic impacts of agricultural land conversion. However, attention to how structural pressures in peri-urban areas trigger land-use conversion through farmers’ decision-making processes and how these behavioral mechanisms can be linked to policy instruments for agricultural land protection and food security, remains relatively limited. Therefore, this study aims to project the impact of paddy field conversion on economic value and local food availability in peri-urban areas; analyze the driving factors behind paddy field conversion; and examine strategic policy recommendations to anticipate paddy field conversion based on compensation values for farmers to prevent them from converting their land. This study contributes to a comprehensive assessment of the dynamics of peri-urban paddy field conversion and recommends strategic policies to anticipate it, based on farmer compensation through Willingness to Pay (WTP) and Willingness to Accept (WTA) preferences, aspects that have not yet been thoroughly examined, particularly in Indonesia. Thus, this study provides a concrete picture of the dynamics of peri-urban paddy field conversion and the strategic policies needed to address it. Consequently, it contributes to the framework of the Sustainable Development Goals (SDGs), specifically SDG 1 and SDG 2 and the “Golden Indonesia 2045” vision.

2. Research Methods

2.1 Research Approach and Design

This study employs a descriptive quantitative approach. This approach was chosen because the phenomenon of paddy fields conversion is fundamentally multidimensional and cannot be fully assessed through a single methodological paradigm (Creswell & Clark, 2017). This study examines the intersection between economic value, food security, urbanisation, agricultural transformation, and sustainable agricultural systems within the dynamics of paddy fields conversion. The primary focus is to assess paddy field production in the context of the dynamics of paddy field conversion and its impact on local food security, the factors influencing paddy field conversion, and policy recommendations to control paddy field conversion in order to achieve the mission of “Golden Indonesia 2025” and the Sustainable Development Goals, particularly SDG 1 and SDG 2. The rate of paddy fields conversion is calculated based on changes in land use over the last 5 (five) years, from 2020 to 2025.

2.2 Research Location and Time

This study was conducted in Sidoarjo Regency, East Java Province, Indonesia. The location was selected based on several strategic criteria. Firstly, the location is adjacent to the Surabaya metropolitan area (the Gerbangkertosusila region). Secondly, Sidoarjo Regency is one of the most dynamically developing peri-urban zones in Indonesia, resulting in intense pressure for the paddy fields conversion due to the expansion of residential and industrial areas. Thirdly, the paddy fields in this region contribute to farmers’ household income through rice farming and serve as a source of local food. These conditions make Sidoarjo Regency a highly relevant research location for evaluating the impacts of paddy field conversion, whilst comprehensively identifying the underlying factors. This study was carried out over a period of six months, from September 2025 to March 2026. A geographical map of Sidoarjo Regency can be seen in Figure 1.

Peta Kab. Sidoarjo

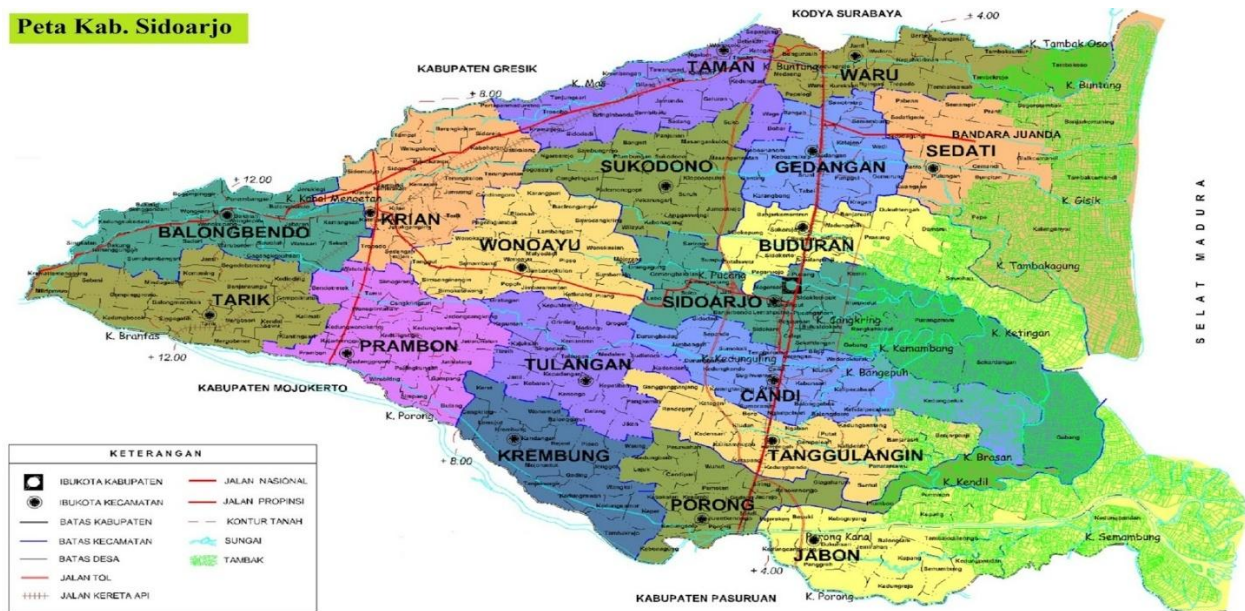


Figure 1. Geographical map of Sidoarjo Regency

Source: <https://id.pinterest.com/pin/568579521723239251/> (Accessed: 26 August 2026)

2.3 Population and Sampling Methods

According to the results of the 2023 Agricultural Census, which is the most recent structural agricultural data from the Central Statistics Agency, the number of farmers using agricultural land in Sidoarjo Regency was recorded at 33,441. However, the respondents used in this study consisted of farmers who had sold their land for conversion in Sidoarjo Regency. Since the population of farmers who have converted their land to other uses is unknown, with regard to the sample, Hair et al. (Hair et al., 2021) suggest that, in analyses using Structural Equation Modelling–Partial Least Squares (SEM-PLS), the sample size should be calculated using the formula: ten times the number of indicators. Given that there are 28 (twenty-eight) indicators in this study, the minimum sample size for SEM-PLS analysis is $28 \times 10 = 280$ respondents. This method was chosen because not all farmers were willing to participate as respondents, and only those who were willing were included. As a result, it was difficult to determine an appropriate sample size based on the total number of farmers. Consequently, a minimum sample size of 280 respondents was used in this study, with the details set out in Table 1.

Table 1. Respondent Profile

Demographics	Category	Respondent (n)	Percentage (%)
Age	26–30	30	10.7
	31–35	52	18.6
	36–40	93	33.2
	>40	105	37.5
	Total	280	100.0
Gender	Male	264	94.3
	Female	16	5.7
	Total	280	100.0
Level of Education	Primary School	55	19.6
	Junior High School	85	30.4
	Senior High School	120	42.9
	Diploma	9	3.2

Demographics	Category	Respondent (n)	Percentage (%)
	Beachelor degree	11	3.9
	Total	280	100.0
Main Job	Farmer	280	100.0
	Others	0	0.0
	Total	280	100.0

Source: Primary data, processed (2026)

Prior to data collection, all respondents were given a verbal explanation of the study's objectives, procedures, benefits and risks, as well as their right to refuse to participate or to withdraw at any time without any consequences. Verbal consent to participate was obtained from each respondent before the questionnaire was completed. The verbal approach was chosen on the basis that: (1) the majority of respondents were farmers with varying levels of formal literacy, meaning that written procedures could potentially hinder participation; (2) this study was a socio-economic survey posing minimal risk to respondents; and (3) the verbal approach was deemed more in line with the communication norms of the community in the study location. All respondents in this study were adult farmers; no underage participants were involved.

2.4 Research Data Collection and Analysis Methods

2.4.1 Research Data Collection

The data for this study were obtained from primary and secondary sources. The primary data collected included farm data, covering productivity, total production costs, the selling price of paddy, harvest season and the factors influencing land-use conversion. Primary data were collected through surveys and interviews with respondents, using a questionnaire that had been tested for validity and reliability. The survey was carried out intensively from the beginning of September to the end of November 2025. Data on the factors influencing land-use conversion, with the operationalisation of the research variables and indicators, are presented in Table 2.

Table 2. Operationalisation of variables and indicators driving the paddy fields conversion

Variables	Indicators Code	Indicators
Economic Factors (X1)	EF1	Unstable income
	EF2	Production costs continue to rise
	EF3	Fluctuations in commodity selling prices
	EF4	Household financial pressures
Physical Factors (X2)	PF1	Land degradation
	PF2	Access to irrigation water
	PF3	vulnerability to the risk of flooding
	PF4	Access to supporting infrastructure
Changes Employment Preferences (X3)	CEP1	The younger generation's job expectations
	CEP2	Parents' expectations regarding their children's careers
	CEP3	Motivating the younger generation to take up farming
	CEP4	An increase in employment in other sectors
Regional Growth (X4)	RG1	Industrial growth
	RG2	Property expansion
	RG3	Regional infrastructure development
	RG4	Population growth

Variables	Indicators Code	Indicators
Policy and Spatial Planning (X5)	PSP1	Implementation of LP2B
	PSP2	Implementation of the Regional Spatial Plan (RTRW)
	PSP3	Lax licensing
	PSP4	Land protection incentive scheme
Farmers' Decision (Z)	FD1	Selling price of agricultural land
	FD2	Economic considerations
	FD3	Licensing considerations
	FD4	Work preferences
Paddy Fields Conversion (Y)	PFC1	Converted land area
	PFC2	Percentage change in land area
	PFC3	Frequency of land conversion
	PFC4	Rate of land conversion

Source: Primary data, processed (2026)

The Likert scale was used as a measurement tool to ascertain respondents' responses to the factors influencing land-use change, as shown in Table 2. The Likert scale is a systematic series of statements that measures respondents' attitudes towards a particular object or phenomenon (Supriatin et al., 2022). This scale ranges from five (5) to one (1) to reflect respondents' attitudes, opinions, and perceptions regarding the variables under study (South et al., 2022). Furthermore, data on Willingness to Pay and Willingness to Accept were also collected via a questionnaire. Meanwhile, secondary data was obtained from various relevant scientific publications, including agricultural statistics published by the Central Statistics Agency (BPS) of Sidoarjo Regency, the annual reports of the Sidoarjo Regency Agriculture Department, regional spatial planning documents (RTRW), as well as scientific journal publications and research institute reports relating to paddy field conversion dynamics. Based on data obtained from the research site and several data sources supporting the research result, the data measurement parameters were obtained as presented in Table 3 below.

Table 3. Research data measurement parameters

Parameters	Total	Units	Data Sources
Area of paddy fields in 2020 (A _b)	34,321.14	ha	BPS, Sidoarjo Regency (2020)
Area of paddy fields in 2025 (A _a)	29,004	ha	BPS, Sidoarjo Regency (2026)
Area of paddy fields that has been converted (A _x)	5,317.14	ha	Land area data analysis
Average rate of paddy fields conversion	1,063.43	ha yr ⁻¹	Land area data analysis
Land productivity prior the land-use conversion (Y _b)	6,093	kg ha ⁻¹ season ⁻¹	BPS, Sidoarjo Regency (2020)
Land productivity following the land-use conversion (Y _a)	6,057	kg ha ⁻¹ season ⁻¹	BPS, Sidoarjo Regency (2026)
Harvest seasons (HS)	2	season	Interview
Price of milled dry paddy (P)	8,200	IDR kg ⁻¹	Interview
Average production cost (C)	40,000,000	IDR ha ⁻¹ yr ⁻¹	Interview
Per capita rice consumption (CP)	64.92	kg person ⁻¹ yr ⁻¹	BPS, Sidoarjo Regency (2026)
Population (Pop)	2,041,260	people	BPS, Sidoarjo Regency (2026)
Population growth rate	0.66	%	BPS, Sidoarjo Regency (2026)

Source: Sidoarjo Regency Central Statistics Agency; Primary data, processed (2026)

Note: BPS is Central Statistics Agency; BPS data for the year of the study refers to data from the previous year

Ethical approval for this research was obtained from the Ethics Approval Committee of the Faculty of Agriculture, Wijaya Kusuma University, Surabaya, with number: 268/FP/UWKS/VIII/2025. Furthermore, this research has also received approval from the Agriculture Department and the Agency for National Unity and Politics (BAKESBANGPOL) of Sidoarjo Regency, Indonesia, with number: 000.9/3721/438.6.5/2025. This research was conducted in accordance with the principles set out in the Helsinki Declaration, which involves human respondents, in this case farmers. Respondents were given an explanation of the content and purpose of this research, and were assured that their participation was voluntary and that their personal information would be kept confidential.

Data analysis in this study utilised four analytical methods integrated within a single research framework. Firstly, a farm enterprise analysis was conducted to determine the economic value of paddy field production within the context of paddy fields conversion. Secondly, an analysis of the local food availability index was carried out to assess the capacity of paddy fields to produce food, particularly rice to meet the community's food needs amidst paddy fields conversion. Thirdly, Structural Equation Modelling–Partial Least Squares (SEM-PLS) analysis to examine the factors influencing paddy fields conversion. Fourth, a Contingent Valuation Method (CVM) analysis to assess farmers' Willingness to Pay (WTP) and Willingness to Accept (WTA) as a policy recommendations for mitigating paddy field conversion aimed at preserving paddy fields (Bani & Damnyag, 2017; Do et al., 2022). The following are the stages of data analysis to be used in this study.

2.4.2 Calculating Paddy Fields Production and Its Economic Value within the Context of Paddy Fields Conversion

Calculations of paddy fields production and economic value are carried out to estimate the volume of production and economic value generated by paddy fields before and after land-use conversion (Fitri et al., 2022). The volume of paddy fields production before and after conversion provides an indication of the land's productive capacity, whilst the economic value of that production serves as a benchmark for determining the level of income generated for farmers from the land's output. The production and economic value of paddy fields before and after land-use conversion were calculated in three stages. First, calculated production of paddy fields prior the land-use conversion. The production volume prior the land-use conversion can be calculated using the following equation (1).

$$Q_b = Y_b \times A_b \times HS \quad (1)$$

Where, Q_b is the total paddy field yield prior the land-use conversion (kg yr^{-1}); Y_b is the paddy field productivity prior the land-use conversion (kg); A_b is the area of paddy field prior to the conversion (ha); HS is the harvest season in a year.

Then, the economic value of paddy fields was calculated prior to their conversion. The economic value of paddy fields prior the land-use conversion can be calculated using the following equation (2).

$$EV_b = (Q_b \times P) - (C \times A_b) \quad (2)$$

Where, EV_b is the economic value of the paddy field prior the land-use conversion (IDR yr^{-1}); Q_b is the total paddy field yield prior the land-use conversion (kg yr^{-1}); P is the price of paddy (IDR kg^{-1}); C is the average production cost ($\text{IDR ha}^{-1} \text{yr}^{-1}$); and A_b is the area of paddy field prior to the conversion (ha).

Secondly, calculations were carried out to determine the production and economic value of paddy fields following the land-use conversion. These calculations were carried out to ascertain the changes in production and economic value of paddy fields following the conversion. The production of paddy fields following land-use conversion can be calculated using the following equation (3).

$$Q_a = Y_a \times (A_b - A_x) \times HS \quad (3)$$

Where, Q_a is the total paddy fields yield following the land-use conversion (kg yr^{-1}); Y_a is the paddy field productivity following the land-use conversion (kg); A_b is the land area prior to land-use conversion (ha); A_x is the area of land converted (ha); HS is the harvest season in a year.

Next, the economic value of paddy fields production following land-use conversion is calculated. The economic value of paddy field production following land-use conversion can be calculated using the following equation (4).

$$EV_a = (Q_a \times P) - (C \times A_a) \quad (4)$$

Where, EV_a is the economic value of paddy fields following the land-use conversion (IDR yr^{-1}); Q_a is the paddy fields yield following the land-use conversion (kg yr^{-1}); P is the price of paddy (IDR kg^{-1}); C is the average production cost ($\text{IDR ha}^{-1} \text{yr}^{-1}$); A_a is the area of paddy fields following land-use conversion (ha); HS is the harvest season in a year.

Thirdly, once the economic value of paddy field production before and after land-use conversion is known, the final step is to calculate the economic value of paddy fields lost as a result of the conversion. This value is obtained by calculating the difference between the economic values before and after the land-use conversion. The resulting difference in economic value represents the economic value of the land's production lost due to the conversion. This difference in economic value can be calculated using the following equation (5).

$$\Delta EV = EV_b - EV_a \quad (5)$$

Where, ΔEV is the difference in the economic value of paddy fields lost as a result of land-use conversion (IDR); EV_b is the economic value of the paddy field prior to land-use conversion (IDR yr^{-1}); EV_a is the economic value of paddy fields following land-use conversion (IDR yr^{-1}).

2.4.3 Assessing the Impact of Paddy Field Production on the Local Food Availability Index Resulting from Land-Use Conversion

The local food availability index is calculated to determine the capacity of paddy fields and the implications of land-use conversion on the community's food needs (Keson et al., 2023). The total yield serves as an indicator to assess the extent to which paddy fields can meet the food needs of the surrounding community. The local food availability index is calculated in several stages. First, calculated production of paddy from paddy fields. Paddy production can be determined using the following equation (6).

$$Q_p = Y_a \times A_a \times HS \quad (6)$$

Where, Q_p is the paddy yield per unit area of paddy field (kg yr^{-1}); Y_a is the productivity of paddy field following land-use conversion (kg); A_a is the area of land following land-use conversion (ha); and HS is the harvest season in a year.

The next step is to calculate the conversion of paddy production into rice. This calculation is carried out to obtain an estimate of the amount of rice produced from the paddy harvest. This is important because the paddy produced does not entirely become ready-to-eat rice; rather, it undergoes a milling process with a specific yield rate. Therefore, paddy production must first be converted into rice using a standard yield factor (approximately 62–65 per cent), so that the analysis of food availability can be more accurate (Kalsum et al., 2020). The milling yield percentage of rice is 64.02% (Aminudin, 2025). The amount of rice produced from the paddy harvested from paddy fields can be determined using the following equation (7).

$$Q_r = Q_p \times R \quad (7)$$

Where, Q_r is the quantity of rice produced from paddy (kg yr^{-1}); Q_p is the quantity of paddy produced by paddy fields (kg); R is the percentage yield of paddy converted into rice (%).

Next, rice requirements are calculated. This calculation is carried out to determine the balance between rice production and the amount of rice consumed by the population. This evaluation process plays a role in determining the level of local food availability, particularly in ensuring that the rice supply is able to meet consumption needs on a sustainable basis (Isnawati, 2022). To determine the population's rice consumption requirements, the following equation (8) can be used.

$$R_n = \text{Pop} \times \text{CP} \quad (8)$$

Where, R_n is the total rice requirement of the population (kg yr^{-1}); Pop is the population (people); CP is per capita consumption per year ($\text{kg capita}^{-1} \text{ yr}^{-1}$)

The final stage is to calculate the implications of paddy field production for the Local Food Availability Index (LFAI). The Local Food Availability Index (LFAI) is used to measure the extent to which rice production is able to meet the food needs of the community at a local level. This index is derived from a comparison between the amount of rice produced and the amount of rice required by the community. The LFAI value provides an indication of a region's level of food self-sufficiency; an LFAI value greater than 1 indicates a rice surplus, whilst an LFAI value less than 1 indicates a potential food deficit (Pratama et al., 2019). The Local Food Availability Index (LFAI) can be calculated using the following equation (9).

$$\text{LFAI} = \frac{Q_r}{R_n} \quad (9)$$

Where, LFAI is the local food availability index; Q_r is the quantity of rice produced from paddy (kg yr^{-1}); R_n is the community's rice requirement (kg yr^{-1}).

2.4.4 Analysing the Factors Influencing Land-Use Conversion

Structural Equation Modelling-Partial Least Squares (SEM-PLS) was used to identify and analyse the factors influencing decisions regarding the paddy fields conversion at the study site. The SEM-PLS analysis in this study comprised three main analyses, namely the measurement model (outer model) to evaluate the convergent validity, discriminant validity and composite reliability of each variable using the indicators employed; the structural model (inner model) to test the causal relationships between variables; and hypothesis testing through the estimation of path coefficients and their significance levels using the Bootstrapping method with 5.000 subsamples (Hair JR. et al., 2014). Construct model used in this study is reflective-formative. The SEM-PLS analysis was conducted using SmartPLS software, with the following research hypotheses proposed.

- H1: Economic factors, as mediated by farmers' decisions, have a positive and significant effect on the paddy fields conversion.
- H2: Physical factors, as mediated by farmers' decisions, have a positive and significant effect on the paddy fields conversion.
- H3: Changes Employment Preferences, mediated by farmers' decisions, have a positive and significant effect on the paddy fields conversion.
- H4: Regional growth, mediated by farmers' decisions, has a positive and significant effect on the paddy fields conversion.
- H5: Policy and spatial planning, mediated by farmers' decisions, have a positive and significant effect on the paddy fields conversion.

2.4.5 Analysing of Policy Recommendations for the Protection of Paddy Fields

A study on recommendations for mitigating paddy field conversion was analyzed using the Contingent Valuation Method (CVM) to measure non-market monetary values through estimates of community or farmer preferences (Girma et al., 2021; Nyongesa et al., 2016). This analysis can be carried out using two methods, namely Willingness to Pay (WTP) and Willingness to Accept (WTA). WTP is measured to determine the extent to which farmers are willing to pay to prevent their paddy fields from being converted

to other uses (Budiasa et al., 2020; Chen et al., 2016). Whilst WTA is measured to determine the minimum compensation farmers are willing to accept in order to protect their paddy fields from the threat of conversion (Zhang et al., 2023). The average values of WTP and WTA are calculated using the following equations (10) and (11).

$$\overline{\text{WTP}} = \frac{\sum_{i=1}^n \text{WTP}_i}{n} \quad (10)$$

Where, $\overline{\text{WTP}}$ is the average willingness to pay among farmers (IDR yr⁻¹); WTP_i is the willingness to pay of farmer i to retain their paddy fields (IDR); n is the number of respondents.

$$\overline{\text{WTA}} = \frac{\sum_{i=1}^n \text{WTA}_i}{n} \quad (11)$$

Where, $\overline{\text{WTA}}$ is the average minimum willingness to accept compensation by farmers (IDR yr⁻¹); WTA_i is the minimum willingness to accept compensation by farmer i to retain their paddy fields (IDR); n is the number of respondents.

3. Research Results

3.1 Paddy Field Production and Economic Value within the Context of Land-Use Conversion

3.1.1 Production and Economic Value of Paddy Fields Prior the Land-Use Conversion

The production output of paddy fields prior to land-use conversion was calculated using the 2020 reference area of 34,321.14 hectares, with a land productivity of 6,093 kg ha⁻¹ season⁻¹ and two harvests per year (Table 3). Substituting the parameter values (Table 3) into Equation (1), yields $Q_b = 6,093 \times 34,321.14 \times 2 = 418,237,412.04$ kg yr⁻¹. This result is equivalent to 418.24 t yr⁻¹ of paddy production from all paddy fields in Sidoarjo Regency. This production figure is then substituted into Equation (2), together with the parameter values for paddy price, production costs, and land area, yielding $EV_b = (418,237,412.04 \times 8,200) - (40,000,000 \times 34,321.14) = \text{IDR}2,056,701,178,728$ yr⁻¹. This result reflects the net economic value generated by all paddy fields in Sidoarjo Regency from paddy cultivation prior to land-use conversion. Converted to a value per hectare, the paddy fields in Sidoarjo Regency generate a net economic value from paddy cultivation of $\text{IDR}59,925,200$ ha⁻¹ yr⁻¹.

3.1.2 Production and Economic Value of Paddy Fields Following to Land-Use Conversion

Table 3 shows several data parameters used in calculating and analysing the research results. According to data obtained from the Sidoarjo Regency Central Statistics Agency in Table 3, paddy fields in Sidoarjo Regency has undergone land-use conversion over the last five years. Specifically, the area under paddy cultivation and harvest in 2020 was 34,321.14 ha, whilst in 2025 it was only 29,004.00 ha (Statistics of Sidoarjo Regency, 2020; Statistics Sidoarjo Regency, 2026). The changes in land area over the past five years are shown in detail in Table 4 and Figure 2 below.

Table 4. Changes in the area of paddy fields over the last five years (2020–2025) in Sidoarjo Regency

Years	Area of Paddy Fields (ha)	Decrease Area of Paddy Fields (ha)
2020-2021	32,586.19	-1734.95
2021-2022	31,368.74	-1217.45
2022-2023	31,030.46	-338.28
2023-2024	32,100.11	1069.65
2024-2025	29,004.00	-3096.11
Total Decrease Area of Paddy Fields (ha)		-5317.14
Average Annual Decrease of Paddy Field (ha)		-1063.43

Source: Sidoarjo Regency Central Statistics Agency (2020-2026)

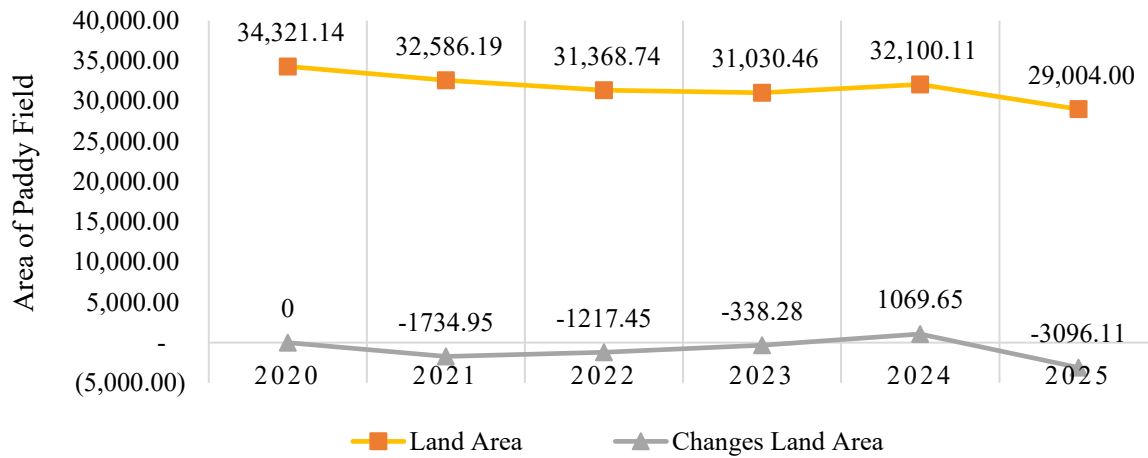


Figure 2. Graph showing changes in the area of paddy fields in Sidoarjo Regency

Figure 2. above shows a visualisation of changes paddy fields in Sidoarjo Regency. From 2022 to 2023, there was a decrease in the area of land converted from its original use compared to previous years. This change had a positive impact on the following year, namely from 2023 to 2024, during which the area of paddy fields saw a positive change with an increase of 1,069.65 ha. This positive change occurred due to the intensification of the use of neglected land, driven by the government to increase paddy fields production. However, from 2024 to 2025, there was a further reduction in land area, reaching 3,096.11 hectares in just one year.

The paddy fields conversion has an impact on land productivity, particularly in the rice cultivation sector (Nurliani & Rosada, 2016). The quantity of paddy fields production following land-use conversion was calculated using the projected paddy field area for 2025 of 29,004 hectares (Table 3). This parameter was substituted into Equation (3), together with a land productivity of $6,057 \text{ kg ha}^{-1} \text{ season}^{-1}$ and two harvests per year, yielding $Q_a = 6,057 \times (34,321.14 - 5,317.14) \times 2 = 351,354,456 \text{ kg yr}^{-1}$. This result is equivalent to 351.35 t yr^{-1} of paddy production generated by all paddy fields in Sidoarjo Regency following land-use conversion. Subsequently, this production figure is substituted into Equation (4), together with the parameter values for paddy price, production costs, and land area, yielding $EV_a = (351,354,456 \times 8,200) - (40,000,000 \times 29,004) = \text{IDR}1,720,946,539,200 \text{ yr}^{-1}$. This result reflects the net economic value that can still be generated by all paddy fields in Sidoarjo Regency from paddy cultivation following the land-use conversion.

3.1.3 Economic Value of Paddy Fields Lost Due to Land-Use Conversion

The economic value of paddy fields lost due to land-use conversion is calculated as the difference between the economic value prior to conversion and the economic value after conversion (Keson et al., 2023). This result reflects the cumulative financial loss of paddy fields resulting from land-use conversion. In Equation (5), substituting the economic value of the land prior to land-use conversion (EV_b) and the economic value of the land following land-use conversion (EV_a), obtain $\Delta EV = 2,056,701,178,728 - 1,720,946,539,200 = \text{IDR}335,754,639,528$ as shown in Table 5. This result represents the economic value lost due to land-use conversion over the past five years. If this result is converted based on the economic value of paddy paddy land lost each year, the economic value lost is approximately equal to $\text{IDR}67,150,927,905.60 \text{ yr}^{-1}$.

Table 5. Comparison the impact land-use conversion on the economic value of paddy fields in Sidoarjo Regency

Indicators	Before the Land-Use Conversion (2020)	After the Land-Use Conversion (2025)	Impact of Land-Use Conversion
Area of paddy fields (ha)	34,321.14	29,004	−5,317.14 (−15.49%)
Total paddy production (kg)	418,237,412.04	351,354,456	−66,882,956.04 (−15.99%)
Economic value of land (IDR)	2,056,701,178,728	1,720,946,539,200	−335,754,639,528 (−16.32%)

Source: The results of the research data analysis were processed (2026)

Table 5 above shows a comparison of the economic value of paddy fields in Sidoarjo Regency between the situation prior to land-use conversion in 2020 and the situation following land-use conversion in 2025. The land-use conversion that has taken place has resulted in a 15.99% reduction in production and a 16.32% reduction in economic value compared to the normal conditions that would have prevailed had the land not been converted. This comparison also provides a comprehensive overview of the magnitude of the impact caused by land-use conversion over this five-year period. If not addressed, this will have a lasting impact on the agricultural sector, particularly on rice production, which is the community's primary food source and the main source of income for farmers.

3.1.4 The Implications of Land-Use Conversion on Local Food Availability

Land-use conversion affects the production of paddy produced by paddy fields (Islam et al., 2015). This decline in paddy production also affects the amount of rice that can be produced from the paddy itself. By substituting the productivity and land area parameters following the land-use conversion (Table 3) into Equation (6), we obtain $Q_p = 6,057 \times 29,004 \times 2 = 351,354,456 \text{ kg yr}^{-1}$. This paddy production is then substituted into Equation (7) to determine the quantity of rice produced at a yield rate of 64.02%, yielding $Q_r = 351,354,456 \times 64.02\% = 224,937,122.73 \text{ kg}$ of rice per year. The rice produced serves as the primary foodstuff used by the community to meet their daily rice consumption. In Equation (8), the per capita rice consumption parameter is substituted with the population figure to determine the community's rice requirement, yielding $R_n = 2,041,260 \times 64.92 = 132,518,599.20 \text{ kg}$ of rice per year. With the total amount of rice and the rice requirement now known, these values were substituted into Equation (9) to determine the local food availability index, yielding $LFAI = 224,937,122.73 / 132,518,599.20 = 1.67$. The resulting value is greater than one (>1), meaning that paddy fields production following land-use conversion is still sufficient to meet local food supply needs. Rice production totalled 224,937,122.73 kg; when this is reduced by the population's rice requirements of 132,518,599.20 kg, this leaves a rice reserve of approximately 92,418,523.53 kg.

However, if land-use conversion at an average rate of 1,063.43 ha yr^{-1} and a productivity of 12,114 kg yr^{-1} is not properly anticipated, whilst the population growth rate continues to rise by 0.66% annually with per capita rice consumption of 64.92 kg yr^{-1} , it is possible to project the extent to which land resources will be able to meet food requirements in the rice supply sector over the coming years, as shown in Tables 6 and 7 below.

Table 6. Projected paddy and rice production if land conversion continues to occur in the next few years

Transition Period	Remaining Land Area (ha)	Paddy Production (kg)	Estimated Rice Production (kg) (Rendemen: 64.02%)
Year 2025	29,004	351,354,456	224,937,122.73
Next 5 years (2025–2030)	23,685.86	286,930,508.04	183,692,911.25
Next 10 years (2025–2035)	18,369.72	222,530,788.08	142,464,210.53

Transition Period	Remaining Land Area (ha)	Paddy Production (kg)	Estimated Rice Production (kg) (Rendemen: 64.02%)
Next 15 years (2025–2040)	13,052.58	158,118,954.12	101,227,754.43

Note: Projected results are calculated based on conversion rates over a 5-year period

Table 7. Projected population, needs and availability of rice in the next few years

Population Growth Period	Total Population (souls) (Growth Rate: 0.66%)	Rice Requirement (kg)	Availability of Rice (kg) (Production-Needs)*
Year 2025	2,041,260	132,518,599.20	92,418,523.53
Next 5 years (2025–2030)	2,109,438	136,944,714.96	46,748,196.29
Next 10 years (2025–2035)	2,180,066	141,529,884.72	934,325.81
Next 15 years (2025–2040)	2,252,939	146,260,799.88	– 45,033,045.45

Source: Projected results of paddy and rice production with the growth and rice needs of the population (2026)

Note: The data used in the projections refer to the availability of data in 2026

**The availability of rice is calculated by subtracting the amount of production by the amount of rice needed*

Table 6 above shows that the ongoing conversion of agricultural land each year is leading to a decline in paddy and rice production, thereby affecting the availability of rice for the population. However, these findings are at odds with the population growth shown in Table 7, where the population continues to rise each year and the population's demand for rice is also increasing. The projections in Table 7 indicate that over the next 15 years, there is projected to be a shortfall in food availability from rice production of approximately 45,033,045.45 kg by 2040 if paddy fields continue to be converted for other uses alongside the ongoing growth in population. Between 2040 and 2045, Indonesia will also experience a demographic dividend, during which the working-age population will outnumber the non-working-age population (UNFPA, 2025). This will drive up demand for food; consequently, if land conversion continues over the next 15 years, it is entirely possible that food shortages will occur, particularly in peri-urban areas such as Sidoarjo Regency.

3.2 Factors Driving of Paddy Fields Conversion

3.2.1 Testing of Measurement Models

Testing of the measurement model (outer model) was carried out to analyse the extent to which the constructs used in the measurement model reflect the research context and the indicators used represent the latent variables being measured (Hair et al., 2014). The measurement model was tested using two main tests: validity testing and reliability testing. Validity testing comprises convergent validity testing and discriminant validity testing (Ab Hamid et al., 2017). The results of the convergent validity test can be seen from the Outer Loadings values, which are considered valid if they are ≥ 0.70 , and the Average Variance Extracted (AVE) values, which are considered good if they are ≥ 0.50 . The discriminant validity test utilises the Heterotrait-Monotrait Ratio of Correlations (HTMT), with the model considered to be of good quality if the HTMT value is below 0.90. The reliability test utilises Cronbach's Alpha and Composite Reliability, with the model considered to be reliable if the values are ≥ 0.70 . The testing of the measurement model was in accordance with the criteria set out by Hair et al. (Hair et al., 2011). Based on the results of the convergent validity test in Table 8, the outer loadings for all indicators of the latent variables were found to be greater than 0.70 and the AVE values greater than 0.50 (Hair et al., 2011). This means that the indicators used in the measurement model reflect the latent variables and that the latent variables are able to explain their respective indicators. These results are further supported by the outer loadings from the measurement model test shown in Figure 3, which illustrates the loadings of the indicators on their respective latent variables.

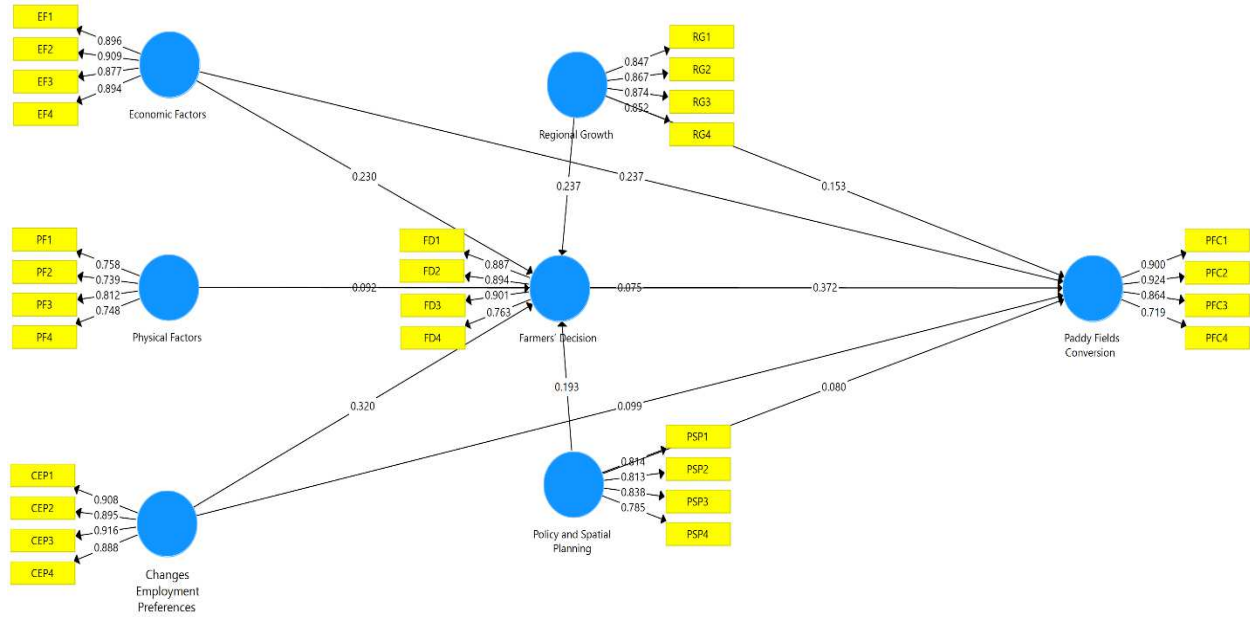


Figure 3. Output of outer model testing measurement model

The results of the instrument reliability test in Table 8 show that the Cronbach's Alpha and Composite Reliability values are greater than 0.70. These values indicate that the instrument is reliable. This means that the instrument used demonstrates strong consistency and reliability when tested repeatedly, with the data produced remaining stable. Furthermore, the results of the discriminant validity test in Table 9 show that all HTMT values between constructs are below 0.90. This means that each latent variable used in the measurement model is truly distinct from the others, so there is no multicollinearity between the latent variables in the measurement model.

Table 8. Compilation of the results of the validity and reliability test of the measurement model

Variables	Indicators	Outer Loadings	Cronbach's Alpha	rho_A	Composite Reliability	AVE
X1	EF1	0.896	0.916	0.918	0.941	0.799
	EF2	0.909				
	EF3	0.877				
	EF4	0.894				
X2	PF1	0.758	0.767	0.777	0.849	0.585
	PF2	0.739				
	PF3	0.812				
	PF4	0.748				
X3	CEP1	0.908	0.923	0.923	0.946	0.813
	CEP2	0.895				
	CEP3	0.916				
	CEP4	0.888				
X4	RG1	0.847	0.883	0.887	0.919	0.740
	RG2	0.867				
	RG3	0.874				
	RG4	0.852				
X5	PSP1	0.814	0.829	0.830	0.886	0.661
	PSP2	0.813				

Variables	Indicators	Outer Loadings	Cronbach's Alpha	rho_A	Composite Reliability	AVE
	PSP3	0.838				
	PSP4	0.785				
Z	FD1	0.887	0.885	0.901	0.921	0.745
	FD2	0.894				
	FD3	0.901				
	FD4	0.763				
Y	PFC1	0.900	0.875	0.893	0.915	0.732
	PFC2	0.924				
	PFC3	0.864				
	PCF4	0.719				

Source: Validity and reliability test output using SmartPLS Version 3 (2026)

Table 9. Results of the discriminant validity test of the measurement model

Heterotrait-Monotrait Ratio (HTMT)							
Variables	X1	X2	X3	X4	X5	Z	Y
X1							
X2	0.340						
X3	0.519	0.532					
X4	0.443	0.265	0.498				
X5	0.474	0.258	0.532	0.533			
Z	0.639	0.459	0.734	0.653	0.659		
Y	0.682	0.455	0.667	0.637	0.613	0.832	

Source: Output of discriminant validity test using SmartPLS Version 3 (2026)

3.2.2 Structural Model Testing

Following a series of evaluations of the measurement model (outer model), the next stage is to test the structural model, or inner model. This testing includes the R-squared (R^2) test to measure the percentage of variance in the dependent (endogenous) variable that can be explained by the independent (exogenous) variables in the model, the F-squared (f^2) to measure the substantive influence of an exogenous variable on a specific endogenous variable within the structural model, and the predictive relevance test (Q^2) to evaluate how well the structural model (inner model) can predict observed values. Taken together, these metrics provide a comprehensive evaluation of the hypothesised relationships and the overall validity of the structural model.

The structural model testing in Figure 4 shows the percentage of variance in the dependent variable that can be explained by the independent variables (R^2) and a measure of the substantive effect of an exogenous variable on a specific endogenous variable within the structural model (F^2) in this study; the strength of these effects is detailed in Tables 10 and 11 below.

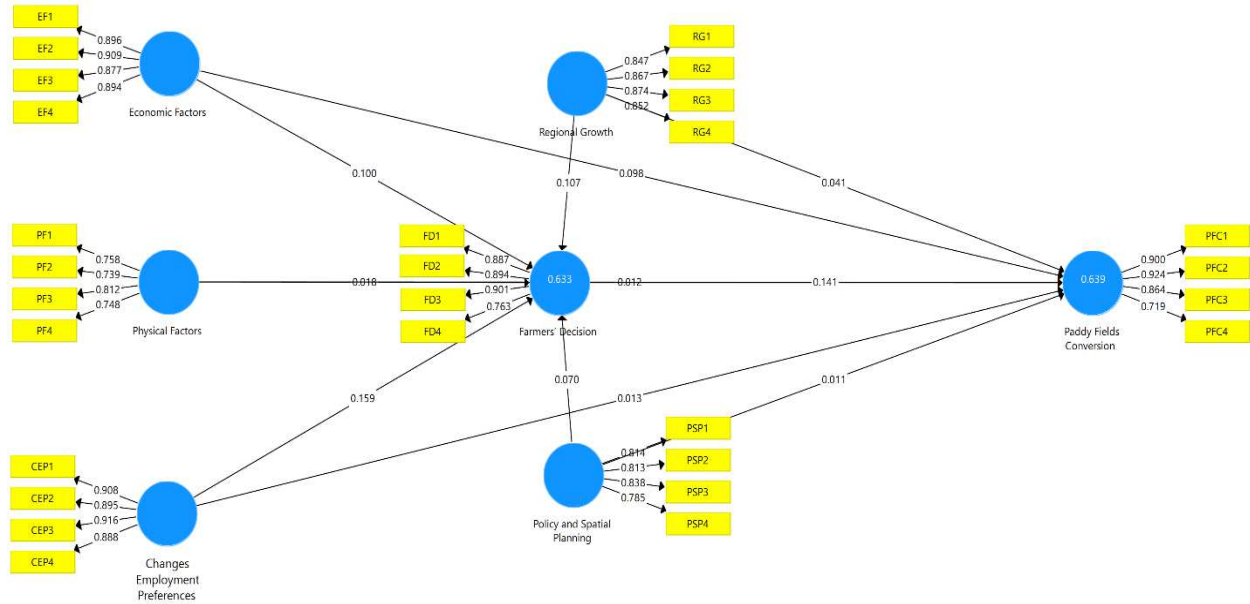


Figure 4. Structural model testing output

Table 10 shows an R^2 value of 0.633 for the farmers' decision-making construct. This means that farmers' decisions can be explained by the independent variables in the model to the extent of 63.3%, with the remainder being influenced by other factors outside the model. This value is categorised as a moderate effect. Meanwhile, the R^2 value for the paddy fields conversion construct is 0.639. This means that paddy fields conversion can be explained simultaneously by economic factors, physical factors, changes employment preferences, regional growth, policy and spatial planning, and farmers' decisions to the extent of 63.9%, with the remainder influenced by other factors outside the model (see Figure 4). This R-squared value is categorised as having a moderate effect. The F-squared (F^2) test in Table 11 and Figure 4, shows the influence of the independent variables on the mediating variable and the dependent variable, as well as the simultaneous influence of the mediating variable on the dependent variable. The test results indicate that the strongest influence was found in the relationship between the variable 'changes employment preferences' (X3) and the variable 'farmers' decisions' (Z), with a value of 0.159. The strength of this influence falls within the moderate category. The weakest influence was found in the relationship between the variable 'policy and spatial planning' (X5) and the variable 'paddy fields conversion' (Y), with a value of 0.011 (see Figure 4). The strength of this influence falls into the low category. The predictive relevance (Q^2) test in Table 11 also shows that the predictive values of all variables are greater than zero (>0). This means that the predictive relevance values in the structural model have good observational values and are capable of accurately predicting the dependent variable.

Table 10. R-square (R^2) test results

Construct	R-square	R-square adjusted	Effects
Z	0.633	0.626	Moderate Effect
Y	0.639	0.631	Moderate Effect

Source: R-square (R^2) test output using SmartPLS Version 3 (2026)

Table 11. Results of the f-square (f^2) and predictive relevance (Q^2) tests

f-square (f^2)			Construct Cross-Validated (Q^2)			
Variables	Z	Y	Redundancy		Communality	
			SSE	Q^2	SSE	Q^2
X1	0.100	0.098	1120.000	-	462.030	0.587
X2	0.018	0.012	1120.000	-	779.111	0.304
X3	0.159	0.013	1120.000	-	406.311	0.637
X4	0.107	0.041	1120.000	-	517.892	0.538
X5	0.070	0.011	1120.000	-	648.295	0.421
Z	-	0.141	608.380	0.457	509.569	0.545
Y	-	-	614.572	0.451	505.334	0.549

Source: F-square (f^2) and predictive relevance (Q^2) test outputs using SmartPLS Version 3 (2026)

Note: Predictive relevance (Q^2) testing is performed through the Blindfolding procedure on SmartPLS software

3.2.3 Path Coefficient Analysis and Hypothesis Testing

The analysis of path coefficients (β) and hypothesis testing in PLS-SEM are processes carried out to assess the relationships between latent constructs within a structural model. Path analysis involves calculating path coefficients that indicate the strength and direction of the relationship between exogenous and endogenous variables. Meanwhile, hypothesis testing is conducted by examining the statistical significance of the path coefficients, usually through a t-test or P-value. Path coefficients are considered significant if the P-value is less than the specified significance level of 0.05 and the T-statistic is greater than 1.96. Thus, path analysis and hypothesis testing enable the evaluation of the strength and significance of relationships between constructs. The significance of these coefficients is tested statistically using the Bootstrapping method. Through the bootstrapping method, it is possible to determine the direction and strength of the direct relationship between the independent variable and the mediating variable, as well as the direct and simultaneous relationship of the mediating variable to the dependent variable within the model.

The results of the path coefficient (β) tests for direct effects, as shown in Figure 5, indicate that all independent variables comprising economic factors, physical factors, changes employment preferences, regional growth, policy and spatial planning have a positive and significant effect on the mediating variable, namely farmers' decisions. These results are evidenced by positive β values, T-statistics greater than 1.96, and P-values less than 0.05. However, there is also an independent variable that has a direct effect on the dependent variable (paddy fields conversion) firstly, the economic factor, with β value of 0.237, T-statistic of 4.246 (> 1.96), and P-value of 0.000 (< 0.05). This means that economic factors shape farmers' decisions whilst simultaneously directly driving land-use conversion if not anticipated; secondly, regional growth with β value of 0.153, T-statistic of 2.259 (> 1.96), and P-value of 0.024 (< 0.05). This implies that structural pressures beyond farmers' control, such as population growth and regional infrastructure development, can directly alter the use of agricultural land. The mediating variables also simultaneously exert a positive and significant influence on the dependent variable namely, paddy fields conversion as evidenced by positive β values, T-statistics greater than 1.96, and P-values less than 0.05 (see Figure 5).

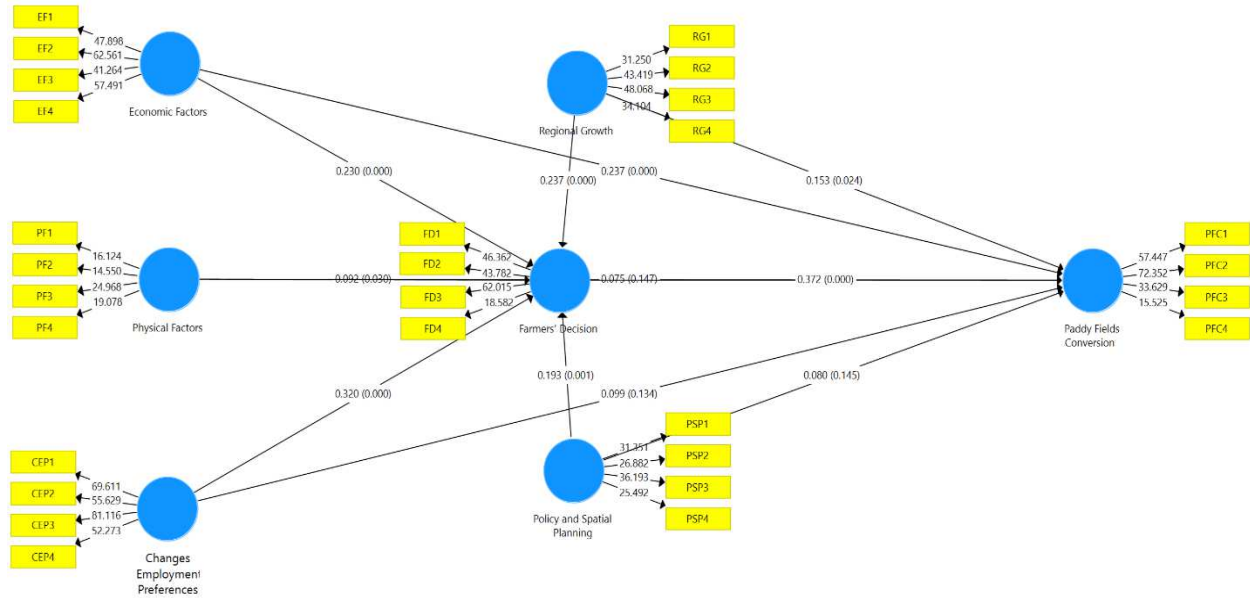


Figure 5. Path coefficient test output

The results of the hypothesis test (Table 12) on the indirect effect of economic factors, mediated by farmers' decisions, on paddy fields conversion yielded β value of 0.086, T-statistic of 2.683 (> 1.96), and P-value of 0.007 (< 0.05). These results indicate that economic factors have a positive and significant indirect effect on paddy fields conversion via farmers' decisions, which act as a significant mediator in the relationship between economic factors and paddy fields conversion under investigation; therefore, Hypothesis 1 is accepted. The results of the hypothesis test on the indirect effect of physical factors, mediated by farmers' decisions, on paddy fields conversion yielded β value of 0.034, T-statistic of 1.976 (> 1.96), and P-value of 0.048 (< 0.05). These results indicate that physical factors exert a positive and significant indirect influence on paddy fields conversion via farmers' decisions, which act as a significant mediator in the relationship between physical factors and paddy fields conversion under investigation; therefore, Hypothesis 2 is accepted. Furthermore, the results of the hypothesis test on the indirect effect of changes employment preferences, mediated by farmers' decisions, on paddy fields conversion yielded β value of 0.119, T-statistic of 2.960 (> 1.96), and P-value of 0.003 (< 0.05). These results indicate that changes employment preferences have a positive and significant indirect effect on paddy fields conversion through farmers' decisions, which act as a significant mediator in the relationship between changes employment preferences and paddy fields conversion as tested; therefore, Hypothesis 3 is accepted. Furthermore, the results of the hypothesis test on the indirect effect of regional growth, mediated by farmers' decisions, on paddy fields conversion yielded β value of 0.088, T-statistic of 2.374 (> 1.96), and P-value of 0.018 (< 0.05). These results also indicate that regional growth exerts a positive and significant indirect effect on paddy fields conversion via farmers' decisions, which act as a significant mediator in the relationship between regional growth and paddy fields conversion under investigation; consequently, Hypothesis 4 is accepted. Finally, the results of the hypothesis test on the indirect effect of policy and spatial planning mediated by farmers' decisions on paddy fields conversion yielded β value of 0.072, T-statistic of 2.275 (> 1.96), and P-value of 0.023 (< 0.05). These results also indicate that policy and spatial planning can have a positive and significant indirect effect on paddy fields conversion through farmers' decisions, which act as a significant mediator in the relationship between policy and spatial planning and paddy fields conversion as tested; consequently, Hypothesis 5 is accepted.

Table 12. Output path coefficients indirect effects: hypothesis test

Hipotesis	Path Analysis	β -value	STDEV	T-statistics	P-values	Decision
H-IE ₁	X1 → Z → Y	0.086	0.032	2.683	0.007	Significant and accepted
H-IE ₂	X2 → Z → Y	0.034	0.017	1.976	0.048	Significant and accepted
H-IE ₃	X3 → Z → Y	0.119	0.040	2.960	0.003	Significant and accepted
H-IE ₄	X4 → Z → Y	0.088	0.037	2.374	0.018	Significant and accepted
H-IE ₅	X5 → Z → Y	0.072	0.032	2.275	0.023	Significant and accepted

Source: Output Bootstrapping Path Coefficients Indirect Effects using SmartPLS Version 3 (2026)

Note: STDEV = Standard Deviation; H-IE = Indirect Effects Hypothesis

3.3 Estimates of Willingness to Pay (WTP) and Willingness to Accept (WTA) as Recommendations for Policy Measures to Anticipate Paddy Field Conversion

Willingness to Pay and Willingness to Accept values were collected to measure the amount of money farmers are willingness to pay and receive in order to protect their paddy field from the threat of paddy fields conversion. A survey of 280 farmers revealed that they are willingness to pay a sum of money in the form of an annual contribution and to receive a sum of money in the form of monthly compensation from the government in order to retain their land. The survey results showed that the total amount the 280 farmers were willingness to pay (WTP) was IDR100,800,000 yr⁻¹, whilst the total minimum compensation they were willingness to accept (WTA) was IDR140,000,000 month⁻¹. From the total WTP value obtained, a substitution was made in Equation (10), yielding $\overline{WTP} = 100,800,000 / 280 = \text{IDR}360,000 \text{ yr}^{-1}$. The WTA value obtained is also substituted into Equation (11), yielding $\overline{WTA} = 140,000,000 / 280 = \text{IDR}500,000 \text{ month}^{-1}$. Thus, Table 13 presents a comparison of farmers' WTP and WTA.

Table 13. Comparison of WTP and WTA values of farmers in the preservation of paddy fields

Indicator	Willingness to Pay	Willingness to Accept	Units
They respond	280	280	People
Total annual value	100,800,000	1,680,000,000	IDR yr ⁻¹
Average per individual annually	360,000	6,000,000	IDR yr ⁻¹
Average per individual monthly	12,000	500,000	IDR month ⁻¹
Policy implications	Farmers support land preservation	Farmers need land incentives	-

Source: Primary data, processed (2026)

The difference between WTP and WTA in Table 13 above has implications for what farmers want and are willing to give up to preserve their land. According to environmental economics theory Bateman et al. (2002), a situation where WTA exceeds WTP is a common phenomenon that can be attributed to several factors, including: (1) the endowment effect, which is the tendency for individuals to value assets they own more highly than their actual market value; (2) information asymmetry amongst farmers regarding the true value of paddy fields; and (3) market imperfections in determining the true price of paddy fields.

4. Discussion

4.1 Economic Value of Lost Paddy Fields and Its Implications for Farmers' Incomes

Calculations of economic value show that the paddy fields in Sidoarjo Regency generated a net economic value of IDR2,056,701,178,728 yr⁻¹ prior to land-use conversion, which fell to IDR1,720,946,539,200 per year following conversion. The difference of IDR335,754,639,528 represents the economic value lost over five years, equivalent to IDR67,150,927,905.60 yr⁻¹. This 16.32% decline in economic value is greater than

the reduction in land area (15.49%) or the decline in production (15.99%), indicating a multiplier effect from land conversions. The loss of land is exacerbated by a decline in productivity from 6,093 kg ha⁻¹ season⁻¹ in 2020 to 6,057 kg ha⁻¹ season⁻¹ in 2025. This decline in productivity is a manifestation of the negative externalities of land conversion, namely the disruption of irrigation networks, the fragmentation of paddy field areas, and the deterioration of the growing environment due to surrounding non-agricultural activities.

4.2 The Impact of Paddy Fields Production on Local Food Availability

The calculation of the Local Food Availability Index (LFAI) for 2025 yielded a value of 1.67, meaning that rice production of 224,937,122.73 kg still exceeds the population's consumption needs of 132,518,599.20 kg, resulting in a surplus of 92,418,523.53 kg. Statistically, Sidoarjo Regency still maintains a rice surplus status despite having lost 5,317.14 hectares of paddy fields. The fact that the LFAI value remains above one risks creating a false sense of security amongst policy-makers, meaning that the urgency of controlling land conversion tends to be overlooked. The projections from this study indicate that, with an average conversion rate of 1,063.43 ha yr⁻¹ and a population growth rate of 0.66% yr⁻¹, the rice surplus will shrink to 46,748,196.29 kg by 2030, will be almost exhausted by 2035, with only 934,325.81 kg remaining, and will turn into a deficit of 45,033,045.45 kg by 2040. This situation directly contradicts the pillar of food self-sufficiency in the 2025–2045 National Long-Term Development Plan, whilst also threatening the achievement of SDG 2, specifically Target 2.1 on access to safe and nutritious food and Target 2.4 on sustainable food production systems.

4.3 Factors Driving Land-Use Conversion and the Central Role of Farmers' Decisions

The results of the hypothesis testing indicate that all five exogenous factors have a positive and statistically significant indirect effect on paddy fields conversion through farmers' decisions. Changes employment preferences exert the greatest indirect influence ($\beta = 0.119$; T-statistic = 3.013; P-value = 0.003), a finding reinforced by the f^2 test, which identifies the relationship between changes in work preferences and farmers' decisions as the strongest influence in the model ($f^2 = 0.159$). These findings indicate that land-use conversion in peri-urban areas is not driven solely by high land prices, but also by the declining willingness of the younger generation to continue farming. This situation is consistent with the concept of deagrarianisation proposed by Bryceson (1996) and the findings of White (2012) regarding the declining interest of rural youth in the agricultural sector in Indonesia, which is caused by low social prestige, income uncertainty, and the availability of alternative employment in the industrial and service sectors.

The role of farmers' decisions as a significant mediating variable across all pathways constitutes the main contribution of this study. These findings indicate that structural factors do not operate deterministically, but are filtered through the decision-making process at the household level. These results support the Theory of Planned Behaviour (Ajzen, 1991), which posits that individual intentions and attitudes are the proximate determinants of behaviour, and are consistent with the agent-based approach to land-use change developed. In addition to these indirect pathways, two factors were found to have a direct influence on paddy fields conversion namely economic factors ($\beta = 0.237$; T-statistic = 4.246; P-value = 0.000) and regional growth ($\beta = 0.153$; T-statistic = 2.259; P-value = 0.024). The fact that the coefficient for the direct effect of economic factors is far greater than that for the indirect effect suggests the existence of conversion mechanisms that take place without involving decisions by tenant farmers, for example through transactions by absentee landowners or large-scale land acquisitions by developers. Meanwhile, the direct effect of regional growth reflects land conversion driven by infrastructure development and the expansion of settlements, which lie beyond the control of farmers. The significance of policy and spatial planning variables, which have the lowest f^2 coefficient in relation to paddy fields conversion (0.011), should be

interpreted critically. This low value indicates that existing regulatory instruments, including Law No. 41 of 2009 on LP2B, have not yet provided adequate control on the ground.

4.4 Estimates of WTP and WTA as the Basis for Policy Recommendations to Anticipate Paddy Field Conversion

A survey of 280 farmers yielded an average willingness to pay (WTP) of IDR360,000 yr⁻¹ or IDR12,000 month⁻¹, and an average willingness to accept (WTA) of IDR500,000 month⁻¹ or IDR6,000,000 yr⁻¹. Farmers' willingness to pay conservation fees, although the amount is modest, is an important indicator of a collective awareness of the economic value of paddy fields that extends beyond their productive function. The ratio of WTA to WTP from the research findings is quite high. The gap between WTA and WTP stems from the endowment effect, information asymmetry, and market imperfections. The endowment effect explains that individuals perceive the loss of an asset they already own as far more significant than an equivalent gain. For farmers, paddy fields are not merely productive assets, but also represent social identity, an intergenerational legacy, and a guarantee of livelihood in old age; consequently, their subjective value exceeds their market value.

Pressure to convert paddy field, particularly in suburban areas, is driving farmers to decide to repurpose their land for other uses. This change in land use eliminates the land's economic value, which directly erodes farmers' household income. The cumulative effect of land-use changes also leads to a decline in food production capacity, which could potentially result in a projected rice deficit by 2040 if not properly addressed. Research findings indicate that the impacts of land-use conversion extend from the household level to the regional level, and even to the national level if not properly addressed. Consequently, the issue of farmers' income, as outlined in SDG 1, and the issue of food security, as outlined in SDG 2, cannot be addressed separately. Therefore, strategic recommendations are needed, one of which is the implementation of a farmer incentive scheme to prevent ongoing land conversion.

5. Conclusion

The area of paddy fields in Sidoarjo Regency has shrunk from 34,321.14 ha in 2020 to 29,004 ha in 2025, representing a decrease of 5,317.14 ha at an average rate of 1,063.43 ha yr⁻¹. Land-use conversion has reduced the net economic value of paddy fields from IDR2,056,701,178,728 yr⁻¹ to IDR1,720,946,539,200 yr⁻¹, with a total loss of IDR335,754,639,528 over five years. This figure is equivalent to a loss of IDR67,150,927,905.6 yr⁻¹, averaging IDR59,925,200 ha⁻¹ yr⁻¹. The Local Food Availability Index (LFAI) for 2025 remains at a surplus level (1.67), with rice reserves of 92,418,523.53 kg. However, if the rate of land-use conversion continues and population growth continues to rise, it is projected to shrink and turn into a deficit of 45,033,045.45 kg by 2040. The turning point from surplus to deficit, which coincides with the peak of the demographic dividend between 2040 and 2045, warrants particular attention, as it has the potential to threaten the region's food self-sufficiency just as national demand reaches its peak.

An analysis of the factors influencing paddy fields conversion revealed that the five exogenous factors comprising economic factors, physical factors, changes employment preferences, regional growth, and policy and spatial planning were found to have a positive and significant indirect effect on paddy fields conversion through the mediation of farmers' decisions, with changes employment preferences acting as the strongest indirect driver. Meanwhile, the low influence of policy and spatial planning variables indicates the weak effectiveness of existing regulatory instruments, including UU No. 41 of 2009 on LP2B. Farmers' willingness to pay (WTP) and willingness to accept compensation (WTA) represent strategic measures recommended for policy recommendations to anticipate paddy field conversion. Farmers are willing to pay an average conservation contribution of IDR360,000 yr⁻¹ and are willing to receive an average compensation of IDR500,000 month⁻¹ or IDR6,000,000 yr⁻¹. The gap between the WTA and WTP values

remains at a reasonable level and is fiscally viable as the basis for policy recommendations to anticipate paddy field conversion to support the conservation of paddy fields.

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Generative AI Statement

The author(s) declared that generative AI was not used in the creation of this manuscript.

Conflict of Interest

The author(s) declare no conflict of interest.

Ethical Approval and Consent to Participate

Ethical approval for this research was obtained from the Ethics Approval Committee of the Faculty of Agriculture, Wijaya Kusuma University, Surabaya, with number: 268/FP/UWKS/VIII/2025. Furthermore, this research has also received approval from the Agriculture Department and the Agency for National Unity and Politics (BAKESBANGPOL) of Sidoarjo Regency, Indonesia, with number: 000.9/3721/438.6.5/2025. All farmers gave their informed consent for inclusion before they participated in the study.

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