Agricultural land availability and farmer's income in Java Island, Indonesia, 1990–2018

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Keywords:
agricultural land availability,
farmers' income,
three-stage least squares

Java, an island in Indonesia, plays an essential role as the centre of food crop production. However, over the last few decades, the conversion of agricultural land on this island has increased. The pressure on the availability of agricultural land has increased, and the problems regarding farmers' income have not been appropriately resolved. This research was conducted to determine the relationship between the availability of agricultural land and farmers' income on Java Island using structural equations. The panel data used in this research consist of annual time-series data from 1990–2018 and cross-section data of all provinces in Java. Furthermore, the data were analysed using a three-stage least-squares model. The results prove that agricultural land availability and the level of farmers' income simultaneously positively affect each other. Therefore, to maintain the performance of Java Island as the primary producer of food crops in Indonesia, the availability of agricultural land and the level of farmers' income are the main focus areas for improvement.

Introduction

Indonesia plays an essential role as the third-largest rice producer globally (Shiotsu et al. 2015). The high rice yield in Indonesia bolsters this argument. Rice production in Indonesia is concentrated on the Java Island. According to the Indonesian Central Statistics Agency, rice production in Java Island reached 33,51 million tons per year, equivalent to 53.53% of the total rice production in Indonesia. Furthermore, rice productivity on Java Island is higher than the national productivity. The average annual rice productivity on Java Island is 5.45 tons per hectare, while rice productivity at the national level only reaches 4.89 tons per hectare (ICSA 2020).

In addition to rice, Indonesia also produces corn and soybeans with an average production of 24,23 million tons and 859 thousand tons and exports 716 tons and 2.763 tons in 2020, respectively (ICSA 2020, Trademap 2021). The Java Island also contributes to the total production of corn and soybeans in Indonesia, at 54.03% and 64.63%, respectively. These data indicate that Java Island has a great potential for crop production in Indonesia. Moreover, 40.81% of the agricultural land in Indonesia is located on Java Island. However, crop production in Java Island faces serious challenges, such as the massive conversion of agricultural land and the low level of farmers' income.

The conversion of agricultural land into non-agricultural land in Java Island has occurred over the last few decades due to various factors, such as high population growth. The population density of Java reached 1,171 people per km^2 in 2019, with a population growth of 1.19% per year (ICSA 2020). The high population density and growth increase results in food and other requirements and urges the availability of agricultural land (Jiang–Zhang 2016, Guneralp et al. 2017, Abdul-Rahaman–Abdulai 2020). Furthermore, the growing population's need for tourism attractions negatively impact agricultural land availability (Kirca–Özer 2021). Another factor is expanding urban areas to rural areas due to solid urbanisation (Dekolo et al. 2015, Yu–Wu 2018, do Carmo Dias Bueno– Neves de Souza Lima 2019, Beckers et al. 2020, Salvati 2020, Krishnan–Firoz 2021, Zagyi et al. 2021). This condition is also worsened by urban agglomerations that drive Java's economic transformation, initially relying on the agricultural sector and shifting to the industrial and trade sectors (Tóth–Nagy 2014, Gardi et al. 2015, Rondhi et al. 2018, Krishnan–Firoz 2021).

The area of agricultural land in Java Island fluctuates a lot, as seen by the standard deviation value reaching 440,125.60 hectares with the average land area per year reaching 806,135.90 hectares (ICSA 2020). This is related to agricultural land clearing activities in the 1990s and widespread agricultural land conversion in the 2000s. It is estimated that 1.63 per cent of agricultural land has been converted to non-agricultural land in the last five years, equating to 52,904 hectares. Additionally, the income level of food crop farmers on Java Island is included in the low category. This condition can increase trade-offs in land use and encourage the conversion of agricultural land into non-agricultural land.

Several studies have shown that the level of farmers' income can affect the availability of agricultural land. Farmers tend to convert their agricultural land into non-agricultural land when agricultural activities are considered inefficient, resulting in lower profits than if the area is used for other sectors (Ghatak–Mookherjee 2014, Zhou et al. 2020). Thus, farmers have high expectations that converting agricultural land into other uses can increase their income and welfare (Zahri et al. 2019).

Another study shows the opposite relationship, where the availability of agricultural land affects the level of farmers' income. Farmers who manage agricultural land on a large scale tend to earn higher incomes (Mishra et al. 2018, Noack–Larsen 2019, Yusuf et al. 2020). Conversely, the level of farmers' income worsens when farmers decide to sell or convert part of their agricultural land due to the decreased amount of agricultural land (Mariyono 2019, Zhang–Xie 2019). This is triggered by increased per-unit land management costs, risk, and the vulnerability of plants cultivated on small-scale land (Abdullah et al. 2019, Kumar et al. 2020).

Previous studies have shown a link between the availability of agricultural land and farmers' income. However, previous studies have separately estimated these two variables using an ordinary least squares model. Therefore, based on the results of previous studies, there are indications of a simultaneous relationship between the variables of agricultural land availability and farmers' income. This research gap can be resolved through the objectives of this study. This research was conducted simultaneously to determine the relationship between agricultural land availability and farmers' income through structural equations.

Research methods

The secondary data sourced from the Indonesian Central Statistics Agency were used in this study. These data include agricultural land area (AL) in hectares, farmers' terms of trade (ToT) for the base year 2018 (2018=100), real producer price of rice (PR) in IDR per kg, real producer price of rice squared (PRSQ), real producer price of maize (PM) in IDR per kg, real producer price of maise squared (PMSQ), real producer price of soybean (PS) in IDR per kg, real producer price of soybean squared (PSSQ), labour real wages of the agricultural sector (LW) in IDR per day, labour real wages of the agricultural sector squared (LWSQ), the dummy of agricultural land protection policy (DAPP) where 1=the period after the policy is implemented (Special Region of Yogyakarta (2011), East Java Province (2015), West Java Province (2010), Central Java Province (2013)), 0=the period before the policy is implemented, total population (POP), number of medium and large industries (IND) in units, square of the number of industries (INDSQ), dummy of the Special

Region of Yogyakarta (DDIY) where 1=Special Region of Yogyakarta (DIY), 0=provinces other than DIY, dummy for East Java Province (DJTM) where 1=East Java Province, 0=province other than East Java, and dummy for Central Java Province (DJTG) where 1=Central Java Province, 0=province other than Central Java. This study uses three dummy provinces from the four provinces used in this study because the maximum use of dummy variables is n-1, where n indicates the number of provinces available. West Java Province was not chosen as a dummy variable because the Province is a merger of two provinces, namely, West Java Province and Banten.

The panel data method was used to compile data, which combines time-series and cross-sectional data. The time-series data in this study are from 1990–2018, while the cross-section data are all provinces on Java Island, except for the Special Capital Region of Jakarta Province. These are East Java, Central Java, Yogyakarta Special Region, and West Java Provinces. Data from Banten Province were merged with West Java Province because Banten Province was separated from West Java Province in 2000 through Law No. 23 of 2000. The Special Capital Region of Jakarta Province is not included in this study because this Province is not an area designated for agricultural activities, indicated by the low area of agricultural land in the Province. The Special Capital Region of Jakarta Province contributes only 0.04% of the total agricultural land in Java (ICSA 2020).

These variables are used considering previous research and the economic theory related to the availability of agricultural land and farmers' income levels. Previous studies have shown that the availability of agricultural land is influenced by the increasing demand for housing land and industrialisation in an area (Rondhi et al. 2018, Peerzado et al. 2019, Duan et al. 2021). Rapid industrialisation has increased land demand resulting in higher land-use trade-offs. When the trade-offs increase, lands with low rental values are converted into usages with higher rents. Another study concluded that the availability of agricultural land is determined by population growth (Stehfest et al. 2019, Kobayashi et al. 2020). Furthermore, research conducted in Southwest China showed that the availability of agricultural land was influenced by the agricultural land conservation policy set by the government (Zhao et al. 2018). Additionally, the level of farmers' income from cultivation also affects the availability of agricultural land at the macro level. (Ghatak–Mookherjee 2014, Msofe et al. 2019, Zhou et al. 2020). Therefore, the first equation can be arranged as follows:

$$AL = \gamma_0 + \gamma_1 ToT + \gamma_2 DAPP + \gamma_3 POP + \gamma_4 IND + \gamma_5 INDSQ + u \quad (1)$$

Meanwhile, we find cases where the availability of agricultural land affects farmers' income levels (Mishra et al. 2018, Noack–Larsen 2019, Yusuf et al. 2020). Another study conducted in Haryana, India, showed that agricultural commodity prices also influence farmers' income at the producer level (Ceballos et al. 2021). Furthermore, a study conducted in Vietnam concluded that the high and low costs incurred by farmers in managing their farms would impact their level of income (Hoang 2021). The higher the farming costs incurred, such as input and labour costs, the greater the potential for a reduced income. Based on previous studies, farmers' income equation can be arranged as follows:

$$ToT = \beta_0 + \beta_1 AL + \beta_2 PR + \beta_3 PRSQ + \beta_4 PM + \beta_5 PMSQ + \beta_6 PS + \beta_7 PSSQ + \beta_8 LW + \\ +\beta_9 LWSQ + \beta_{10} DDIY + \beta_{11} DJTM + \beta_{12} DJTG + v \quad (2)$$

Equation (1) shows the availability of agricultural land in Java Island, determined by the high and low areas of agricultural land. Equation (2) shows the level of farmers' income in Java Island. The farmers' terms of trade represent their income in this study. The farmers' terms of trade can be calculated using the following formula:

$$ToT = (PR_t / PP_t) \times 100 \quad (3)$$

The PR_t variable shows the farmers' level of income, where PP_t shows the cost they incur. Therefore, if the PR_t value is greater than PP_t, it can be concluded that farming activities can positively contribute to increasing farmers' income. However, if the PR_t value is less than PP_t, it can be interpreted that farming activities run by farmers cannot positively contribute to farmers' income.

Equations (1) and (2) show that there is an endogenous variable in each equation, variable AL in equation (1), and ToT in equation (2). These variables are explanatory in the other equations. Endogenous variables that become explanatory variables in an equation can cause error terms and correlate with each other, making the ordinary least squares model impractical. This is known as an endogeneity problem in simultaneous equations. When a simultaneous equation is detected as an endogeneity problem, the equation can be solved using the three-stage least squares model (Redehegn et al. 2019). The three-stage least squares model combines calculations using an instrumental variable approach (stage 1). Then it uses the residuals from stage 1 to consistently estimate the covariance matrix of the disturbance equation (stage 2). Finally, it estimates using the generalised least squares (GLS) model so that the correlation structure can be calculated in the disturbance in each equation (step 3) (Greene 2002).

Before the three-stage least-squares analysis, it was necessary to test the panel data stationarity using the Levin Lin and Chu (LLC) method (Levin et al. 2002). The stationarity test was conducted to eliminate spurious regression due to non-stationary time-series data used for the entire period (Nyeadi et al. 2018, Shrestha–Bhatta 2018). The results of the stationarity test showed that the variables AL, POP, LW, and LWSQ were stationary at the 1st difference stage. Additionally, the IND and INDSQ variables were stationary at the 2nd difference stage, while the other variables were stationary at this level (Table 1).

Table 1

LLC stationarity test

Variable	Stage	LLC statistic	Prob.	Information
AL	1st Difference	–3.46	0.00	Stationary
ToT	Level	–3.19	0.00	Stationary
POP	1st Difference	–4.63	0.00	Stationary
IND	2nd Difference	–3,48	0.00	Stationary
INDSQ	2nd Difference	–2.53	0.01	Stationary
PR	Level	–2.76	0.00	Stationary
PRSQ	Level	–3.56	0.00	Stationary
PM	Level	–1.37	0.09	Stationary
PMSQ	Level	–1.34	0.09	Stationary
PS	Level	–2.99	0.00	Stationary
PSSQ	Level	–3.92	0.00	Stationary
LW	1st Difference	–5.32	0.00	Stationary
LWSQ	1st Difference	–5.32	0.00	Stationary

After all the data are stationary at each level, the three-stage least squares analysis can be performed correctly. The three-stage least-squares analysis shows that the Adjusted R^2 values in the AL and the ToT equations are 0.2122 and 0.4782, respectively. This means that the independent variable can explain 21.22% of the variation in the AL variable and 47.82% of the ToT (see Table 2). The structural model compiled shows an F-statistic value of 1.65 and 7.54, which are significant at the 10% and 1% alpha levels so that the model compiled is valid. Furthermore, Model (1) shows that the significance level of the endogeneity test is 0.051, while Model (2) shows a significance level of 0.070. The significance level of the endogeneity in both models is lower than the 10% alpha level, indicating that both models have endogeneity problems in their respective structural equations. Additionally, the overidentification test and the weak instrument test show a significant value at the 5% alpha level, meaning that the structural model is included in the over-identified category, and each equation has a strong instrument variable. These results indicate that the specification of the three-stage least squares model used in this study is correct.

Results and discussion

The high rate of agricultural land conversion has prompted central and local governments to develop a policy framework to protect agricultural land. This policy is legal protection through a law enacted by the central government; Law No. 41 of 2009 concerning the Protection of Sustainable Food-Agricultural Land. All provinces in Java Island have also established regional regulations as a follow-up to the law's enactment. Although laws and regional regulations have been enacted and enforced in each

Province, these policies are not a strong 'fortress' to restrain the rate of agricultural land conversion. The coefficient of the dummy variable (DAPP) is negative, meaning that the area of agricultural land after implementing the policy is lower than before (Table 2). This is caused by the ineffectiveness of implementing these policies The incomplete inventory of agricultural land in the regions and the unclear incentives for farmers to maintain agricultural land further complicate the implementation of this policy (Perrin et al. 2020). Additionally, the low involvement of farmers in policymaking and their lack of information about the details of land protection policies also hinder policy implementation at the farmer level (Perrin et al. 2018).

The average ToT value for farmers in Java Island was 101.50, a relatively high value because it exceeds 100, indicating that farmers receive more income than their total costs (Jebran et al. 2018). This means that farming activities have improved the income of farmer households in Java Island positively. However, the value of farmers' ToT in each Province in Java Island tends to increase, especially the ToT values in East Java, West Java, and Central Java (Figure 1).

The ToT value in the Special Region of Yogyakarta decreased from 1990–2018 due to increased farming costs and low productivity. Farmers' low-quality planting materials, low-quality water and irrigation channels, and the high cost of implementing agricultural technologies together contributed to higher farming costs and lower productivity (Souvannachith et al. 2017, Triyono Rahmawati–Rozaki 2021). Although the ToT value decreases, the average ToT value in this Province is higher than that in the other three provinces. The average ToT values in the Special Region of Yogyakarta reached 111.97, while in East Java, West Java, and Central Java, the values were only 96.26, 98.53, and 99.26, respectively.

The ToT value of the Special Region of Yogyakarta, higher than that of other provinces in Java Island, can be seen in the regression results in Table 2. The Dummy of the Special Region of Yogyakarta (DDIY) in the ToT model shows a significant result at an alpha level of 1%. These results indicate a significant difference between farmers' incomes in the Special Region of Yogyakarta and other provinces in Java. The regression coefficient on the DDIY variable is positive, so it can be interpreted that farmers' income in the Special Region of Yogyakarta is higher than the income level of farmers in other provinces. High-income results from the high price of rice at the producer level. Based on data from the Central Statistics Agency, the lowest rice price at the producer level in the Special Region of Yogyakarta was on average IDR 4,700 per kg (or 0.283 euro), while in East Java, Central Java, and West Java was only IDR 4,600 per kg, IDR 4,500 per kg, and IDR 4,200 per kg, respectively (ICSA 2020).

The population of Java Island also showed a high +level of density. The total area of Java Island is 129,438.28 $km^{2,}$ with an average annual population of 28,500,000. The densest population in this study is in West Java province combined with data from Banten (excluding the Special Capital Region of Jakarta Province).

Additionally, the number of medium and large industries in West Java was also the largest after East Java. Overall, the number of industries in Java Island was, on an average, 167,581 units spread across each Province.

The PR fluctuates, with a standard deviation of IDR 2,322.38 per kg, while the average PR on the whole island is IDR 3,871.43 per kg. Additionally, the average real producer price of corn is IDR 3,215.00 per kg, while that of soybean in Java Island is IDR 8,465.06 per kg. Actual producer prices of corn and soybeans also showed significant fluctuation, as indicated by the standard deviation of each commodity price reaching IDR 2,323.78 per kg and IDR 7,107.15 per kg, respectively. The highest real producer prices for food commodities in Java Island are commodities marketed in the Special Region of Yogyakarta Province. The higher producer prices incentivise farmers to increase their production and maintain their agricultural land to support the production process (Short et al. 2014, Abokyi et al. 2020). Furthermore, the average real wage of labour in the agricultural sector in Java Island is IDR 19,047.89 per day. Contrary to the actual producer prices of food crops, the labour wages in the agricultural sector have a low level of fluctuation, with a standard deviation of only IDR 7,770.53 per day.

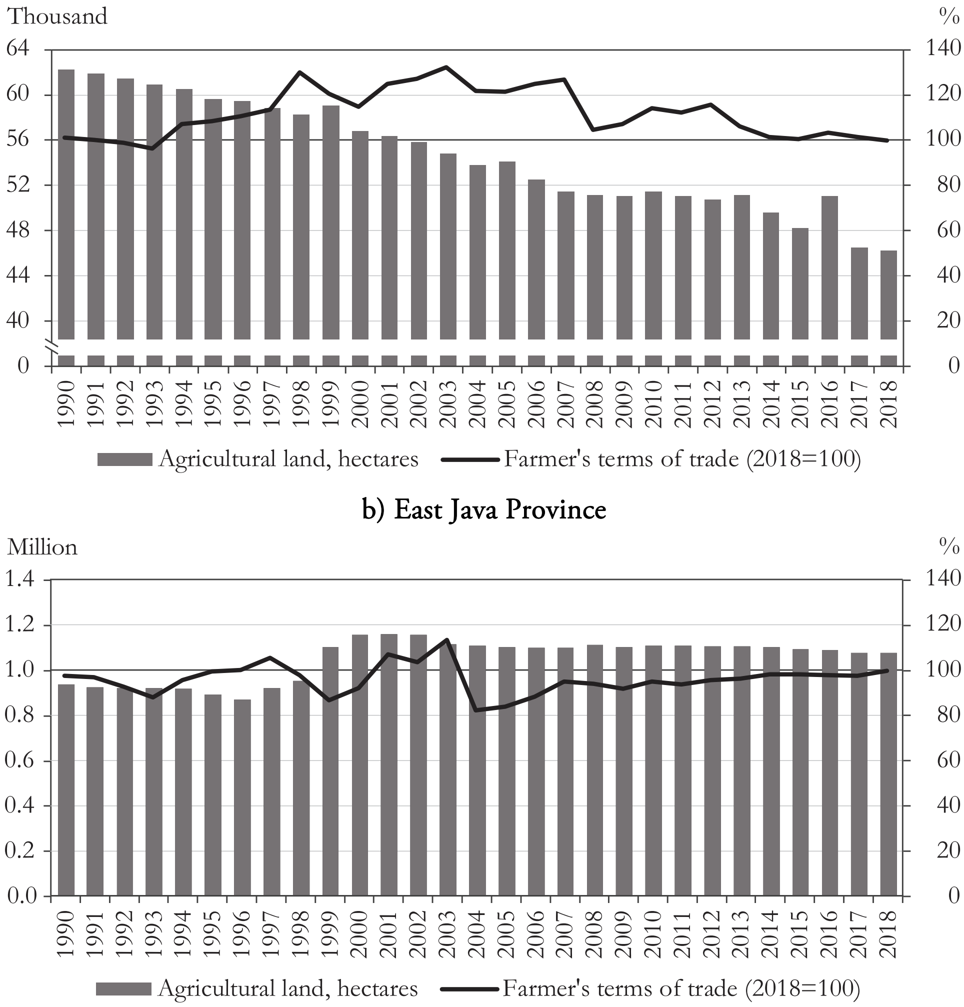
The development of agricultural land in the Special Region of Yogyakarta shows a negative trend – the area of agricultural land progressively decreases annually. For example, the area of agricultural land in this Province reached its highest point of 62,233 hectares in 1990, but it decreased until 2018. However, the ToT value in the Special Region of Yogyakarta reached its highest point in 2003 (132.26) and then decreased until it reached its lowest point in 2018. Therefore, the growth of agricultural land area in this region is directly related to the farmers' ToT value, indicating a pattern wherein the higher the agricultural land, the higher the ToT that the farmer can gain, and vice versa [Figure 1 a)].

West Java Province also shows a phenomenon similar to the Special Region of Yogyakarta. Agricultural land in West Java decreased by 2,028 ha annually [Figure 1 c)]. The same phenomenon occurred in Central Java Province. This Province is recorded to experience a decline in agricultural land by 2,271 hectares per year [Figure 1 d)]. However, farmers' ToT for both provinces increased from 1990 to 2018. Farmers' ToT in West Java and Central Java increased by 0.07 and 0.01 per year, respectively. This shows the tendency of a negative relationship between the area of agricultural land and the ToT value in West Java and Central Java. Several notes form the basis for the pattern of this relationship, such as improvements in environmental conditions, especially the quality of irrigation water and channels that boost crop production and productivity (Fridayani 2020, Banik et al. 2021). The Special Effort Program drove these improvements for rice, corn, and soybeans (*Program Upaya Khusus (UPSUS) padi, jagung, dan kedelai*), actively conducted by the central and local governments. Additionally, previous studies have shown that West Java and Central Java have implemented intensive and commercial farming systems to increase farm production and income (Mariyono 2019). This phenomenon is proven by the trend of increasing the farmer acceptance index. Furthermore, using local variety seeds helps farmers reduce production costs, and ultimately, increases farmers' incomes (Hidayat et al. 2020). Data from the Indonesian Central Bureau of Statistics show that the structure of seeds and the average cost of renting agricultural equipment in West Java and Central Java is lower than in East Java and the Special Region of Yogyakarta (ICSA 2020).

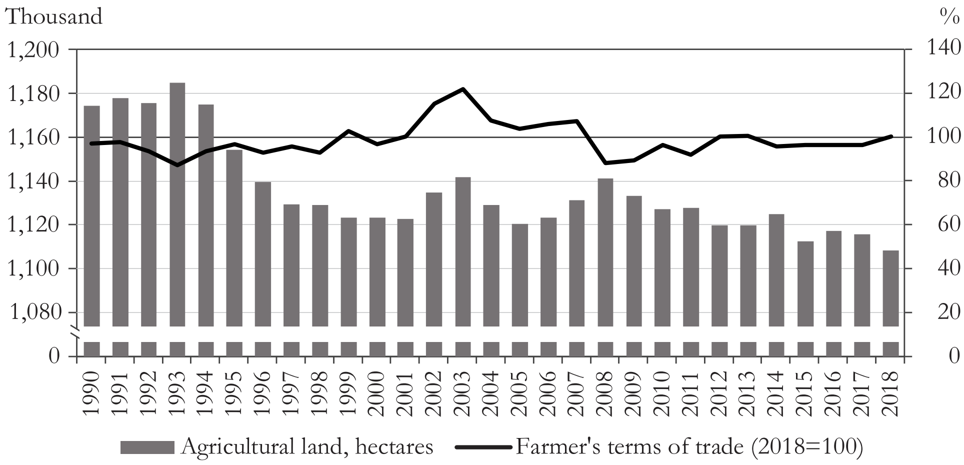
Figure 1

Agricultural land versus farmer's welfare

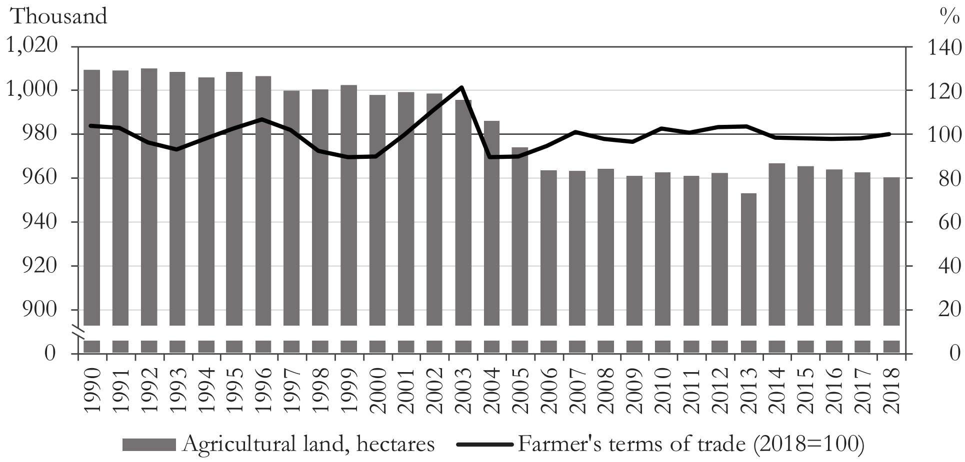
a) The special region of Yogyakarta Province



c) West Java Province



d) Central Java Province



Among all the provinces on Java Island, East Java is recorded to have agricultural land with a positive trend [Figure 1 b)]. Additionally, the farmers' ToT in this Province also showed a positive trend. The data visually show a positive relationship between agricultural land and farmers' welfare in the East Java Province. This Province has been aggressively diversifying agricultural activities with the development of organic rice farming to increase the added value of agricultural land and support the increase in farmers' income (Soetriono et al. 2020). Additionally, the diversification of agricultural activities minimises the negative impact of urbanisation on the sustainability of agricultural land on the city's outskirts (Caruso–Conto 2018, Yoshida 2020).

The analysis results using the three-stage least squares model show that the availability of agricultural land in Java is influenced by the level of farmers' income (Table 2). Simultaneously, farmers' income is significantly affected by the availability of agricultural land. Each of these variables has a positive relationship, indicating that increasing farmers' income can increase the availability of agricultural land, and increasing agricultural land availability can boost farmers' incomes.

The availability of agricultural land in Java is influenced by the level of farmers' income, with a regression coefficient of 456.4818. The regression coefficient of ToT shows that an increase in ToT by one unit can increase the area of agricultural land by 456.4818 hectares. Farmers' increased income reflects more profitable farming activities, an incentive for farmers to maintain agricultural land. Based on Table 2, the area of agricultural land also affects the level of farmers' income. The regression coefficient value of AL to ToT is 0.0003, indicating that an increase in the area of agricultural land by one ha can increase the ToT of farmers by 0.0003 units. These two variables are mutually supportive and interconnected, meaning that an increase in one variable increases the other simultaneously. This allows for the faster achievement of a high level of farmers' income and maintaining the availability of agricultural land in Java Island. Conversely, a decrease in one variable can cause a decrease in the performance of the other variable. This can decrease the level of farmers' income and the threat of available agricultural land.

The greater the availability of agricultural land, the larger the land size farmers can use to carry out their farming activities. This can encourage the achievement of economies of scale in a farm and increase farmers' income and farm efficiency (Nayak 2018, Molinos-Senante–Maziotis 2021). Research conducted in Central Java and the Special Region of Yogyakarta concluded that most farmers (80.20%) in the two provinces only manage agricultural land of less than 0.50 hectares (Antriyandarti 2018). Another study in different sub-districts in Central Java showed that the average size of agricultural land cultivated by food crop farmers was only 0.14 hectares in the dry season and 0.13 hectares in the rainy season with an average income of USD 1,433.08 and USD 1,414.53 per hectare, respectively (Connor et al. 2021). Agricultural land cultivated by farmers in Java is less than 2 hectares and is categorised as small-scale farming (Lowder et al. 2016). The results of other studies show that the larger the scale of the farming economy managed by farmers, the higher the income earned (Wardana et al. 2018, Xhoxhi et al. 2020).

Additionally, the results show that the number of medium and large industries (IND) and squared industries (INDSQ) significantly affect agricultural land availability in Java. IND has a negative regression coefficient of 0.0828, and INDSQ has a positive regression coefficient of $9.77E^{-08}$, meaning that an increase in the number of medium and large industries by one unit can reduce the availability of agricultural land in Java by 0.0828 hectares until it reaches its optimum point. Suppose that the number of medium and large industries in Java Island grows and exceeds its optimum point. Then, the decline in the availability of agricultural land will continue to occur at a slower rate. The increased performance of the industrial sector has an impact on increasing land demand for industrial activities, thereby potentially increasing trade-offs in land use and encouraging the conversion of agricultural land into industrial land (Debela et al. 2020, Lai 2021). Therefore, it is necessary to develop a zoning policy to reduce the trade-offs in land use and conversion of agricultural land into non-agricultural land. The formulation of this policy must be inclusive, meaning that it involves various elements, including farmers as owners and managers of agricultural land.

Table 2

Three-stage least square regression results

Variable	Coefficient	Std. error	t-statistic	Prob.
Dependent variable: AL				
ToT	456.4818*	247.7759	1.8400	0.0650
DAPP	–6,896.8210 *	3,792.6710	–1.8200	0.0690
POP	0.0006ns	0.0012	0.4600	0.6440
IND	–0.0828**	0.0350	–2.3700	0.0180
INDSQ	9.77E–08**	4.71E–08	2.0800	0.0380
Cons.	–48,049.0300*	26,119.8900	–1.8400	0.0660
Adj. R^2				0.2122
F test				1.6500
Overidentification test				14.7217
Weak identification test				20.9000
Endogeneity test				3.9139
Dependent variable: ToT				
AL	0.0003**	0.0002	1.9900	0.0460
PR	0.0075***	0.0027	2.7800	0.0050
PRSQ	5.60E–07***	1.94E–07	–2.8800	0.0040
PM	–0.0007ns	0.0040	–0.1700	0.8660
PMSQ	6.90E–08ns	2.86E–07	0.2400	0.8090
PS	–0.0002ns	0.0004	–0.4700	0.6370
PSSQ	4.09E–09ns	1.57E–08	0.2600	0.7940
LW	–0.0015ns	0.0013	–1.1900	0.2350
LWSQ	3.32E–08ns	3.05E–08	1.0900	0.2760
DDIY	10.0156***	2.6985	3.7100	0.0000
DJTM	–2.7302ns	2.7568	–0.9900	0.3220
DJTG	0.8330ns	2.0135	0.4100	0.6790
Cons.	82.5517***	7.6999	10.7200	0.0000
Adj. R^2				0.4782
F test				7.5400
Overidentification test				11.7964
Weak identification test				16.8500
Endogeneity test				3.3567

*** Significant at 1% alpha; ** Significant at 5% alpha; * Significant at 10% alpha; ns Not Significant.
Note: The overall summary statistics see Table A1 in the Appendix.

The analysis results also show that the PR influences farmers' income in Java Island. The PR has a positive relationship with farmers' income. This shows that the higher the PR, the higher the level of farmers' income. Table 2 also shows that the PRSQ variable has a positive relationship with farmers' income: an increase in the real price of rice by IDR 1 per kg can increase farmers' income by 0.0075 (PR regression coefficient) until it reaches its optimum point. If the PR increases and can exceed its optimum point, the farmers' income increases more quickly. The high price of rice at the producer level is an incentive for farmers to conduct farming activities on agricultural land. Additionally, rice is one of the main crops in Java. Annually, farmers can plant and harvest this commodity 2-3 times, depending on the availability of water and the quality of irrigation facilities (Apriyana et al. 2021). Therefore, the high intensity of rice cultivation and favourable rice prices will increase the contribution of farming to farmers' household incomes (Zahri et al. 2018).

Conclusions

Farmers' income influences the availability of agricultural land in Java Island, and the availability of agricultural land affects farmers' income. Therefore, the two variables have a positive relationship in each equation; it can be concluded that increasing the availability of land for farmers can increase farmers' income, and increasing farmers' income can increase the availability of agricultural land simultaneously. Additionally, farmers' income can be increased by keeping PR favourable to farmers. Therefore, diversifying agricultural activities can be an alternative strategy to increase farmers' incomes in Java Island.

The availability of agricultural land can be improved by implementing agricultural land protection policies. This can be done by compiling land inventories that are included in the agricultural land protection zone. Furthermore, it is necessary to focus on the incentives received by farmers for maintaining their agricultural land, providing input or output subsidies, counselling, training, and assistance in farming activities. Additionally, farmers must also obtain precise information about the policies implemented; for that, farmers must be actively involved in policymaking and need structured socialisation.

This research did not include social variables, such as the average age of farmers, education level, and human capital index. This is a research limitation that needs to be addressed. Therefore, further research that includes the social variables affecting the availability of agricultural land variables and farmers' income variables is needed in the future.

Appendix

Table A1

Overall summary statistics

Variable	Obs	Mean	Std. Dev.	Min.	Max.
AL	116.00	806,135.90	440,125.60	52,304.00	1,184,628.00
ToT	116.00	101.50	10.09	82.33	132.26
POP	116.00	28,500,000.00	16,600,000.00	2,912,311.00	6,140,000.00
IND	116,00	167,580.50	29,082.00	162.00	816,804.00
PR	116.00	3,871.43	2,322.38	1,670.42	13,487.22
PM	116.00	3,215.00	2,323.76	1,575.73	12,207.53
PS	116.00	8,465.06	7,107.15	4,319.73	41,053.53
LW	116.00	19,047.89	7,770.53	5,552.79	39,032.55
DAPP	116.00	0.23	0.43	0.00	1.00
DDIY	116.00	0.25	0.43	0.00	1.00
DJTM	116.00	0.25	0,43	0.00	1.00
DJTG	116.00	0.25	0,43	0.00	1.00

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