Urbanisation, Paddy Field Conversion and its Impact on Rice Production in Indonesia: A Synthesis of Panel Data 2015-2019

Muhammad Ali Yafi[1, a)] and M. Rondhi[1, b)]

Author Affiliations
[1] *Department of Agribusiness, Jember University, Jember, Indonesia.*

Author Emails
[a)] *yafimuhammadali35@gmail.com*
[b)] *rondhi.faperta@unej.ac.id*

Abstract. Agricultural land conversion is a threat to the fulfilment of food needs. Conversion of agricultural land has increased along with the increase in the fulfilment of human needs for both housing and industry. This study focuses on the growth rate of conversion of paddy fields in Indonesia, the factors that influence the rate of conversion of paddy fields in Indonesia, and the impact of paddy field conversion on rice production in Indonesia. This study uses panel data on 34 provinces in Indonesia from 2015-2019. The data analysis method used is panel regression with the fixed effect method (FEM) approach. The results showed that the average conversion of agricultural land during the period 2015-2019 was 5.68% per year. Furthermore, the variables that significantly affect the conversion of paddy fields in Indonesia are population, the proportion of paddy fields to the total area in Indonesia, the ratio of agricultural GRDP to industrial GRDP, and the ratio of agricultural GRDP to total GRDP. This causes that industrial development will have an impact on the conversion of agricultural land. Finally, the conversion of agricultural land has an impact on the loss of rice production of 73,635,810 quintals with a lost rice production value of IDR 35,132,748,789,089 trillion. The recommendation given is to maintain a balance between increasing rice production with land intensity and industrial development.

Keywords: Paddy field conversion, panel regression analysis, rice production impact

INTRODUCTION

Land is an essential resource used by humans to fulfil needs ranging from agriculture, housing, industry, and other sectors [1]. Additional land use to fulfil the needs of one sector will reduce the availability of other sectors. Increased land use for the housing and industrial sectors will have an impact on reducing the availability of agricultural land.

The conversion of agricultural land to non-agricultural land is a serious threat to national food security where food availability is highly dependent on land availability [2-3]. Many regions that started as rice self-sufficient regions have turned into regions that need rice import assistance to fulfil the food needs of their people. On the other hand, the conversion of paddy fields that occurs on productive land will result in a decrease in employment opportunities in the agricultural sector. The narrowing agricultural land has an impact on the production produced [4].

Land conversion has increased in recent decades, especially in urban areas [5]. This is due to the demands for housing, industry, office buildings, schools, and supermarkets [6]. In Java Island in the period 1995 - 2013, there was a land conversion of 370 thousand hectares at a rate of around 0.57% per year [7]. Likewise, in Sigi Regency, Aceh, land conversion has occurred by 4% annually during the period 2009-2020. Prayuga [8], found that the area of paddy fields decreased by an average of 1.65% per year.

Land conversion is rampant in paddy fields, which have been converted into non-rice fields. Although the government has issued Law No. 41/2009 on the protection of sustainable food agricultural land, the implementation of the regulation is still not fully implemented. This is because landowners have different perceptions of land use,

I. H. Agustin (ed.), *Proceedings of the 2nd International Conference on Neural Networks and Machine Learning 2023 (ICNNML 2023)*, Advances in Intelligent Systems Research 183,
https://doi.org/10.2991/978-94-6463-445-7_28

Land conversion is rampant in paddy fields, which have been converted into non-rice fields. Although the government has issued Law No. 41/2009 on the protection of sustainable food agricultural land, the implementation of the regulation is still not fully implemented. This is because landowners have different perceptions of land use, especially in urban areas [3]. The following is data on the area of paddy fields and the area of conversion of paddy fields in Indonesia in 2010-2019:

TABLE 1. Indonesia's rice field area in 2010-2019

No	Year	Rice Field Area (Ha)	Area of Paddy Field Conversion (Ha)
1.	2010	8.002.552	0
2.	2011	8.094.862	0
3.	2012	8.132.345	0
4.	2013	8.128.499	3.846
5.	2014	8.114.829	13.670
6.	2015	8.092.907	21.922
7.	2016	8.187.734	0
8.	2017	8.164.045	23.689
9.	2018	7.105.145	1.058.900
10.	2019	7.463.948	0
Total Area of Paddy Field Conversion			1.122.027
Average Area of Paddy Field Conversion			112.203

Source: BPS (2020) [9]

The loss of paddy fields driven by rapid urbanisation can trigger regional and national food security issues [10]. Urbanisation is the process of increasing population growth in urban areas [11]. The development of urbanisation is influenced by the conversion of paddy fields, which causes the loss of rice fields as a source of income for farmers. This situation forces farming communities to look for work in urban areas. As many as 56.7% of the Indonesian population chose to live in urban areas in 2020. This is predicted to increase to 66.6% by 2035 [12].

In general, it can be classified that there are two factors that cause land conversion, namely pull factors and push factors. Pull factors come from outside (external factors) that affect the conversion of agricultural land to non-agricultural land in the form of macroeconomic conditions, non-agricultural needs, non-agricultural land prices.

Meanwhile, push factors are factors originating from within the landowner such as the amount of production and the amount of income from the declining agricultural sector, limited per capita land ownership, and declining interest of young farmers in urban areas [13].

Land use change is indirectly caused by competition for prime agricultural land, trade in agricultural commodities, and agronomic innovations to support cultivation under certain conditions. Different land uses will compete for available land [14]. Rapid population growth, population migration, and the shift of rural areas to cities are some of the reasons for land conversion [15].

Many studies have discussed the factors that influence the conversion of paddy fields; among others, [7], [16], [17], [18], and [4], studies have been conducted. According to [7] and [19] the factors that influence the conversion of paddy fields are the exchange rate of farmers and the industrial sector. In addition to these two factors, construction factors and population are factors that can affect the conversion of paddy fields [16] Land price and rice productivity are factors that influence the conversion of paddy fields [17]. Other factors that can affect the conversion of paddy fields are the number of schools in an area [18].

Research that has been conducted by previous researchers, only discusses the factors that affect the conversion of paddy fields and does not describe the level of conversion of paddy fields in each part of the regions. The results of the research that will be conducted can find out the mapping of conversion of paddy fields in each region in Indonesia. Mapping the conversion of paddy fields can make it easier to distinguish the level of conversion of paddy fields in each province in Indonesia. However, the research focuses on each region which has a limited scope of discussion. The results of this study can be useful in providing long-term considerations about efforts to protect agricultural land.

In addition, land conversion has an impact on the decline in rice production in Indonesia. The growth of rice production in Indonesia in 2010-2019 was -1.59% [20-24]. Many studies have discussed the impact of decreased rice production due to conversion of paddy fields; among others [20] and [16] In accordance with research by Prayuga, [20]. Land conversion in Tamansari District, Bogor Regency experienced an impact of 424.97 tonnes of rice lost and suffered a loss of Rp. 2,434,209,348.02. Rice production losses occurred in Karawang Regency due to

the conversion of paddy fields amounting to 12,887.97 tonnes during the last six months with a value of 37.56 billion rupiah [16].

The research that has been done only focuses on the topic of the rate of land conversion, knowing the factors that can affect the conversion of paddy fields, and calculating the impact of losses caused by conversion of paddy fields. Research that links the rate of land conversion with the mapping of paddy field conversion areas is still limited. Therefore, this research will discuss more about the rate of conversion of paddy fields with conversion area mapping, along with discussing the relationship between land conversion and urbanisation in Indonesia. With the mapping of the conversion area of paddy fields, readers will find it easier to understand the level of conversion of paddy fields in the region. From the level of conversion of paddy fields in each region, it can be seen which areas are experiencing urbanisation. Because basically urbanisation is one of the factors causing land conversion. The purpose of this study is to determine the rate of conversion of paddy fields in Indonesia, find out what factors affect the conversion of paddy fields in Indonesia, and determine the impact of conversion of paddy fields on rice production in Indonesia.

Research Methods

This study uses secondary data in 34 provinces of Indonesia. Indonesia is one of the countries located on the Asian continent, namely Southeast Asia. Indonesia has a total of 16,766 islands consisting of 34 provinces, 416 districts and 98 cities spread across five major islands namely Java Island, Sumatra Island, Kalimantan Island, Sulawesi Island, and Papua Island.

This study uses panel data starting from 2015 to 2019 which covers all provinces in Indonesia, namely 34 provinces, so that the total data used is 170 data. The panel data used in the study are the population in Indonesia, the proportion of paddy fields to the total area of the province in Indonesia, rice productivity in Indonesia, the ratio of agricultural GRDP to industrial GRDP in Indonesia, the price of grain in Indonesia, and the ratio of agricultural GRDP to overall GRDP in Indonesia.

First analysis is rate of land conversion to determine the value of the rate of conversion of paddy fields in Indonesia using the formula:

$$V = \frac{L_t - L_{t-1}}{L_t} \times 100\% \quad (1)$$

Description:

V = Conversion rate of paddy field (%)
Lt = Area of paddy field at present/year t (Ha)
L(t-1) = Area of paddy field in the previous year (Ha)

Decision-making criteria:

V < 0 = The conversion rate of paddy fields in Indonesia is high
V ≥ 0 = Conversion rate of paddy field in Indonesia is low

The next analysis tool is linear regression analysis with panel data used to answer the factors that influence the conversion of paddy fields. There are three regression models with panel data, namely the CEM (Common Effect Model), FEM (Fixed Effect Model), and REM (Random Effect Model) models. The formula used is [4]:

$$Y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + \beta_4 X_{4it} + \beta_5 X_{5it} + \beta_6 X_{6it} + \varepsilon_i \quad (2)$$

Description:

Y = Conversion of paddy fields in Indonesia (Ha)
X_1 = Total population (Thousand people)
X_2 = Proportion of paddy field area to provincial area in Indonesia (%)
X_3 = Rice productivity (Quintal/Ha)
X_4 = Ratio of Agricultural GRDP to Industrial GRDP (%)
X_5 = Grain Price (Rp/Kg)
X_6 = Ratio of Agricultural GRDP to Overall GRDP (%)
i = The i-th Individual (Province)
t = The tth period (Year)
εi = Error

The stage of panel linear regression is to test together the effect of variation in variable X on variable Y, F test. The next step is to identify how far the model's ability to explain the value of variations in the dependent variable caused by variations in the independent variable using the coefficient of determination (R^2). At the time of testing

if the obtained F-count > F-table then continue with the t-test with the aim of knowing how far the influence of each independent variable individually on the dependent variable. there are several classical assumptions that must be considered so that the linear regression model with panel data can be fulfilled, namely the Normality Test, Multicollinearity, Heteroscedasticity, and Autocorrelation.

In determining the best panel data regression model for a problem in research, namely by conducting two special tests, namely the Chow Test, Hausman Test, and Lagrange Multiplier Test. The Chow test tests between the CEM and FEM models. The CEM model is selected if the Chow Test result ≥ 0.05, the FEM model is selected if the Chow Test result ≤ 0.05. The Hausment test tests between the FEM model and the REM model. The FEM model is selected if the Hausment Test result is ≤ 0.05, the REM model is selected if the Hausment Test result is ≥ 0.05. The next test is the Lagrange Multiplier Test which compares between the CEM and REM models. The CEM model is selected if the Lagrange Multiplier Test result ≥ 0.05, the REM model is selected if the Lagrange Multiplier Test result ≤ 0.05. In panel data regression, there are FEM and REM models that can produce a fixed effect coefficient. The fixed effect coefficient is additional information that can distinguish between regions in this case the province. The results of the fixxed effect coefficient output will later be categorised. The constant value of each province will then be categorised into high, medium and low categories.

To determine the impact of land conversion, several formulas were used to obtain the lost rice production and its value. The lost rice production is obtained from the total area of converted paddy fields multiplied by the average productivity of rice. Meanwhile, the value of lost rice production was obtained by multiplying the amount of lost rice production by the price of grain. The following is a summary of the formula used [25] and [26]:

$$Qi = \sum(Si \times Hm) \tag{3}$$

Description:
Si = Area of converted paddy fields in Indonesia (Ha)
Hm = Productivity of paddy rice per year in Indonesia (Kuintal/Ha)

$$Qt = \sum Qi \tag{4}$$

Description:
Qi = Rice paddy production lost per year in Indonesia (Kwintal/Year)

$$NQ = \sum(Pt \times Qt) \tag{5}$$

Description:
NQ = Value of rice paddy production lost in Indonesia (Rp)
Pt = Grain price in Indonesia (Rp)
Qt = Rice paddy production lost in Indonesia per year (Kwintal)
t = Year of data

Result and Discussion

Conversion Rate of Paddy Fields in Indonesia

Changes in paddy fields in Indonesia in 2015-2019 can be seen in the following graph:

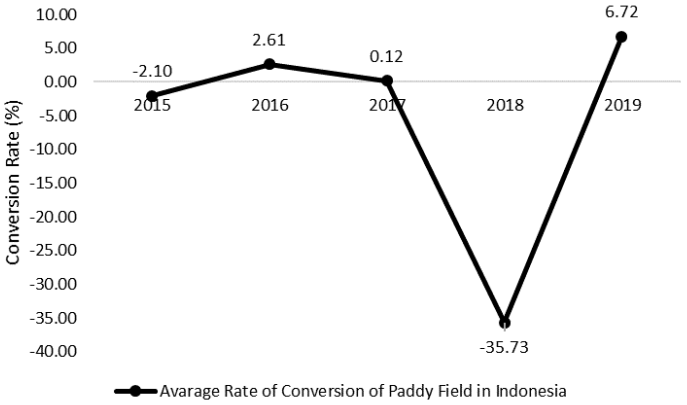

FIGURE 1. Average Rate of Conversion of Paddy Fields in Indonesia in 2015-2019

Based on FIGURE 1, it is known that 2018 was the highest year of conversion of paddy fields, namely -35.73%. This condition was caused by the addition of 1,969 medium and large-scale industries from 2017 to 2018 [25]. The housing sector in 2018 built 5,999 new housing units [27, 28]. The addition of infrastructure in the form of toll roads from 2017 to 2018 reached 459.23 km with a total length of 1,740.79 km [29].

West Papua Province is the province with the highest amount of conversion of paddy fields compared to other provinces. Factors driving the conversion of paddy fields in West Papua Province are the continuous development of road infrastructure, limited and non-functional dam and irrigation infrastructure, unstable soil texture that is difficult for farmers to adjust, and relatively high land prices [4]. The province that has a positive average value is Riau Islands Province at 8.83%.

The conversion rate of paddy fields in Java Island from 2015 to 2019 has an average of -0.79% per year. DKI Jakarta Province experienced the largest conversion of paddy fields with an average of -13.77% per year. The factor that causes the large average conversion of paddy fields in DKI Jakarta Province is the development of facilities and infrastructure. One example is in 2019. The conversion rate of paddy fields outside Java

Island reached an average of -6.72% per year. West Papua Province became the province outside Java with the largest average rate of conversion of paddy fields, reaching -19.81% per year.

TABLE 2. Average Rate of Conversion of Paddy Fields in Indonesia 2015-2019

No.	Provinsi	Average Conversion Rate of Paddy Fields 2015-2019 (%)
1.	Aceh	-8.51
2.	Sumatera Utara	-10.58
3.	Sumatera Barat	-3.16
4.	Riau	-8.65
5.	Jambi	-10.86
6.	Sumatera Selatan	-8.41
7.	Bengkulu	-14.74
8.	Lampung	-3.56
9.	Kep, Bangka Belitung	-5.09
10	Kep, Riau	8.83
11.	Dki Jakarta	-13.77
12.	Jawa Barat	0.08
13.	Jawa Tengah	1.59
14.	Di Yogyakarta	5.37
15.	Jawa Timur	1.63
16.	Banten	0.36

17.	Bali	-1.60
18.	Nusa Tenggara Barat	-2.06
19.	Nusa Tenggara Timur	-2.76
20.	Kalimantan Barat	-17.64
21.	Kalimantan Tengah	-10.32
22.	Kalimantan Selatan	-12.09
23.	Kalimantan Timur	-8.90
24.	Kalimantan Utara	-13.20
25.	Sulawesi Utara	-5.46
26.	Sulawesi Tengah	-4.12
27.	Sulawesi Selatan	0.98
28.	Sulawesi Tenggara	-4.42
29.	Gorontalo	0.27
30.	Sulawesi Barat	-11.22
31.	Maluku	4.55
32.	Maluku Utara	1.75
33.	Papua Barat	-19.81
34.	Papua	-17.44
	Average	-5,68

Based on TABLE 1, the average rate of conversion of paddy fields in Indonesia reached -5.67% per year. West Papua Province is the highest province of conversion of paddy fields with an average rate of land conversion reaching -19.81% per year when compared to other provinces in Indonesia. Riau Islands Province is the lowest paddy field conversion province with an average value of paddy field conversion rate with an average value of 8.83% per year. Conversion of paddy fields in Indonesia can be divided into Java Island and Outer Java Island.

The province with the highest rate of conversion of paddy fields in Java Island is DKI Jakarta with an average of -13.77% per year. The high rate of conversion of paddy fields in DKI Jakarta is caused by the construction of facilities and infrastructures, one of which is the toll road [31]. The region outside Java Island with the highest rate of conversion of paddy fields is Papua Province with an average rate of conversion of paddy fields reaching -19.81% per year. Road infrastructure development, non-functioning dams and irrigation, high land prices, and poor soil texture are the driving factors for the highest conversion of paddy fields in western Papua outside Java [32].

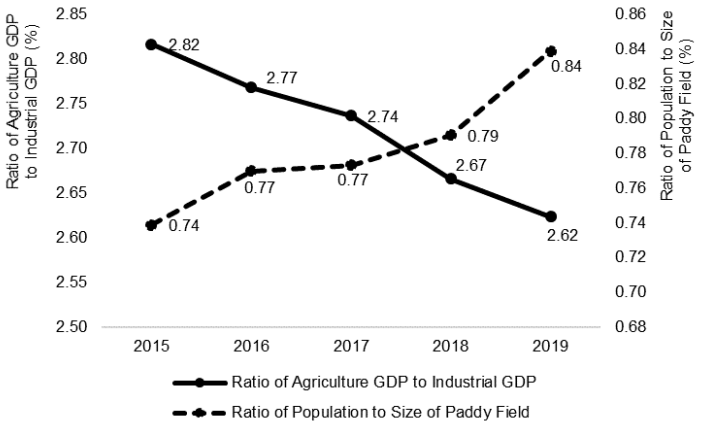

FIGURE 2. A composite graph of the average ratio of population to paddy field area and the average ratio of agricultural GRDP to industrial GRDP

Based on FIGURE 2, the ratio of population to the size of paddy fields in Indonesia for the period 2015-2019 tends to increase every year. This shows that the increase in population is relatively faster than the size of paddy fields. The increase in the ratio shows that the conversion of paddy fields is increasing due to the increase in

population. Population development that increases every year has an impact on housing needs. The need for housing will have an impact on paddy fields that become victims to make housing land [33].

The ratio of agricultural GRDP to industrial GRDP in Indonesia in the 2015-2019 period tends to decrease each year. This shows that the increase in industrial GRDP is faster than that of agricultural GRDP. In this graph, industrial GRDP has a major role in growing compared to agricultural GRDP. This is supported by data from the Ministry of Industry [33], the number of additional industries from 2015 to 2019 has always increased with an average of 5,520 industries per year.

The loss of paddy fields certainly has an impact on the loss of people's livelihoods in farming. This is what causes urbanisation, where people seek decent jobs in the city because their agricultural land has been converted. The existence of urbanisation will affect agricultural land which is converted into residential, industrial, commercial, civic, and cultural land so that people can find space in urban areas. Population growth and the process of urbanisation are associated with the conversion of large areas of paddy fields into urban development [34].

According to research by Wijayanti & Priyanto [35], in 1961-2016 the urbanisation population in Indonesia showed an increasing trend. The high level of urbanisation in Indonesia is not proportional to the development of agricultural land. Urbanisation causes the number of people in urban areas and regional income to increase, resulting in the conversion of paddy fields. The results of research by Wijayanti & Priyanto [35], showed that the growth of urbanisation will reduce the area of arable land by 7.85 Ha. This urbanisation activity can trigger a decrease in rice production due to the depletion of paddy fields. Rapid urbanisation in urban areas, especially in developing countries, can increase the economic prosperity of the community. However, it can have a negative impact on the environment if the balance between population growth, economic development, and the environment is not considered [36].

Factors Affecting Paddy Field Conversion in Indonesia

The process of testing the factors that can affect the conversion of paddy fields in Indonesia was carried out using panel data in 2015 - 2019 by taking 34 provinces. Based on the model tests that have been carried out, namely the chow test and the hausmen test, the FEM (Fixed Effect Model) model is the best model to use. Because the best model is FEM, the Langrange Multiplier Test does not need to be done. The significant variables in the FEM model are population (X1), proportion of paddy field area to area (X2), ratio of agricultural GRDP and industrial GRDP (X4), and ratio of agricultural GRDP and total GRDP (X6). The following output is generated in the FEM model:

TABLE 3. Result of Analysis Factors Affecting Paddy Field Conversion in Indonesia Basen on the FEM Model

Variable	Coefficient	Value	Prob. t
Constant	-159,486	-3,094253	0,0024
X1	18,458	2,864408	0,0049
X2	1,311	2,859726	0,0049
X3	0,050	0,029703	0,9763
X4	3,209	2,051093	0,0423
X5	-0,952	-0,733287	0,4647
X6	11,552	2,679407	0,0083
R-squered	0,648450	*F-statistic*	6,148476
Adj R-squered	0,542985	*Prob(f-statistic)*	0,000000
		Durbin -Watson	2,831519

Based on TABLE 3, the R-squered value is 0,648450%, this shows that the diversity of the dependent variable is 64,84%, meaning that the conversion of paddy fields in Indonesia is influenced by the independent variables in the equation model. While the remaining 35,16% is influenced by independent variables outside the equation model. The F-count value of 6,148476 is greater than the f-table of 2,15 (F-count > F-table), with this H0 is rejected. This situation shows that all independent variables consisting of population (X1), the proportion of paddy field area to area (X2), rice productivity (X3), the ratio of agricultural GRDP to industrial GRDP (X4), the price of grain (X5), and the ratio of agricultural GRDP to overall GRDP (X6) together affect the dependent variable, namely the conversion of paddy fields in Indonesia. Based on the t-test, the variables of population (X1), the proportion of paddy field area to the total area (X2), the ratio of agricultural GDP to industrial GDP (X4), and the ratio of agricultural GDP to total GDP (X6) have a significant effect on the conversion of paddy fields in Indonesia, which is indicated by the probability value of these variables smaller than the 5% significant level. While the variables of rice

productivity (X3) and price of grain (X5) do not significantly affect the conversion of paddy fields in Indonesia, which is shown in the probability value greater than 5% significant level. Thus, the regression model equation is obtained as follows:

$$Y = -159{,}4868 + 18{,}45809\,X_1 + 1{,}311858\,X_2 + 3{,}209657\,X_4 - 0{,}952508\,X_5 + 11{,}55242\,X_6 \quad (6)$$

The results of the regression equation can be interpreted that the constant coefficient value of -159.4868 means that if the variable population ($X1$), the proportion of paddy field area to the total area ($X2$), rice productivity ($X3$), the ratio of agricultural GDP to industrial GDP ($X4$), grain price ($X5$), and the ratio of agricultural GDP to overall GDP ($X6$) are considered constant, there will be a decrease in paddy fields in Indonesia of 159,4868 ha. Based on the results of panel data analysis in the FEM model, the fixed effect coefficient estimation value is obtained that can distinguish each provincial region. Following are the results of the fixed effect coefficient estimation:

TABLE 4. Fixed effect coefficient results

No.	Province	Fixed Effect Coefficient	Constant	Category
1.	Aceh	0.846498	-158.640302	Medium
2.	North Sumatra	-15.90126	-175.388060	Medium
3.	West Sumatra	-0.729148	-160.215948	Medium
4.	Riau	-3.823113	-163.309913	Medium
5.	Jambi	8.583414	-150.903386	Medium
6.	South Sumatra	-7.769256	-167.256056	Medium
7.	Bengkulu	18.24401	-141.242790	Medium
8.	Lampung	-1.13775	-160.624550	Medium
9.	Kep, Bangka Belitung	22.12745	-137.359350	Low
10	Kep, Riau	-3.817859	-163.304659	Medium
11.	DKI Jakarta	-64.68408	-224.170880	High
12.	West Java	-42.06479	-201.551590	High
13.	Central Java	-31.32308	-190.809880	High
14.	DI Yogyakarta	0.815246	-158.671554	Medium
15.	East Java	-35.04562	-194.532420	High
16.	Banten	-22.13804	-181.624840	High
17.	Bali	-1.852933	-161.339733	Medium
18.	West Nusa Tenggara	-0.892375	-160.379175	Medium
19.	East Nusa Tenggara	-4.810566	-164.297366	Medium
20.	West Kalimantan	2.49296	-156.993840	Medium
21.	Central Kalimantan	13.07047	-146.416330	Medium
22.	South Kalimantan	4.36294	-155.123860	Medium
23.	East Kalimantan	-3.090141	-162.576941	Medium
24.	North Kalimantan	30.18131	-129.305490	Low
25.	North Sulawesi	12.56767	-146.919130	Medium
26.	Central Sulawesi	12.40697	-147.079830	Medium
27.	South Sulawesi	-6.594877	-166.081677	Medium
28.	Southeast Sulawesi	11.09215	-148.394650	Medium
29.	Gorontalo	26.46229	-133.024510	Low
30.	West Sulawesi	29.26074	-130.226060	Low
31.	Maluku	14.01053	-145.476270	Medium
32.	North Maluku	21.74446	-137.742340	Low
33.	West Papua	22.77894	-136.707860	Low
34.	Papua	-5.373151	-164.859951	Medium

Based on TABLE 4, the results of the fixed effect output show that the lowest fixed effect coefficient value is North Kalimantan Province, meaning that there is a decrease in paddy fields in North Kalimantan Province by 129.30549 ha if all independent variables are considered constant. The province that has the highest fixed effect coefficient value is DKI Jakarta Province, which means that there is a decrease in paddy fields in DKI Jakarta Province by 129.30549 ha if all independent variables are considered constant. The table above can be depicted in the form of a thematic map. The following is a thematic map of conversion of paddy fields in Indonesia:

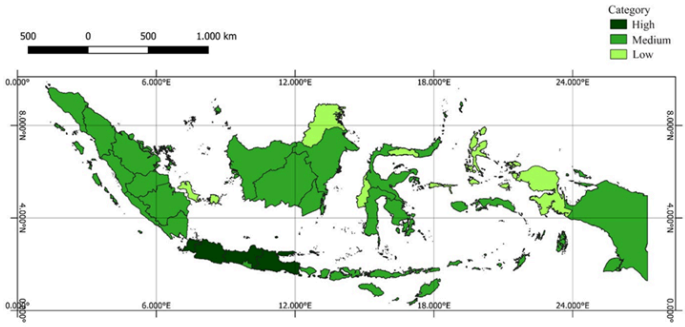

FIGURE 3. Thematic map of paddy field conversion in Indonesia

Based on the thematic map image, provinces with light green colour are provinces with low conversion value of paddy fields. Provinces with green colour have moderate conversion value of paddy fields. While provinces that have dark green colour have a high value of conversion of paddy fields. Java Island shows a dark green colour, which means that it has the highest conversion of paddy fields.

According to [37], the factor of population growth and the increasing need for land in various sectors such as housing, services and industry sectors that tend to increase have an impact on provinces located on Java Island, almost all of which are in the high category. This was also expressed by [38], who stated that population growth has a role in the conversion of paddy fields. The increase in population, especially in urban areas or what is commonly referred to as urbanisation, is one of the factors that make provinces on the island of Java in the high category. The more people who move to urban areas, the more the need for housing and industry. So that it will have an impact on the condition of agricultural land that is converted into non-agricultural.

Based on the results of the classical assumption test, the correlation value between independent variables is obtained for each independent variable less than 0.9, which means that the panel data regression model does not experience multicollinearity. The result of the probability value is 0.026431, with this the probability value is smaller than the α level of 0.05. These results mean that the data is not normally distributed. However, based on the experience of several statisticians, data totalling more than 30 numbers (n> 30), it can be assumed that the data is normally distributed [39]. The results of the heteroscedasticity test obtained the probability value of each variable is more than the significant value of 0.05. With this result, it means that the panel data regression model does not occur herokeadsticity. Based on the results of the autocorrelation test, the durbin-watson value is DW = 2.831519. the results obtained d_L = 1.6767 and d_U = 1.8226. Because the DW>d_U result, it is concluded that random errors do not occur autocorrelation.

Total Population

The results of the analysis on panel data regression, the population variable (X1) has a significant effect on the conversion of paddy fields in Indonesia. This is indicated by the probability result of 0.0049. This value is smaller than 0.05. The population variable has a positive coefficient value of 18.45809, meaning that every additional population of 1 thousand people will increase the conversion of paddy fields in Indonesia by 18.45809 Ha assuming other variables are considered constant. These results are also similar to the research of [21]. which states that population density has a positive influence on the conversion of paddy fields. The population has a relationship with the demand for land for housing facilities.

Proporion of Paddy Field Area to Area

The variable proportion of paddy field area to the total area has a significant This is indicated by the probability result of 0.0049. This value is smaller than 0.05. The variable proportion of paddy field
area with the area has a positive coefficient value of 1.311858, meaning that every 1% increase in the proportion of paddy field area with the area will increase the conversion of paddy fields in Indonesia by 1.311858 Ha assuming other variables are considered constant. In line with research by [40]. which states that the proportion of land will

have a positive impact on land conversion. So, the greater the proportion of land area to area, the higher the rate of conversion of paddy fields.

Rice Productivity

Rice productivity variable (X3) has no significant. This is indicated by the probability result of 0.9763. This value is greater than 0.05. Similar to the research of [41], which states that rice productivity has no significant effect on the conversion of paddy fields. High and low rice productivity is not necessarily a factor causing conversion of paddy fields. Low rice productivity is not necessarily the reason farmers convert land into non-field land.

Based on the theory presented by David Ricardo, it states that soil fertility can affect land rent. Fertile soil has a high level of productivity, so that plant development becomes faster and affects high production. However, this does not affect the high and low conversion of paddy fields to the non-agricultural sector.

Ratio of Agricultural GRDP to Industrual GRDP

Variable ratio of agricultural GRDP to industrial GRDP (X4) has a real effect on the conversion of paddy fields in Indonesia. This is indicated by the probability value of 0.0423. This value is smaller than 0.05. The variable ratio of agricultural GRDP to industrial GRDP has a positive coefficient value of 3.209657, meaning that any increase in the ratio of agricultural GRDP to industrial GRDP by 1% will increase the conversion of paddy fields in Indonesia by 3.209657 Ha assuming other variables are considered constant.

Von Tunen's theory states that land located in economic and industrial centres has more advantages. These advantages are easy access and adequate facilities. In accordance with the results, Java Island is the centre of the economy and industry in Indonesia, marked by high land conversion in Java Island. Therefore, more industrial centres will increase conversion in Java.

Grain Price

The results of the analysis on panel data regression, the Grain Price variable (X5) has no significant. This is indicated by the probability result of 0.4647. This value is greater than 0.05. Similar to the research of [42] stated that the price of grain does not have a significant influence on the conversion of paddy fields. Grain price is not significant because the increase in grain price that occurs is not commensurate with the increase in production costs.

Farmers convert paddy fields not necessarily because of the price of grain. As infrastructure development, farmers who convert land are not influenced by grain prices but are affected by government infrastructure development, one of which is toll road construction. Thus, farmers are forced to convert their rice fields into non-agricultural land.

Ratio of Agricultural GRDP to Total GRDP

The variable ratio of agricultural GRDP to overall GRDP (X6) has a significant effect on the conversion of paddy fields in Indonesia. This is indicated by the probability result of 0.0083. The ratio of agricultural GRDP to total GRDP has a positive coefficient value of 11.55242, meaning that every increase in the ratio of agricultural GRDP to total GRDP by 1% will increase the conversion of paddy fields in Indonesia by 11.55242 Ha assuming other variables are considered constant.

Factors Affecting Paddy Field Conversion in Indonesia

The following is the impact of conversion of paddy fields on the production and value of rice production in Indonesia in 2015-2019.

TABLE 4. Impact of rice field conversion on the value of rice production in Indonesia

Year	Total Converted land (ha)	Productivity (Kwintal/Ha)	Production lost (Quintal)	Production value lost (000 Billion)	Indonesia's GRDP (000 Billion)
2015	102.179	46	4.661.930	2.141	11.540
2016	21.400	44	943.980	439	12.406

2017	66.506	44	2.936.700	1.349	13.588
2018	1.272.812	44	56.162.280	26.968	14.837
2019	20.7675	43	8.930.920	4.233	15.833
Total	1.670.572	44,2	73.635.810	35.132	68.204

Declining paddy fields can lead to declining rice production. This condition is inversely proportional to the growing population. Based on the results of the calculation of the impact analysis of land conversion, the impact caused by the conversion of paddy fields in Indonesia in 2015 - 2019 was a total loss of rice production of 73,635,810 quintals. Conversion of paddy fields in Indonesia has an impact on the value of lost rice production, which for 5 years (2015-2019) has a value of Rp 35,132,748,789,089 or Rp 35 trillion The higher the area of converted paddy fields, the more the amount of lost rice production will cause, so that the impact on the value of lost rice production is also higher.

The impact of conversion of paddy fields results in the emergence of problems in rice production which is decreasing. The loss of rice production will affect food security which is not easy to recover in a short time. This is due to the fact that some converted paddy fields are permanent, constrained to return to paddy fields. In addition, printing new paddy fields needs a long time. Thus, the impact of conversion of paddy fields requires several government policies in overcoming the problem, namely through the protection of sustainable agricultural land (LP2B) such as providing farmer incentives, insurance in case of crop failure, and providing subsidies [43-45].

CONCLUSION

The rate of conversion of paddy fields in Indonesia in 2015-2019 can be seen to be in the high criteria with an average value of 5.68% per year. DKI Jakarta Province is the largest province of paddy field conversion in 2015-2019 in Java with a decrease in paddy field area of 13.77% per year, while West Papua Province is the largest province of paddy field conversion in 2015-2019 outside Java with a decrease in land area of 19.81% per year.

Factors that significantly affect the conversion of paddy fields in Indonesia are population, the proportion of paddy field area to the total area in Indonesia, the ratio of agricultural GRDP to industrial GRDP, and the ratio of agricultural GRDP to overall GRDP. While the factors that do not significantly affect the conversion of paddy fields in Indonesia are rice productivity and grain prices. Rice productivity and grain prices are not necessarily the cause of farmers to convert their land to non-agriculture because of the pattern of social change in the farming community.
The impact of conversion of paddy fields on rice production in Indonesia in 2015 - 2019 resulted in a loss of rice production of 73,635,810 quintals with a lost rice production value of IDR 35,132,748,789,089 or IDR 35 trillion. The lost rice production will affect food security in Indonesia.

Acknowledgments

This article would not have been completed without the support of my parents, UNEJ agribusiness lecturers, my seniors, and my friends. Therefore, I would like to thank them for encouraging and helping me in writing this research.

References

1. P. I. S. Mokodompit, J. I. Kindangen, and R. C. Tarore, “Perubahan Lahan Pertanian Basah di Kota Kotamobagu”, in *Jurnal Perencanaan Wilayah dan Kota*, **6**(3), 792–799 (2019).
2. R. Prabowo, Bambang, A. Nur, and Sudarno, “Pertumbuhan Penduduk Dan Alih Fungsi Lahan Pertanian”, in *Jurnal Ilmu-Ilmu Pertanian*, **16**(2), 26–36 (2020).
3. M. Rondhi, P. A. Pratiwi, V. T. Handini, A. F. Sunartomo, and S. A. Budiman, “Agricultural land conversion, land economic value, and sustainable agriculture: A case study in East Java, Indonesia”, in *Land*, **7**(4) (2018). https://doi.org/10.3390/land7040148
4. A. N. Mandamdari, D. Kusnaman, A. Herry, and K. Elyanto, “Analisis Faktor-Faktor Yang Mempengaruhi Konversi Lahan Pertanian”, in *Jurnal Ilmiah Membangun Desa dan Pertanian*, **6**(4), 131–137 (2021).
5. N. Novira, A. S. Dalimunthe, M. Pinem, Elfayetti, and K. Pinem, “Rice field conversion and urban agglomeration in Indonesia: Between power and options”, in *Journal of Physics: Conference Series*, **1175**(1) (2019).

6. G. A. Y. S. Pia, "Konversi Penggunaan Lahan Produksi Beras dan Ketahanan Pangan", in *Jurnal Penelitian Pendidikan Tinggi SMCC*, **8**, 135–147 (2021).
7. W. D. Febriana, "Analisis Faktor-Faktor Yang Memengaruhi Konversi Lahan Sawah dan Dampaknya Terhadap Produksi Padi Di Pulau Jawa", Institut Pertanian Bogor, (Tesis. IPB University, Bogor, Jawa Barat, Indonesia) (2016). Accessed from https://repository.ipb.ac.id/handle/123456789/82351.
8. A. Prayuga, "Analisis Dampak dan Laju Alih Fungsi Lahan Sawah di Kecamatan Tamansari Kabupaten Bogor", in *Skripsi. IPB University, Bogor, Jawa Barat, Indonesia* (2017). Accessed from https://repository.ipb.ac.id/handle/123456789/83628
9. Badan Pusat Statistik, "Presentase Penduduk Daerah Perkotaan menurut Provinsi 2010-2035", (2020) Accessed from https://www.bps.go.id/statictable/2014/02/18/1276/persentase-penduduk-daerah-perkotaan-hasil-proyeksi-penduduk-menurut-provinsi-2015---2035.html
10. H. Long, G. Dazhuan, Z. Yingnan, T. Shuangshuang, Q. Yi, and M. Li, "Changing man-land Interrelations in China's Farming Area Under Urbanization and Its Implications for Food Security", in *Environmental Management*, **209**: 440-451 (2018).
11. T. W. Prayojana, Mardhatil, N. F. Ade, S. Beben, "Dampak Urbanisasi Terhadap Pemukiman Kumuh (SLUM AREA)", in *Jurnal Kependudukan dan Pembangunan Lingkungan*, **2**, 13-22 (2020).
12. Badan Pusat Statistik. Statistik, "Luas Lahan Pertanian Tahun 2015-2019", Jakarta: Badan Pusat Statistik, (2020).
13. Badan Pusat Statistik, Luas Lahan Sawah 2010-2015, (2021). Accesed from https://www.bps.go.id/indicator/53/179/2/luas-lahan-sawah.html
14. E. F. Lambin, M. Patrick, "Global Land Use Change, Economic Globalization, and the looming land Scarcity", in *PNAS*, **108**(9), 3465-3472 (2011).
15. R. Nedd, L. Katie, O. Marcia, J. Neil, J. Elijah, and A. Aavudai, "A Synthesis of Land Use/Land Cover Studies: Definitions, Classification Systems, Meta-Studies, Challangges and Knowladge Gaps on a Global Landscape", in *Land*, **10**(994) 1-30 (2021).
16. A. S. Hasibuan, "Analisis faktor – faktor yang mempengaruhi konversi lahan pertanian sawah ke non pertanian di Kabupaten Karawang", (Tesis. IPB University, Bogor, Jawa Barat, Indonesia) (2018). Accessed from https://repository.ipb.ac.id/handle/123456789/92429
17. R. Husna, A. Azhar, and E. Marsudi, "Faktor-Faktor yang Mempengaruhi Alih Fungsi Lahan Sawah di Kabupaten Aceh Besar", in *Jurnal Ilmiah Mahasiswa Pertanian*, **3**(4), 525–533 (2018).
18. M. Sri, S. Joko, and A. S. Wuri, "Analisis Faktor-Faktor Yang Mempengaruhi Alih Fungsi Lahan Pertanian Ke Non Pertanian Di Kabupaten Tangerang", in *Jurnal Kajian Ruang*, **1**(2), 12–26 (2019).
19. B. H. Baltagi, "Econometric Analysis of Panel Data, Third Edition", John Wiley and Sons. England (2005).
20. Badan Pusat Statistik, "Luas Panen, Produksi, dan Produktivitas Padi Menurut Provinsi 2019-2021", (2021). Accessed from https://www.bps.go.id/indicator/53/1498/1/luas-panen-produksi-dan-produktivitas-padi-menurut-provinsi.html
21. Badan Pusat Statistik, "Produksi padi tahun 2015 diperkirakan naik 6,64%", (2015). Accessed from https://www.bps.go.id/pressrelease/2015/07/01/1157/produksi-padi-tahun-2015-diperkirakan-naik-6-64-persen.html
22. Badan Pusat Statistik, "Produksi Padi (ton) Menurut Provinsi 2010 – 2015", (2021). Accessed from https://www.bps.go.id/site/resultTab
23. Badan Pusat Statistik, "Sensus Penduduk 2020", Jakarta, (2021).
24. Sjafrizal, "Perencanaan Pembangunan Daerah dalam Otonomi", in *Raja Grafindo*, Depok (2004).
25. D. F. Utama, "Analisis Faktor – Faktor yang Mempengaruhi Konversi Lahan Sawah ke Penggunaan Non Sawah di Kabupaten Cirebon" in *Skripsi. IPB University, Bogor, Jawa Barat, Indonesia* (2006). Accessed from https://repository.ipb.ac.id/handle/123456789/50
26. Karmini, "Ekonomi Produksi Pertanian", Mulawarman University Pres. Samarinda (2018).
27. Ministry of Indusry, "Transformasi Manufaktur Menuju Industru Maju (Laporan Kinerja Kementrian Perindustrian) 2015-2019", in *Kementrian Industri*, Jakarta (2019).

28. Ministry of Public Works and Public Housing: Ditjen Perumahan. (2020) Accessed from https://data.pu.go.id/dataset/rumah-swadaya
29. Ministry of Public Works and Public Housing: Data Jalan Tol Operasi. [23] Accessed from https://bpjt.pu.go.id/assets/js/vendor/ckeditor/uploads/jalan%20tol%20beroperasi/25%20Februari%202022/25-02-2022%20-%20data%20jalan%20tol%20operasi%202493%2C64%20last.pdf
30. A. Palilu, "Faktor-faktor Penyebab Transformasi Lahan Pertanian Di Kabupaten Sorong Provinsi Papua Barat", in *Jurnal Jendela Ilmu*, **2**(2), 41–47 (2021).
31. R. Fajarini, B. Barus, and D. R. Panuju, "Dinamika Perubahan Penggunaan Lahan dan Prediksinya untuk Tahun 2025 serta Keterkaitannya dengan Perencanaan Tata Ruang 2005-2025 di Kabupaten Bogor", in *Jurnal Tanah Lingkungan*, **17**(1), 8-15 (2015).
32. A. Palilu, "Faktor-faktor Penyebab Transformasi Lahan Pertanian Di Kabupaten Sorong Provinsi Papua Barat", in *Jurnal Jendela Ilmu*, **2**(2), 41–47 (2021).
33. F. A. Anggraeni, "Analisis Faktor Yang Mempengaruhi Peningkatan Urbanisasi Di Kota Jakarta Dan Surabaya Pada Tahun 2020-2021", in *Jurnal Jebaku*, **2**(2), 41-53 (2022).
34. E. Ustaoglu and W. Brenden, "Intitutional Setting and Effect on Agricultural Land Convertion : A Global and Spatial Analysis of European Regions", in *Land*, **12**(47), 1-35 (2023).
35. D. E. Wijayanti and W. Priyanto, "Pengaruh Urbanisasi Terhadap Lahan Garapan di Indonesia", in *Agriscience*, **3**(1), 230-239 (2022).
36. J. Han, M. Xing, Z. Xiang, Y. Bailu, L. Min, X. Wei-Ning, "A Long-term Analysis of Urbanization Process, Landscape Chane, and Carbon Sources and Sinks: A Case Study in China's Yangtze River Delta Region", in *Clener Production*, **141**, 1040-1050 (2017).
37. Ashari, "Tinjauan Tentang Alih Fungsi Lahan Sawah ke Non Sawah dan Dampaknya di Pulau Jawa", in *Forum Penelitian Agro Ekonomi*, **21**(2), 83-96 (2003).
38. W. T. Defriyanti, "Pengaruh Luas Lahan Sawah Dan Luas Tanam Terhadap Produksi Padi di Sumatera Selatan Melalui Analisis Regresi", in *Publikasi Penelitian Terapan dan Kebijakan*, **2**(2), 122–124 (2019).
39. D. Fahmeyzan, S. Soraya, and D. Etmy, "Uji Normalitas Data Omzet Bulanan Pelaku Ekonomi Mikro Desa Senggigi dengan Menggunakan Skewness dan Kurtosi", in *Jurnal VARIAN*, **2**(1), 31–36 (2018).
40. K. A. P. Pradhani, U. Sehabudin., Raswatie., and F. Dewi, "Dampak Konversi Lahan Sawah Irigasi Terhadap Ketersediaan Pangan Pokok Beras di Pulau Jawa, in *Skripsi IPB University, Bogor, Jawa Barat* (2021).
41. F. Ainurrahman, "Analisis Faktor-Faktor yang Mempengaruhi Konversi Lahan Sawah di Kabupaten Jember", *Skripsi*, Universitas Jember, Jember, Jawa Timur, Indonesia, (2015). Accessed from https://repository.unej.ac.id/handle/123456789/65557
42. S. M. Sitorus, "Analisis Faktor-Faktor yang Mempengaruhi Konversi Lahan Sawah di Kabupaten Bogor", in *Skripsi*, IPB University, Bogor, Jawa Barat, Indonesia (2011). Accessed from https://repository.ipb.ac.id/handle/123456789/100484
43. A. L. Fahri, L. M. Kolopaking, and D. B. Hakim, "Laju Konversi Lahan Sawah Menjadi Perkebunan dan Faktor-Faktor yang Mempengaruhi Serta Dampaknya Terhadap Produksi Padi di Kabupaten Kampar Riau", in *Jurnal Pengkajian dan Pembangunan Teknologi Pertanian*, **17**(1), 69-79 (2014).
44. K. A. P. Pradhani, U. Sehabudin., Raswatie., and F. Dewi, "Dampak Konversi Lahan Sawah Irigasi Terhadap Ketersediaan Pangan Pokok Beras di Pulau Jawa, in *Skripsi IPB University, Bogor, Jawa Barat* (2021).
45. E. Ustaoglu and W. Brenden, "Determinants of Urban Expansion and Agricultural Land Conversion in 25 EU Countries", in *Environmental Management* (2017).