



The Conversion of Productive Agricultural Land and the Growth of Developed Land in Ciampea District, Bogor Regency

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Abstract – This study examines the conversion of agricultural land due to the expansion of built-up areas in Ciampea District, Bogor Regency, Indonesia, to identify land cover changes, factors driving agricultural land conversion, reasons why farmers sell their land, and the economic impacts on food crop production. Using both quantitative and qualitative methods, the study employs land cover analysis, factor analysis, and lost productivity analysis. Findings indicate a direct relationship between the growth of built-up areas and the reduction of undeveloped land, with built-up areas increasing by approximately 218.7 hectares annually. Six variables influence land conversion: location, irrigation channels, economic pressure, population growth, and housing needs. Additionally, six factors affect farmers' decisions to sell: land size, private sector influence, generational factors, living expenses, family responsibilities, and government policies. The conversion of agricultural land has significantly reduced the economic value of food crop production. From 2019 to 2023, the shift of productive land to non-agricultural use resulted in an estimated revenue loss of IDR 4,138,080,000 from rice farming. These findings highlight the urgent need for sustainable land management strategies to balance development and agricultural productivity.

Keywords: land conversion, agriculture, Indonesia, GIS, remote sensing.

1 Introduction

Ciampea District, located within Bogor Regency, West Java, Indonesia, spans 3,398 hectares and houses a population of 168,359, with an annual growth rate of around 1.16% and a density of approximately 4,955 people per square kilometer (BPS, 2023). As the population grows, the demand for land—particularly for housing and supporting infrastructure—also increases. While this trend aligns with government initiatives aimed at accelerating infrastructure and housing development, it leads to a progressive reduction in available land over time (Sheppard & Civco, 2005). The ongoing changes in population and development patterns make land conversion increasingly inevitable, often resulting in the repurposing of agricultural areas to support urban expansion.

Land conversion is the process of altering land use from one type to another, such as turning undeveloped areas into built environments (Rianingsih et al., 2023). This process is commonly associated with urban growth but becomes problematic when it involves productive agricultural land. Data from 2019 to 2023 indicate a substantial reduction in productive farmland in Ciampea District—about 874.7 hectares, with an average annual decrease of 218.7 hectares, or roughly 6.4% of the total

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3 Results and discussion

3.1 Geometric Correction and RMS Analysis

Table 1. RMS Value of Landsat 8 Image in Ciampea District

Point	Cell-X	Cell-Y	Easting (meter)	Northing (meter)	RMS (meter)
1	816.99	-732.01	684000	9276000	0.05
2	2784.97	-732.00	693000	9276000	0.03
3	2784.97	-1388.01	693000	9273000	0.03
4	2784.99	-2700.01	693000	9267000	0.04
5	816.98	-2700.00	684000	9267000	0.04
6	816.98	-1388.03	684000	9273000	0.07
Total RMSe		0,26			
Average RMSe		0,04			

The geometric correction of Landsat 8 imagery for Ciampea Subdistrict utilized six control points to ensure spatial accuracy. The Root Mean Square Error (RMSE) values for each control point are detailed in Table 1, with individual errors ranging from 0.03 to 0.07 meters. The total RMSE across all points was calculated to be 0.26 meters, resulting in an average RMSE of 0.04 meters.

This level of RMSE indicates that the geometric correction process met the required standards for spatial accuracy. The low error values confirm the reliability of the corrected imagery for further analysis, ensuring that spatial distortions were effectively minimized.

3.2 Land Cover Analysis Using the Supervised Classification Method

Land cover analysis for Ciampea Subdistrict was conducted using the Supervised Classification method on Landsat 8 satellite imagery from 2019 to 2023, processed with ArcGIS 10.8. The classification results divided the area into two categories: built-up land and non-built-up land. The data is summarized in Table 2, with the classification results visually represented in Figure 3.

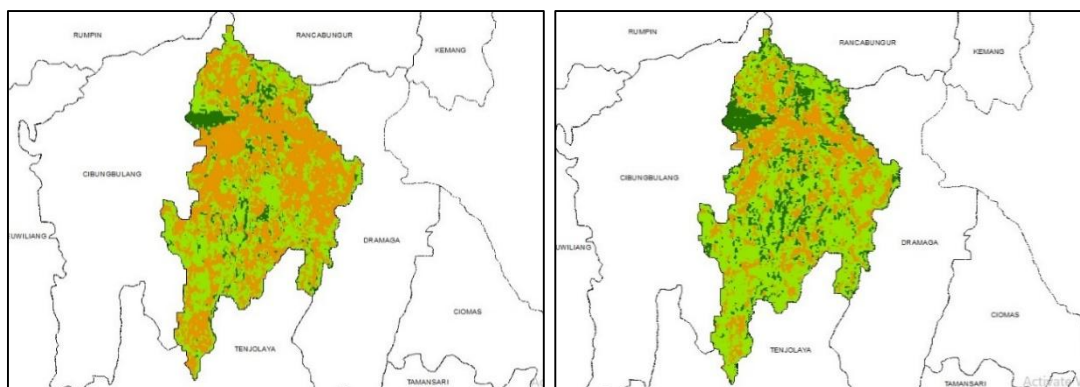


Fig. 3. Results of Supervised Classification 2019–2023

Table 2. Land Cover in Ciampea Subdistrict (2019-2023)

Year	Land Cover Classification	Area (Ha)
2019	Built-up Land	1,032.1
	Non-Built-up Land	2,365.9
2020	Built-up Land	1,514.5

	Non-Built-up Land	1,883.5
2021	Built-up Land	1,752.3
	Non-Built-up Land	1,645.7
2022	Built-up Land	1,843.7
	Non-Built-up Land	1,554.3
2023	Built-up Land	1,906.8
	Non-Built-up Land	1,491.2

Source: Analysis and observations from the study area, 2023

The results indicate a consistent annual decrease in non-built-up land, contrasting with a steady increase in built-up land. This trend highlights the ongoing conversion of agricultural and undeveloped land into urban areas. If left unregulated, this could lead to land degradation and a reduction in productive agricultural land. To mitigate these impacts, it is recommended to impose stricter regulations on granting development permits, particularly for projects that convert productive agricultural areas into built-up land.

3.3 Analysis of Land Cover Changes

Land cover changes are primarily driven by population growth, which continues to rise annually. If this trend persists, it will exacerbate the demand for land resources to accommodate housing and supporting facilities. Meanwhile, the availability of land is diminishing over time. The dynamics of population growth and expanding regional development led to inevitable land-use changes, commonly referred to as land conversion. This issue presents a dilemma for local governments, as they must simultaneously promote economic growth through industrial, service, and property development while preserving and sustaining the agricultural sector for food security.

The land cover classification results for Ciampea Subdistrict from 2019 to 2023 reveal a consistent annual decrease in non-built-up land and a corresponding increase in built-up land. Detailed data on these changes are presented in Table 3.

Table 3. Land Cover Changes in Ciampea Subdistrict (2019-2023)

No.	Year	Built-up Land (Ha)	Non-Built-up Land (Ha)
1	2019 - 2020	+482.4	-482.4
2	2020 - 2021	+237.8	-237.8
3	2021 - 2022	+91.4	-91.4
4	2022 - 2023	+63.1	-63.1
Total		+874.7	-874.7
Average		+218.7	-218.7

Source: Analysis and observations from the study area, 2023

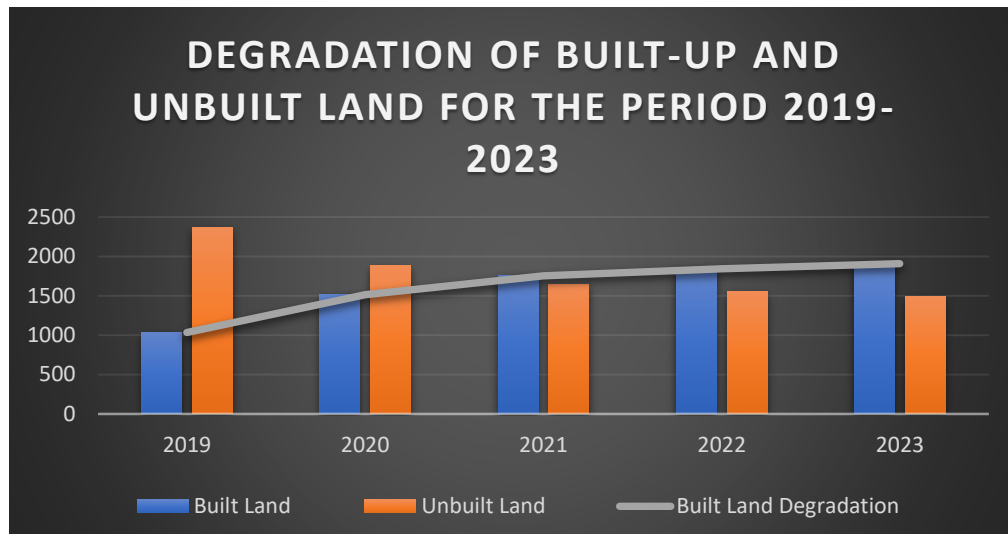


Fig. 4. Illustration the degradation trend of non-built-up land in Ciampea Subdistrict from 2019 to 2023.

The data shows a strong correlation between the increase in built-up land and the reduction of non-built-up land. Between 2019 and 2023, built-up land expanded by 874.7 hectares, averaging an annual increase of 218.7 hectares or approximately 6.4%. This expansion is primarily driven by population growth, which increases the demand for housing and public service facilities each year.

Conversely, non-built-up land shrank by 874.7 hectares over the same period, with an average annual loss of 218.7 hectares or about 6.4%. Much of this loss is attributed to the conversion of productive agricultural land into residential and other supporting facilities.

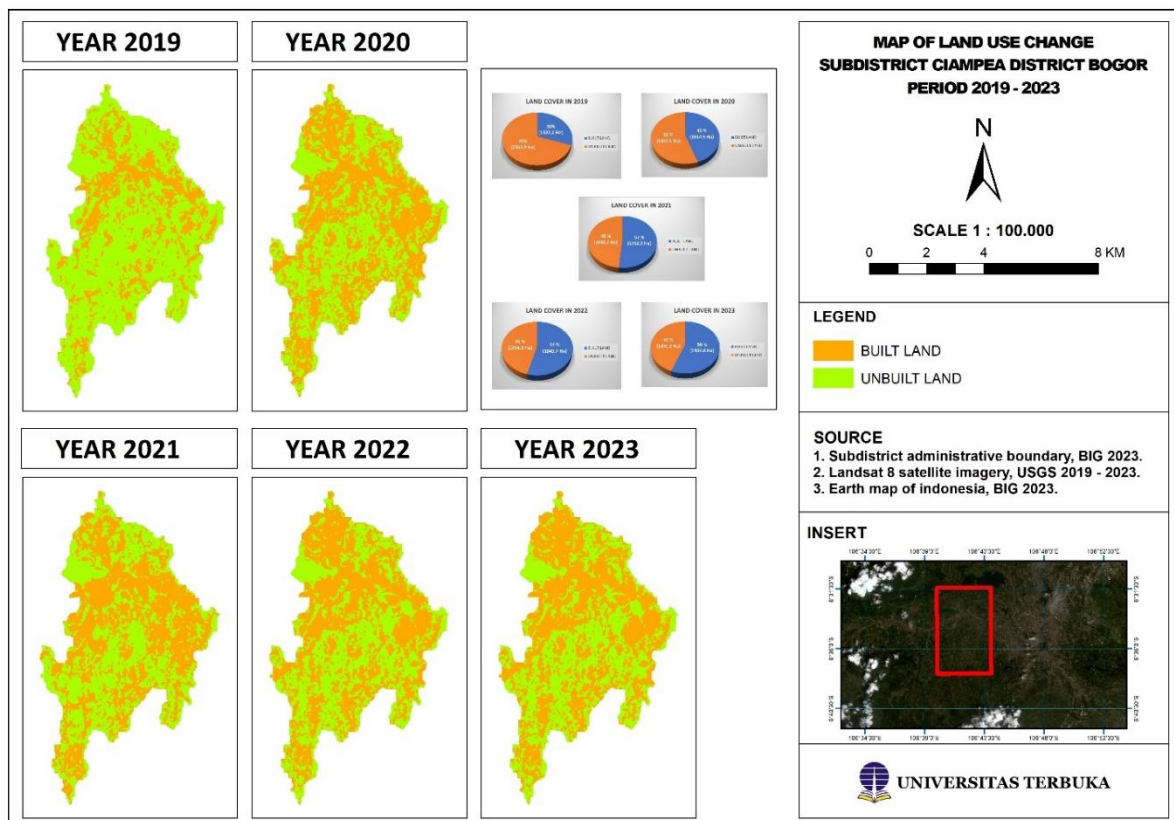


Fig. 5. Land Use Change Map of Ciampea District for 2019–2023

Figure 5. presents a map illustrating the specific locations of land cover changes in Ciampea Subdistrict from 2019 to 2023. These findings highlight the urgent need for policies to manage land conversion and protect productive agricultural areas to maintain sustainable land use in the region.

3.4 Analysis of Factors Driving Productive Agricultural Land Conversion

The analysis of factors contributing to the conversion of productive agricultural land in Ciampea Subdistrict reveals significant insights. During the variable selection stage, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO-MSA) was calculated at 0.695, indicating that the sampling was appropriate for factor analysis. However, during the variable reduction process, two variables were excluded due to MSA values below 0.5: *employment opportunities* (MSA = 0.346) and *influence of other residents* (MSA = 0.415). Consequently, the original 15 variables were reduced to 13.

The extraction process identified three key factors influencing the conversion of productive agricultural land in Ciampea Subdistrict. These factors were determined based on eigenvalues and the percentage of total variance explained:

1. Factor One: Explained 34.61% of the variance, making it the most influential factor due to its eigenvalue exceeding one and its high explanatory power. This factor includes variables such as land location, irrigation channels, economic pressure, population growth, housing demand, and private sector influence.
2. Factor Two: Accounted for 32.26% of the variance.
3. Factor Three: Contributed to 8.77% of the variance.

The remaining variance is influenced by other unidentified factors. Among these, Factor One stands out as the most critical driver of land conversion, emphasizing the interplay of economic, demographic, and infrastructural pressures. This analysis underscores the complexity of land-use dynamics in Ciampea, highlighting the need for targeted policy interventions to mitigate the conversion of productive agricultural land while addressing the demands of economic development and population growth.

3.5 Analysis of Factors Influencing Farmers to Sell Their Land

The analysis of factors driving farmers to sell their land in Ciampea Subdistrict reveals critical insights into their decision-making processes. During the variable selection stage, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO-MSA) was calculated at 0.735, indicating that the dataset was appropriate for factor analysis. During the variable reduction process, only one variable—*income* (MSA = 0.472)—was excluded due to its MSA value being less than 0.5. As a result, the initial 14 variables were reduced to 13.

The extraction process identified four new factors influencing farmers' reasons for selling their land. These factors were determined based on their eigenvalues and the percentage of total variance explained (Dwipradnyana, 2014). Among the four factors, Factor One emerged as the most influential, explaining 32.74% of the variance and having the highest eigenvalue. This makes it the primary driver of farmers' decisions to sell their land.

Variables associated with Factor One include land size, private sector influence, younger generation involvement, the demands of living expenses, family responsibilities, and government policies and regulations (Johnson & Wichern, 2007).

This analysis highlights the multifaceted pressures faced by farmers, ranging from economic and social demands to external influences such as government policies and private sector interventions. Addressing these factors requires a comprehensive approach to safeguard the agricultural sector while balancing the socio-economic needs of farming communities.

3.6 Analysis of Decreased Productivity

The conversion of agricultural land into non-agricultural land has various impacts, such as a decrease in the environmental economic value of the land. Environmental economic value refers to the value where human activities can utilize land in such a way that considers both economic and environmental aspects to ensure that its use can be sustained or even improved over the long term. Therefore, it is essential to quantify both the benefits and costs to ensure that the decision-making process is conducted with fairness in mind.

The first impact of converting productive agricultural land into non-agricultural land is environmental imbalance. For example, during the hot season, temperatures in Ciampea Subdistrict increase compared to previous years. Meanwhile, during the rainy season, flooding occurs as a result of this land conversion. This is because agricultural land, which also serves as a water absorption area, has been significantly reduced. As a result, processes involving water movement or the hydrological cycle are disrupted, leading to flooding, particularly in residential areas that were previously productive agricultural land.

Another impact of converting productive agricultural land into non-agricultural land is the decrease in food production. This is a permanent loss, as the conversion of agricultural land into non-agricultural land is irreversible—once agricultural land changes its function, it can no longer be used as rice fields.

The following is the calculation of the impact of agricultural land conversion on food production, using a model by Soemarno (2010).

$$NEPT = NPT - BPT$$

where:

- **NPT** (Value of Plant Production) refers to the output value of agricultural productivity. This represents the income farmers receive from a single production cycle each year. In this study, assumptions and literature sources were used to determine plant production values, such as average product (PRT) per unit of land. For example, the researcher assumes that 1 hectare of rice field produces 10 tons of harvested dry grain (GKP), and the price per type of production (HP) is based on a 2023 Presidential Instruction from the Head of the National Food Agency, which set the rice price at IDR 11,000 per kilogram.
- **BPT** (Production Cost) represents the cost incurred during one production cycle. The researcher obtained average production costs from various sources, such as interviews with farmers and government policies/regulations setting agricultural prices annually. These costs include fertilizers (Bokashi or organic, Phonska or NPK, Urea, and ZA) and hybrid seed purchases.

The analysis of lost productivity reveals the loss incurred due to the conversion of undeveloped land into built-up land. The results of the productivity analysis can be seen in Tables 4, 5, and 6 below.

Table 4. Value of Crop Productivity for 2019-2023

Year	Rice Field Area (Ha)	Average Crop Production (kg/ha)	Price per Type of Production (IDR/kg)	NPT (PRT x HP x LS) IDR
2019	2365.9	1000	11,000	26,024,900,000
2020	1883.5	1000	11,000	20,718,500,000
2021	1645.7	1000	11,000	18,102,700,000
2022	1554.3	1000	11,000	17,097,300,000
2023	1491.2	1000	11,000	16,403,200,000

Source: Analysis Results, 2023

Table 5. Cost of Crop Production for 2019-2023

Year	Urea Fertilizer (IDR/kg/ha)	Phonska Fertilizer (IDR/kg/ha)	ZA Fertilizer (IDR/kg/ha)	Bokashi Fertilizer (IDR/kg/ha)	Hybrid Seeds (IDR/kg/ha)	Rice Field Area (Ha)	BPT (PRT x HP x LS) IDR
2019	540,000	900,000	800,000	2,500,000	2,750,000	2365.9	17,720,591,000
2020	540,000	1,200,000	800,000	2,500,000	2,750,000	1883.5	14,672,465,000
2021	675,000	1,500,000	800,000	2,500,000	2,750,000	1645.7	13,535,882,500
2022	675,000	1,500,000	800,000	2,500,000	2,750,000	1554.3	12,784,117,500
2023	675,000	1,500,000	800,000	2,500,000	2,750,000	1491.2	12,265,120,000

Source: Analysis Results, 2023

Table 6. Impact of Agricultural Land Conversion on Food Production

No.	Land Conversion Impact	NPT (IDR)	BPT (IDR)	NEPT (IDR)
1	Year 2019	26,024,900,000	17,720,591,000	8,304,309,000
2	Year 2020	20,718,500,000	14,672,465,000	6,046,035,000
3	Year 2021	18,102,700,000	13,535,882,500	4,566,817,500
4	Year 2022	17,097,300,000	12,784,117,500	4,313,182,500
5	Year 2023	16,403,200,000	12,265,120,000	4,138,080,000

Source: Analysis Results, 2023

Based on the research findings, it is estimated that between 2019 and 2023, productive agricultural land in Ciampea Subdistrict has been converted into non-agricultural land, amounting to 874.7 hectares. This is calculated by subtracting the area of productive agricultural land in 2023 from the area in 2019. The negative value (-874.7 Ha) indicates the decrease in agricultural land over the five years. This conversion is expected to result in a loss of 8,747 tons of paddy, which is equivalent to a loss of 5,472.8 tons of rice production.

To understand the impact on the loss of income from rice farming, the following calculation was made.

$$\begin{aligned}
 NEPT &= NEPT\ 2023 - NEPT\ 2019 \\
 &= \text{IDR } 4,138,080,000 - \text{IDR } 8,304,309,000 \\
 &= \text{IDR } -4,166,229,000
 \end{aligned}$$

Therefore, it can be concluded that over five years (2019-2023), the conversion of productive agricultural land to non-agricultural land has resulted in a loss of income from rice farming amounting to IDR 4,166,229,000. This loss is significant when considering the Gross Regional Domestic Product (PDRB) of Bogor Regency. Hence, it is essential for the government and society to implement effective monitoring and control measures to prevent further reduction of productive agricultural land. This will help maintain food security in Ciampea Subdistrict.

The government should establish limits on permits for land development that do not align with existing spatial planning documents such as the Regional Spatial Planning (RTRW) and Detailed Spatial Planning (RDTR). Additionally, strict sanctions should be imposed on individuals or entities that violate regulations by converting productive agricultural land as outlined in spatial planning documents and regional regulations. It is hoped that the rate of agricultural land conversion in Ciampea Subdistrict can be reduced to prevent further loss each year.

4 Conclusion

Based on the analysis of land cover change in Ciampea District from 2019 to 2023, it was found that there is an inverse relationship between the growth of built-up land area and the decrease in non-built-up land area. From the land cover classification data, it can be seen that non-built-up land has decreased by approximately 218.7 hectares annually. Conversely, built-up land has increased by approximately 218.7 hectares annually.

The factors contributing to the conversion of productive agricultural land in Ciampea District are primarily influenced by the location of the land, irrigation channels, economic pressures, population growth, housing needs, and the influence of private entities. In the process of land sale by farmers, four new factors have emerged that influence their decision to sell land. These factors include land area, the influence of private entities, the younger generation, livelihood demands, family responsibilities, and government policies and regulations.

The impact of the conversion of productive agricultural land on the economic value of food crop production is a decrease in food production. From the 874.7 hectares of productive agricultural land converted in Ciampea District, it is estimated that food production will decrease by 8,747 tons of rice paddy, equivalent to 5,472.8 tons of rice. When converted into Rupiah, the impact of this conversion on the loss of income from rice farming in Ciampea District is approximately Rp. 4,166,229,000.

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