

Small Town Growth and Agricultural Land Loss in the Ciledug Agropolitan Area: A Mixed-Methods Analysis (2010-2020)

Nuri Setiawati^{1*} and Fadjar Hari Mardiansjah²

¹*Research Master Program in Urban and Regional Planning, Universitas Diponegoro*

²*Department of Urban and Regional Planning, Universitas Diponegoro*

ABSTRACT

Urban expansion in peri-urban areas is increasingly threatening agricultural sustainability in agropolitan regions of Southeast Asia. The Ciledug Agropolitan Area (CAA) in West Java, Indonesia, exemplifies this trend, where rapid land conversion and infrastructural disparities challenge the region's original agropolitan goals. This study aims to examine the extent, patterns, and underlying drivers of rice field conversion in the CAA between 2010 and 2020, as well as the implications for irrigation-based agricultural sustainability. A mixed-methods approach was employed, integrating land use classification from satellite imagery, stakeholder interviews, and field surveys. The analysis reveals a >20% reduction in rice fields area, driven by residential expansion, industrial development, and speculative land trading. Babakan and Pabuaran districts exhibit degraded irrigation networks, forcing farmers to rely on rain-fed or drilled water systems, while in Ciledug, better irrigation infrastructure exists but fails to prevent land conversion due to weak spatial planning enforcement. These findings underscore the critical role of infrastructure and governance in shaping land use outcomes. The study concludes that protecting peri-urban agricultural zones requires strengthened spatial policy implementation, irrigation investment, and multi-level institutional coordination to realign regional development with agropolitan objectives.

Keywords: spatial inequality, land governance, irrigation access, peri-urban development, rural sustainability

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Email addresses:

nurisetiawati127@gmail.com (Nuri Setiawati)

fadjarmardiansjah@lecturer.undip.ac.id (Fadjar Hari Mardiansjah)

* Corresponding author

INTRODUCTION

Urbanization is one of the defining processes of the 21st century, reshaping landscapes, economies, and societies globally. In developing countries, especially Southeast Asia and the Global South, urban expansion has transformed peri-urban and rural spaces, shifting land uses, altering economic structures, and reconfiguring social systems (Estoque et al., 2019; Gandharum et al., 2022; Kurnia et al., 2022). While offering regional development opportunities, this process also causes land use conflicts, displacement of agriculture, and pressure on resources and infrastructure (Kondo et al.,

2022; Christiawan, 2024; Petrescu-Mag et al., 2019). These challenges are increasingly visible in Indonesia, where urban growth extends into peri-urban and rural areas, even in smaller cities (Rachman et al., 2024).

Java Island exemplifies the complexity of urban expansion. As Indonesia's most fertile and densely populated island, Java plays a crucial role in national food security while also hosting the country's largest concentration of urban population. Each year, however, Java loses significant areas of productive agricultural land due to conversion into residential, industrial, and infrastructural uses (Firman, 2000; Firman et al., 2015). This dual character being both the heart of agricultural productivity and the locus of urban concentration makes land conversion on Java particularly critical, as it directly threatens food security and rural livelihoods. With over 154 million people in 2020, 56% of Indonesia's population (BPS, 2021). Java's cities are rapidly expanding, encroaching on agricultural land. This intensification, prominent since the 1980s, features declining urban core populations and rising development in surrounding areas, a trend known as "rural urbanization" (Firman, 2016; Mardiansjah & Rahayu, 2020). Key drivers include industrial relocation, speculative land development, rural migration, and uneven growth (Zhao et al., 2024; Yang et al., 2019). These dynamics resonate with patterns in the Global South, where urban-rural transformations often proceed with limited institutional capacity (Hudalah et al., 2007).

Though often studied in Jakarta or Surabaya, similar patterns now affect smaller cities like Cirebon in West Java (Fahmi et al., 2014; Mardiansjah et al., 2021). These areas face rapid change without the robust infrastructure and institutions of larger cities. Comparable conditions, rural marginalization and urban pressure appear in Eastern Europe, where land transitions occur amid institutional uncertainty (Faoziyah et al., 2024; Appelt et al., 2022; Sasongko et al., 2024).

The Ciledug Agropolitan Area (CAA), comprising the sub-districts of Ciledug, Babakan and Pabuaran, was originally established as part of the national agropolitan program in the early 2000s, intended to strengthen agricultural production, support rural livelihoods, and reduce rural-urban disparities. This agropolitan designation, later reaffirmed in the 2018-2038 Spatial Planning Regulation (RTRW) of Cirebon Regency, reflected government efforts to protect fertile agricultural land while promoting integrated rural development. However, despite these policy intentions, the CAA has increasingly experienced rapid agricultural land conversion, with rice fields replaced by residential and industrial uses, particularly along transportation corridors. This paradox between its planned role as an agricultural hub and its actual trajectory of peri-urban growth makes the CAA a critical case for analyzing the challenges of spatial planning and governance in secondary city regions.

Originally, the agropolitan concept aimed to connect rural areas to urban markets by improving agriculture and infrastructure. Yet evidence from CAA shows ongoing land conversion for non-agricultural purposes (Gandharum et al., 2022; Tacoli, 2003). Over the past decade, urban expansion has encroached on fertile land, altering land ownership and rural livelihoods. Field interviews reveal that speculative development and weak institutions are key drivers. Although CAA is officially recognized as an agropolitan zone, local planning operates reactively, with limited enforcement capacity. This gap highlights the disjunction between formal spatial plans and local development trajectories (Wasay et al., 2023).

A clear example is the development of large factories on rice fields. Between 2010 and 2020, about four to five factories were built in CAA, reducing farmland. This suggests that planning tools like RTRW have limited influence, with decisions often shaped by market forces. Moreover, CAA's location on the border of West Java and Central Java complicates coordination, weakening enforcement across jurisdictions (Sulistiyawati et al., 2021).

Theoretically, this mismatch highlights the limits of rational planning in fragmented governance. As Healey (1997) argues, spatial planning is not just technical but shaped by institutional arrangements. Weak or misaligned institutions reduce planning's effectiveness, leading to outcomes driven by ad hoc decisions and market interests. CAA exemplifies this: spatial plans exist but lack enforcement. Similar findings have been observed in peri-urban Vietnam and the Philippines, where formal designations are undermined by informal practices and weak regulation (Camarillo-Naranjo et al., 2022; Pravitasari et al., 2024).

Although past studies have documented the failure of agropolitan and peri-urban planning under weak institutions, many remain focused on macro-level analyses or do not integrate spatial data with local narratives (Tacoli, 2023; Pravitasari et al., 2024). CAA thus offers a critical case for empirical deepening, bringing together spatial mapping and community insights to show how systemic issues play out on the ground. Unlike more generalized studies, this research foregrounds a legally designated agropolitan area that is actively undergoing transformation, making it a distinctive and instructive case.

While CAA's spatial pattern may not be unique, it represents a convergence of stressors agricultural decline, speculation, and reactive planning in a designated agropolitan zone. The lack of institutional capacity highlights a systemic failure to implement spatial plans. This makes CAA an illustrative case of agropolitan strategy under pressure in Southeast Asia and the Global South, where rural development frameworks often lack the governance tools needed to resist urban encroachment (Sasongko et al., 2024; Christiawan, 2024).

This study investigates the scale, patterns, and effects of land use changes in CAA. Using a mixed-methods approach, remote sensing, planning evaluation, and field interviews, it assesses how urban expansion from 2010 to 2020 has affected agricultural land and irrigation in CAA. It also explores the socio-economic drivers and policy implications of these changes.

Building on these gaps, this study asks how urban expansion and rice field conversion gave reshaped the Ciledug Agropolitan Area (CAA) between 2010 and 2020. It further examines the socio-institutional drivers such as land commodification, weak spatial governance, and rural-urban linkages that underpin these transformations. Finally, the study explores the implication of these dynamics for agricultural sustainability and regional planning, situating the CAA as a critical for understanding the challenges of peri-urban development in secondary city regions of the Global South.

METHODOLOGY

Study Area

This study was conducted in the Ciledug Agropolitan Area (CAA), a designated rural development cluster in Cirebon Regency, West Java, Indonesia. The area comprises three sub-districts: Ciledug, Babakan, and Pabuaran. Under the 2018 Cirebon Regency Spatial Planning Regulation (RTRW), these sub-districts were promoted as a strategic node for agropolitan development aiming to enhance agricultural productivity and strengthen rural-urban linkaged.

In practice, however, the CAA has experienced significant land use transformation, with agricultural land being rapidly converted into residential, industrial, and commercial uses. This process has intensified between 2010 and 2020, driven by speculative development, weak spatial enforcement, and growing urban pressures from nearby areas.

For this study, seven villages within the three sub-districts were selected based on the visible extent of land conversion. Village selection was guided by visual interpretation of Google Satellite imagery, identifying areas with substantial reduction in agricultural land and emergence of built-up areas. This selection was further supported by spatial analysis using ArcGIS, focusing on land cover changes. The selected villages represent critical zones of transformation within the CAA and serve as the spatial units for further analysis.

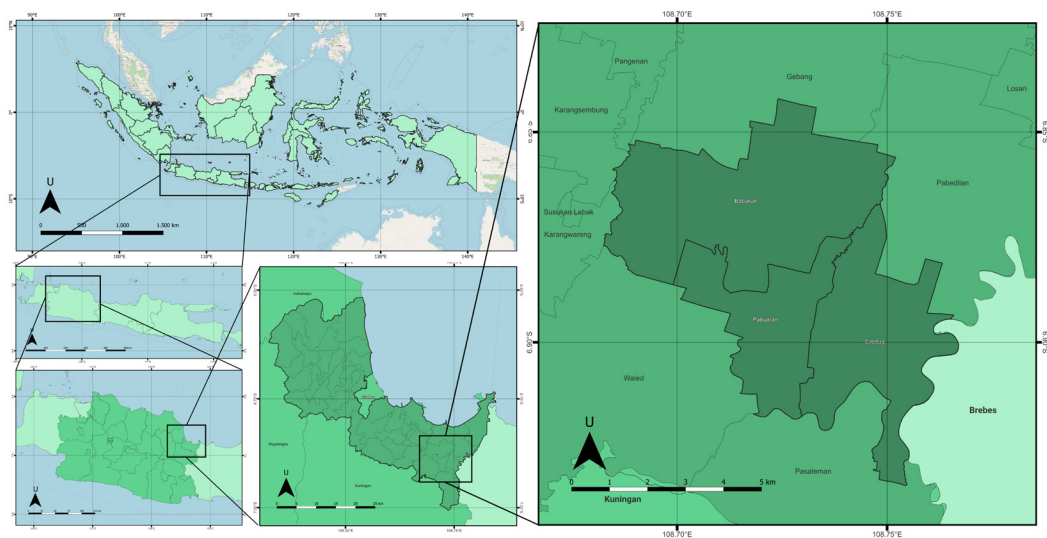


Figure 1. Study Area
Source: Authors

Methods

This study investigates land-use transformation in CAA, with an emphasis on the conversion of agricultural land into built-up areas between 2010 and 2020. Satellite imagery was obtained solely from Google Satellite to visually observe projected land-use change across the decade. ArcGIS was used to support spatial interpretation and mapping of processed data. Village selection was based on visible transformation trends shown in the imagery. Although no precise quantitative threshold was applied, seven villages were selected due to apparent reductions in agricultural land and increases in built-up areas such as housing and factories. The general sequence of research activities and data sources is summarized in the following methodological flowchart to provide a clearer overview of the study’s mixed methods approach.

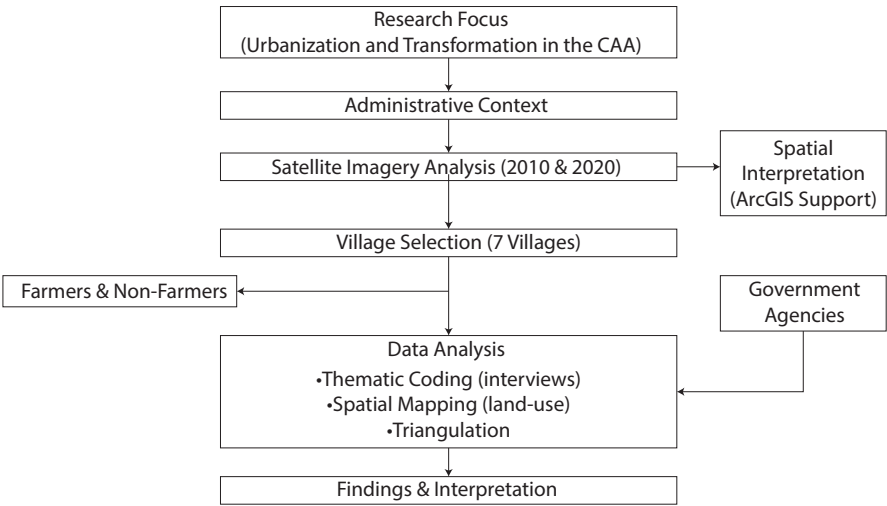


Figure 2. Research Methodology
Source: Authors

Secondary spatial data from regional sources were also used to validate and enrich the satellite-based interpretation. These included administrative boundaries, infrastructure layers, and land classification relevant to understanding spatial context.

To further understand the underlying dynamics of land-use change, fieldwork was conducted from December 4 to 10, 2022. In-depth semi-structured interviews were held with 14 farmers and 14 non-farmers, selected using purposive sampling with assistance from local leaders. Farmers had cultivated land in CAA for at least ten years, while non-farmers were long-term residents (non-migrants) of the comparable duration. Additional institutional perspective were obtained through interviews with officials from Regional Development Planning, Research, and Development Agency (Bappelitbangda), the Agricultural Office, the Housing and Settlement Agency, and the Public Works and Spatial Planning Agency (PUPR).

All interviews followed informed consent protocols and were guided by a pre-established coding scheme. The questions were grouped thematically by sub-themes, including land ownership, conversion impacts, infrastructure, and livelihoods. Thematic coding was used to classify response by recurring content, with similar questions clustered under sub-theme categories to support analytical clarity.

Although no theoretical model was used to determine respondent numbers, triangulation helped enhance validity. Source triangulation was achieved by comparing information from farmers, non-farmers, and institutional actors. Methodological triangulation involved combining insights from spatial analysis, field notes, and interviews data. These strategic provided a comprehensive view of how urban expansion has reshaped CAA and its implications for land governance and community livelihoods.

RESULTS

Urban Growth in the Ciledug Agropolitan Area

The urbanization process in Cirebon Regency is closely linked to the dynamics of Cirebon City as the regional economic core. As argued by Fahmi et al. (2014), the city’s function as an economic magnet has accelerated the movement of people and capital toward surrounding peri-urban areas, including the Ciledug Agripolitan Area (CAA). This pattern align with general findings on urbanization in Indonesia, where secondary cities often influence rapid-urban transformation (Firman, 2004; Hudalah & Firman, 2012).

Table 1 shows a steady increase in the number of urban villages and population in CAA from 1990 to 2020. The data shows a significant demographic and administrative transition; from 18 urban villages in 1990 to 34 in 2020, with the urban population more than doubling within the same period. Figure 3 visualizes this administrative reclassification, illustrating the eastward spread of urban influence. This transition reflects the urban sprawl mechanism occurring in outer-core areas, which according to McGee (1991), forms part of the “desakota” phenomenon, a mixture of rural-urban characteristics driven by industrial and residential development. A long-time farmer in Babakan reflected, “There used to be many rice fields here, but now they have been replaced by housing and factories.” His account underscores the replacement of farmland by built-up areas, a pattern also observable in the reclassified zones in the eastern corridor.

Table 1
Population Growth in Cirebon Regency and Ciledug Agropolitan Area

Population (Inhabitants) & Rural-Urban Growth				
Area	1990	2000	2010	2020
Cirebon Regency	1,649,428/424	1,931,066/424	2,177,355/424	2,270,827/424
Ciledug Agropolitan Area	191,326/49	209,342/39	142,779/31	153,649/31
Urban Population (Inhabitants) & Rural-Urban Growth				
Area	1990	2000	2010	2020
Cirebon Regency	613,853/136	1,082,736/136	1,676,165/303	1,735,399/312
Ciledug Agropolitan Area	77,515/18	82,881/18	139,579/34	139,579/34

Source: Results of 1990, 2000, 2010, and 2020 population censuses

The transformation of the CAA is reflected not only in physical development but also in the shifting configuration of its urban villages. In Ciledug, the number of urban villages declined slightly from 15 in 1990 to 10 in 2020, suggesting that settlement expansion

occurred primarily through peripheral sprawl rather than through the establishment of new settlement areas. Babakan experienced a sharper shift, expanding from 3 urban villages in 1990 to 13 by 2010, a period that aligns with irrigation decline, reduced agricultural viability, and the arrival of industrial activities. A significant turning point occurred in 2010 with the creation of the Pabuaran Sub-District, which was immediately classified into seven urban villages, an administrative change that reveals how newly formalized areas were absorbed rapidly into peri-urban development processes. These administrative shifts demonstrate that settlement growth in the CAA is structurally tied to market-led land conversion and growing spatial inequalities, providing institutional evidence of the region’s transition from agrarian space to peri-urban landscape.

Table 2
Urban village growth in Ciledug Agropolitan Area

Urban Village				
Area	1990	2000	2010	2020
Ciledug	15	15	10	10
Babakan	3	3	13	13
Pabuaran	Not Exist Yet	Not Exist Yet	7	7

Source: Results of 1990, 2000, 2010, and 2020 population censuses

Additionally, Figure 3 visually maps the administrative reclassification of rural to urban villages from 1990 to 2020, confirming the spatial manifestation of this transition. The shift from agriculture land use to residential and industrial functions in the eastern corridor of the Cirebon Regency further underscores the urban expansion described by Majewska et al. (2022), who highlighted the role of transportation infrastructure and housing demand as major drivers of suburban growth.

The data is further supported by urbanization level trends in Table 3, which illustrate dramatic urban status shifts in sub-districts within the CAA. Babakan, for example, transformed from a predominantly rural area (14% urban in 1990) to an almost fully urbanized district (94% urban by 2020). Ciledug and Pabuaran show similarly high levels of urbanization, reflecting internal transformation rather than annexation, a process known as in-situ urbanization (Zhu, 2000).

Table 3
Urbanization Levels in Ciledug Agropolitan Area by Percentage

	1990	2000	2010	2020
Babakan	14	13	95	94
Ciledug	74	73	100	100
Pabuaran	Not Exist Yet	Not Exist Yet	100	100
Total of CAA	41	40	98	97

Source: Results of 1990, 2000, 2010, and 2020 population censuses

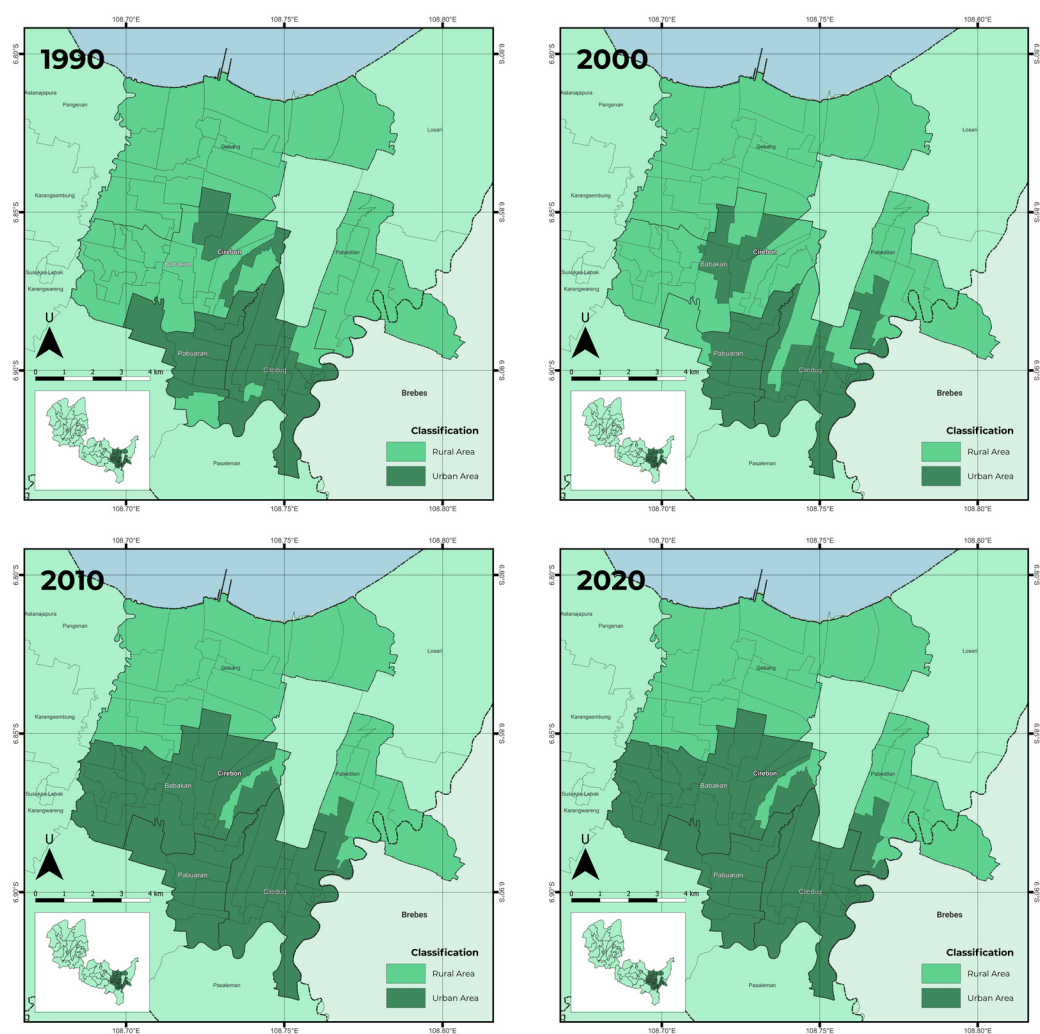


Figure 3. Development of Urban Villages in CAA, 1990-2020
Source: Authors

Interview findings corroborate this quantitative data. One farmer from Babakan stated *“In the past, this area was dominated by rice fields, but over time, much of the land has been converted into residential and industrial uses. Younger generations now tend to seek employment in urban areas or factories, rather than pursuing agriculture.”* (Interview, December 2022). Similarly, a non-farmer resident in Pabuaran noted, *“Improved Road access and the construction of a transport terminal have stimulated activity in the area, leading to the growth of commercial establishments and boarding houses.”* These testimonies align with spatial data that shows clustered development along transportation corridors. These accounts illustrate livelihood diversification and infrastructure-led land conversion, which mirror the patterns observed by Tacoli (2003) in peri-urban Asia.

The development of infrastructure such as the Kanci-Pejagan Toll Road and Ciledug Terminal has deepened the CAA's integration into broader economic networks. As Rahayu and Mardiansjah (2018) note, urban expansion reorganizes social and economic relations as much as it transforms physical scape. This is evident the emergence of new settlement areas across the CAA, much of which has been initiated not by corporate developers but by local communities converting inherited agricultural plots into housing clusters. These community-driven processes underscore the informal and incremental character of peri-urban expansion in the region forms of growth that operate outside state regulation and reinforce the weakening of agricultural protection policies.

These shifts are not purely demographic or spatial, they reflect broader governance dynamics within the Cirebon Regency between 2000 and 2010 also reflects both spatial and political processes. According to Mardiansjah et al. (2021), village reclassification based on urban criteria are population density, non-agricultural livelihoods, and urban infrastructure plays a crucial role in institutionalizing urban transitions. This pattern, observed across CAA, confirms that spatial development is interwind with planning policy and governance.

In summary, the urban growth in the Ciledug Agropolitan Area is result of multiple interrelated forces: population dynamics, economic attraction from the core city, infrastructure expansion, and governance-based adjustments. These findings reflect broader peri-urbanization processes observed across Southeast Asia and validate the significance of combining spatial analysis with qualitative insights to understand urban transformation.

Patterns and Drivers of Rice Field Conversion (2010-2020)

Between 2010 and 2020, the CAA experienced a pronounced decline in agricultural land. As Long et al. (2009) assert, time-series analysis of land use change and its drivers is essential to inform sustainable land management under urban expansion. In line with this, Figure 4 demonstrates the spatial transformation of land in CAA between 2010 and 2020, marked by a clear decline in agricultural land and s sharp increase in built-up zones.

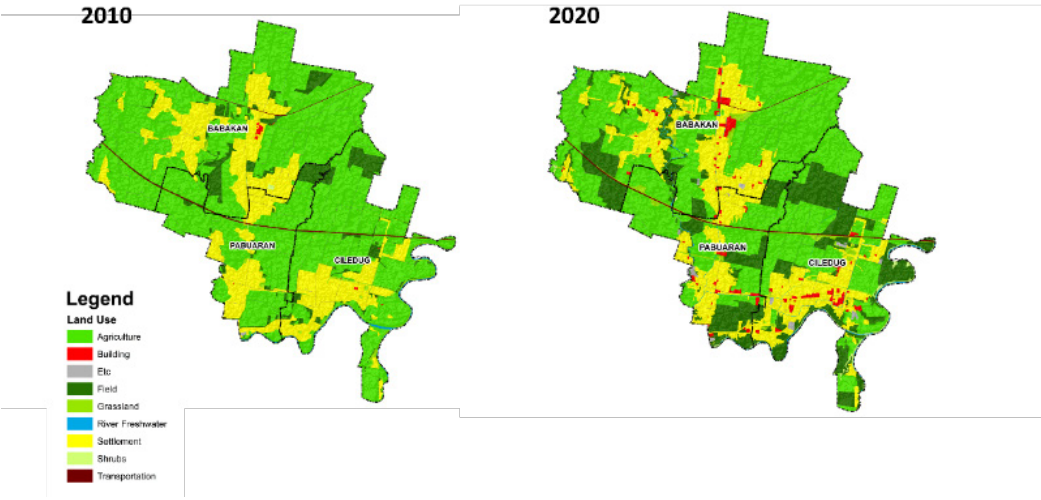


Figure 4. Land Use Change in the Ciledug Agropolitan Area (2010-2020)
Source: Public Works and Spatial Planning Office Cirebon Regency

The visual classification indicates that this change is most prominent in Babakan, Pabuaran, and Ciledug Districts. Field surveys and satellite imagery reveal the densification of residential areas and the emergence of industrial estates, particularly in Babakan. This aligns with Sumaryanto et al. (2005), who identified rice fields as the most vulnerable land type during urban transition. Similarly, in peri-urban South Africa, Patrick and Schaab (2003) found that urban and infrastructure development consistently drives agricultural land conversion, a pattern also echoed in Uganda by Vermeiren et al. (2013), where farmers are projected to lose up to 80% of their land by 2030 due to sprawl.

In the Indonesia context, Mardiansjah et al. (2021) highlight that small cities on Java Island have become hotspot for peri-urbanization and land conversion. Interviews with CAA residents substantiate this trend. A former farmer in Babakan shared, “*We used to farm rice here, but with the irrigation system damaged, many of us sold our land for housing and factory development.*” This lived experience is supported by spatial evidence showing high conversion density around the old irrigation corridors. Similarly, a local official stated, “*People now prefer to build houses because farming isn’t profitable anymore, especially with water shortages and lack of government support.*”

Interview data further highlight the uneven nature of land conversion across the CAA. In Babakan, irrigation failure has accelerated the abandonment of farming and pushed communities toward alternative livelihoods. In Ciledug and Pabuaran, five large-scale factories have been established on former rice fields, transforming land from subsistence production to industrial estates. Residential development also follows different trajectories: Pabuaran exhibits more centralized housing expansion, while Ciledug’s growth follows peripheral and corridor-based patterns that fragment agricultural landscapes. Across all

three sub-districts, rising land values incentivize commodification, with many families opting to sell inherited land despite policy ambitions to sustain agriculture. These findings reveal how local decision-making intersects with structural economic pressure to reshape peri-urban spaces.

This evidence supports the theory of land commodification, where land is treated as a market asset rather than a livelihood base (Zoomers, 2010). The process is accelerated by weak governance structures in land regulation and a lack of enforcement of local spatial plans. Despite formal land-use plans discouraging conversion of rice fields in the Regional Medium-Term Development Plan (RPJMD) and RTRW documents, field evidence suggests that land use decisions are heavily influenced by informal negotiations and market dynamics.

Furthermore, statistical data from the Cirebon Regency Central Bureau of Statistics reveal a dramatic decline in shallot cultivation from 245 hectares in 2016 to just 18 hectares in 2021. This illustrates a broader trend of deagrarianization, reflecting both economic transformation and socio-environmental shifts (Rigg et al., 2020).

While some positive impacts are noted such as new job creation and increased connectivity to urban markets, infrastructure development also contributes to the erasure of farmland without adequate environmental assessment. As seen in similar studies in China and Vietnam (Long et al., 2010; Labbé & Musil, 2020), rural residential and industrial expansion often results in fragmented landscapes and long-term food security concerns.

The widespread and often unregulated conversion of rice fields has generated profound ecological, socio-economic, and spatial consequences. Ecologically, soil sealing undermines water absorption and contributes to hydrological imbalance, threatening the region's long-term agricultural sustainability. Socio-economically, displaced farmers increasingly turn to low-paid industrial or informal work, signaling a downward shift in livelihood stability. Spatially, development concentrates along high-accessibility corridors, deepening inequalities between rapidly urbanizing zones and under-resourced agricultural pockets. These patterns demonstrate that land conversion in the CAA is not simply a physical process but a restructuring of socio-ecological systems under intensifying market pressure.

These findings raise critical questions about the effectiveness of current land governance systems and underscore the need for integrated urban-rural policy mechanism, especially in Java's fast-urbanizing zones.

These transformations illustrate not only the vulnerability of agricultural land to development pressures but also the socio-spatial consequences of weak peri-urban governance, which are further explored in the following sections.

Impacts of Irrigation Network Change on Agricultural Sustainability

Irrigation infrastructure is a critical component for sustaining agricultural productivity, particularly in peri-urban regions undergoing rapid transformation. A farmer from Babakan noted, *“We have relied only on rainfall and well drilling since the irrigation channel stopped functioning more than 10 years ago.”* This aligns with field findings that indicate Babakan suffers the most critical irrigation failures, coinciding with the district’s highest conversion rate as shown in Figure 4. In the CAA, variations in the functionality and availability of irrigation networks have had profound implications for agricultural sustainability across the three main districts, Babakan, Pabuaran and Ciledug.

As supported by Atharinafi and Wijaya (2021), the conversion of agricultural land into built-up land in peri-urban Java also affects the upstream Citarum watershed, which serves as a primary water source for agricultural irrigation across Cirebon Regency. However, detailed data on the exact source and structure of the irrigation systems in CAA remain limited and warrant further clarification and field mapping

Based on the field surveys and interviews with local farmers, it was revealed that Babakan District suffer from the most critical irrigation failures. The irrigation infrastructure there has been largely non-functional for the past decade, forcing farmers to rely on rain-fed systems and the construction of drilled wells (*pengeboran*) to sustain any form of cultivation. One farmer from Babakan noted *“Since the irrigation system ceased to function over a decade ago, farmers have depended exclusively on rainfall and groundwater extraction through well drilling.”* These conditions have made water access highly uncertain, contributing to the decline of productivity rice fields and accelerating land abandonment or conversion.

Pabuaran District presents a transitional condition. Some irrigation channels remain active, but water flow is inconsistent, especially during the dry season. Farmers here are partially able to maintain agricultural activities through a combination of rain-fer irrigation and supplementary sources, but these are not always reliable or efficient.

In contrast, Ciledug District still benefits from a relatively well-functioning irrigation system, which sources water from the Darma Reservoir in Kuningan via the Cikeusik Irrigation Area. The system, while seasonal and somewhat dependent on rainfall patterns, is better managed and supports more consistent agricultural output. As a result, Ciledug theoretically holds the highest potential for sustainable agricultural land use. However, in practice, large portions of its proactive land have been converted to industrial and residential use due to development pressures, creating a paradox of “land potential lost to urban growth.”

The findings reflect patterns observed in similar global peri-urban contexts. Antwi-Agyei et al. (2023) stress that insufficient irrigation networks hinder optimal agricultural productivity. Bannor et al. (2020) found similar irrigation-related declines in rice productivity in Odisha, India, while Dinye (2013) noted that unstable irrigation forces farmers to switch crops, often with lower economic returns. Derib et al. (2011) emphasize that investments in irrigation infrastructure are essential not only for productivity but also for poverty alleviation and climate resilience in agricultural communities.

Beyond functionally, the issue of water allocation is politically and economically contentious. In Babakan, interviews indicated that water from existing irrigation canals is often diverted for industrial use, particularly for sugar factories, reducing access for agricultural purposes. In Ciledug, although the irrigation system supports both household and agricultural needs, land conversion continues unabated due to weak enforcement of local spatial plans of 2018-2038 (RTRW), echoing broader governance challenges in land management.

The reality on the ground reveals a worrying trend: irrigation quality and land productivity do not always align with spatial development priorities. Figure 5 shows the spatial extent of existing irrigation coverage across the three districts, which further illustrate the mismatch between potential and actual agricultural land use.

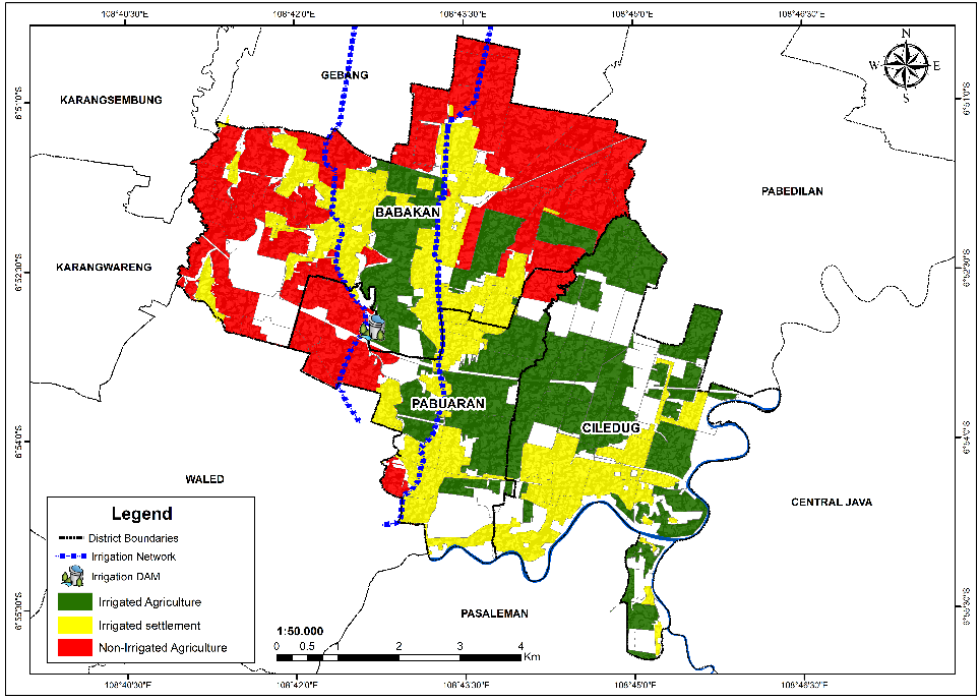


Figure 5. Irrigation Network Overage in the Ciledug Agropolitan Area
Source: Public Works and Spatial Planning Office Cirebon Regency

Ultimately, the degradation of irrigation networks particularly in Babakan and Pabuaran alongside unchecked industrial expansion in high-potential areas like Ciledug, illustrate how spatial misalignment between infrastructure provision, land-use regulation, and development priorities is accelerating the loss of agricultural viability in peri-urban regions.

DISCUSSION

The findings from this study highlight the complex dynamics of peri-urbanization and its significant impact on agricultural land use and sustainability within the Ciledug Agropolitan Area (CAA). The pronounced conversion of rice fields and other agricultural lands into built-up areas over 20% loss between 2010 and 2020 reflects ongoing pressure driven by rapid urban growth and industrial development. This aligns with the peri-urban interface theory, which emphasizes how areas adjacent to urban centers experience competing land uses, commodification, and spatial inequality (Simon, 2008; Tacoli, 2003). The transformation observed in CAA exemplifies how peri-urban zones are sites of negotiation and conflict between agricultural preservation and urban expansion.

Interview data and satellite imagery corroborate that the loss of agricultural land is not only a physical change but also a symptom of weak local governance and inadequate enforcement of spatial plans. The findings suggest that the existing local spatial plans (RTRW), while theoretically designed to manage growth, lack effective implementation mechanisms, contributing to unchecked land conversion. This weak governance is consistent with research by Seto et al. (2012), which highlight governance as a critical factor mediating urban expansion and its environmental consequences. The spatial inequality created by such governance gaps often favors industrial and residential development at the expense of agricultural sustainability.

The irrigation system's condition further complicates agricultural sustainability in the CAA. As discussed, Babakan District's prolonged irrigation failures have significantly reduced land productivity, pushing farmers to rely on rain-fed methods and well drilling, which are less reliable and increase vulnerability to climate variability. Pabuaran's intermediate irrigation condition reflects transitional peri-urban pressures, while Ciledug's better functioning irrigation infrastructure, sourced from the Darma Reservoir via the Cikeusik irrigation area, highlights how water availability remains a critical determinant of land use viability.

These irrigation dynamics reinforce the theoretical understanding that infrastructure, particularly irrigation, is vital in maintaining agricultural productivity in peri-urban contexts (Antwi-Agyei et al., 2023; Derib et al., 2011). However, the paradox in Ciledug where high agricultural potential coexists with significant land conversion to industry

illustrate how infrastructure alone cannot counterbalance economic and spatial pressures without robust policy and governance frameworks.

Moreover, water allocation conflicts, notably in Babakan where irrigation water is diverted to sugar factories, reflects broader political-economic tensions within land and resource governance. This aligns with findings from Perz and Skole (2003) regarding resource competition in peri-urban areas. The overlapping demands of industrial, residential, and agricultural uses complicate equitable water distribution, affecting rural livelihoods and exacerbating land degradation.

In sum, the CAA case underscores the urgent need for integrated approaches that address land use planning, irrigation infrastructure investment, and governance reform. Protecting agricultural land in peri-urban zones demands not only technical solutions but also institutional strengthening and inclusive stakeholder engagement to reconcile competing interest and sustain rural livelihoods amidst urban expansion.

CONCLUSION

The findings of this study show that the transformation of the Ciledug Agropolitan Area (CAA) is shaped by the convergence of market-driven development pressures, infrastructural expansion, and weakening agricultural viability. Although the CAA was formally designated to safeguard agricultural productivity and strengthen rural livelihoods, its actual trajectory demonstrates how planning intentions are increasingly overridden by speculative land markets and community-led settlement processes. The rapid conversion of rice fields, combined with irrigation decline and industrial expansion, has produced a peri-urban landscape that is fragmented, unequal, and ecologically vulnerable. These outcomes highlight a fundamental contradiction between the agropolitan vision and the material realities of rural-urban transitions in secondary city regions.

The CAA thus illustrates the limits of conventional spatial planning frameworks, which assume that rural protection can be maintained through static zoning and long-term designations. In practice, the emergence of new transport corridors, rising land values, and household decisions to commodify inherited land reveal a much more dynamic and contested transformation. This dynamic mirrors broader patterns across the Global South, where peri-urbanization is driven not only by state-led development but also by incremental, informal, and community-led forms of settlement growth. As seen in cases from India, Vietnam, Kenya, and Ghana, these hybrid processes operate beyond the reach of formal planning instruments, exposing governance gaps and reshaping socio-economic relations.

The implications of these transformations are far-reaching. Ecologically, soil sealing and agricultural loss undermine local resilience and intensify hydrological imbalance.

Socio-economically, displaced farmers face downward transition into low-paid industrial or informal labor, amplifying livelihood precarity. Spatially, development concentrates along accessible corridors, producing uneven development and deepening peri-urban inequalities. These multilayered impacts demonstrate that the transformation of the CAA cannot be understood merely as land-use change; it constitutes a restructuring of social-ecological systems under intensifying urban pressure.

Taken together, this study contributes to global debates on peri-urban urbanization by showing how agricultural-designated zones in secondary cities navigate competing logics of rural protection, market speculation, and infrastructural expansion. The CAA exemplifies the need for governance approaches that move beyond static, top-down spatial plans and instead acknowledge the lived realities of rural-urban transitions. Strengthening agricultural sustainability and reducing spatial inequality will require policies that address institutional fragmentation, anticipate informal and community-led forms of development, and integrate ecological considerations more centrally into land and water management. Without such adaptive and context-sensitive approaches, regions like the CAA will continue to experience accelerated land conversion, weakening of rural livelihoods, and long-term environmental risks.

IMPLICATION AND POLICY RECOMMENDATIONS

The findings call for strategic policy interventions to safeguard agricultural sustainability in peri-urban areas such as the CAA. First, rehabilitation and maintenance of irrigation infrastructure must be prioritized especially in Babakan and Pabuaran, where agricultural viability is most threatened. Second, spatial plans (RTRW) 2018-2038 must be rigorously enforced, with clearer zoning protections for productive agricultural land and restrictions on industrial expansion in high-potential districts such as Ciledug. Third, land governance reforms are essential to curb speculative trading and to embed farmers' perspective in land-use decision-making processes. Lastly, stronger institutional coordination between local governments, irrigation authorities, and land management agencies is crucial for realigning development trajectories with agropolitan objectives, ensuring not only the preservation of agricultural land, but also the resilience of rural livelihoods and regional food security.

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