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The Dynamics of Land Use Change in the Rural Urban Area of Malang City (Case Study: Pakis Rural Urban Area)

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A B S T R A C T

This study examines the spatial transformation of Pakis Sub-district as a rural–urban area influenced by the urban expansion of Malang City. The research aims to identify the spatial distribution of rural–urban areas and analyze land use change over the past 15 years. A quantitative approach was applied through spatial–temporal analysis of LANDSAT and Sentinel-2 images (2010, 2014, 2020, and 2024). The Combined Urban-Rural Fringe Index (CUFI) using Nighttime Light, POI density, and NDVI was employed, while land conversion was analyzed with the Normalized Difference Built-Up Index (NDBI). Results indicate that rural–urban areas are concentrated in the western and central Pakis, with built-up land expanding nearly 400%, highlighting significant urbanization impacts from Malang City

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INTRODUCTION

The development of cities in Indonesia has occurred rapidly in line with the increasing flow of urbanization, including Malang City. Rapid urban development accompanied by an increase in land demand has encouraged the expansion of urban areas to surrounding areas (Sarah et al., 2024). The development of Malang City as a growth center in the Malang Raya region has driven urbanization and urban expansion into surrounding areas, including several areas directly adjacent to Malang City (Poerwati et al., 2020).

This phenomenon has led to massive land use change in suburban areas (S. Nugroho et al., 2022). Massive land use change has resulted in the transition of areas that previously had rural characteristics to areas that are beginning to show urban characteristics. This phenomenon has created a hybrid area known as a rural-urban area, where rural and urban characteristics intersect (Insaf, 2004). In the context of Malang City, a rural-urban area has emerged, which is a functional area located outside the administrative boundaries of Malang City but is functionally integrated with the urban system of Malang City.

One part of the rural-urban area of Malang City is the rural-urban area of Pakis. This area is administratively located in Pakis District, Malang Regency. The rural-urban area of Pakis does not cover the entire Pakis District but only a part of the area that shows a mixture of rural and urban characteristics as a result of the urbanization of Malang City. An area can be categorized as a rural-urban area if it is a transition zone between urban and rural areas. This area has characteristics such as a change in land use from agricultural land to built-up land and a density of public facilities that ranges from high to low (Chen et al. 2021).

The phenomenon of land use change in the Pakis area shows significant figures. Based on the data, there has been an increase in land use change from non-built-up land to built-up land, with an increase of 11% between 2013 and 2023 (Nadzirah et al., 2023). This increase in land use change is not only caused by the expansion of Malang City, but also supported by policies contained in the 2010–2030 Malang Regency Spatial Plan (RTRW) and the 2016–2036 Pakis Subdistrict Spatial Plan (RDTR). This policy designates most of the Pakis area as a zone for residential, commercial, and light industrial development, thereby encouraging the conversion of non-built-up land into built-up land (Malang Regency Government, 2016).

This increase in land conversion has had positive impacts, such as improved access to infrastructure, increased employment opportunities, and increased land sale value (Sumastono et al. 2021). On the other hand, this land conversion has also had negative impacts, such as a reduction in productive agricultural land, increased building density, and the emergence of various environmental problems (Laiskodat & Lay, 2023). Cases of flooding and declining sanitation quality have been reported in recent years as a direct result of massive land conversion. If these conditions are allowed to continue, the threat of land degradation and environmental damage will loom in the future (Rijal & Tahir, 2022).

Previous studies on the dynamics of land conversion in rural-urban areas provide an overview of the factors driving land use change. For example, in Colomadu District (Surakarta City), there has been a significant decline in agricultural land area due to residential pressure over the past five years (Pradana et al., 2021). In Sukoharjo Regency, 40% of agricultural land has been converted into residential, industrial, and service areas (Aini et al., 2022). A similar phenomenon also occurred in Purwakarta Regency and the outskirts of Denpasar City, where development tended to follow the main transportation corridors (Rupini et al., 2017; Murtadho et al., 2018).

These findings are in line with the conditions in Pakis, which also show a tendency for agricultural land to be converted into built-up land by 15% between 2018 and 2023 (Nadzirah et al., 2023). This change marks the transformation of the Pakis region from a regionally characterized area to a rural-urban area with increasing building density (Aprildahani, 2013). The similarity in patterns shows that ruralurban pressures are not only triggered by the growth of major cities, but also by factors such as accessibility, spatial planning policies, and local socio-economic dynamics. Therefore, this study aims to further examine the dynamics of land use change in the rural-urban area of Pakis as part of the rural-urban 3 area of Malang City, using a spatial and temporal approach that utilizes multitemporal satellite imagery data.

In view of these issues, it is important to understand the dynamics of land use change in rural-urban areas such as Pakis. This study will focus on the dynamics of land use change in the rural-urban area of Pakis as part of the rural-urban area of Malang City. The dynamics referred to in this study refer to changes in land use that have occurred over the last 15 years, as seen from a comparison of the area of undeveloped and developed land in 2010, 2014, 2020, and 2024. This study utilizes multitemporal satellite imagery data to identify land use change dynamics and the spatial distribution of the rural-urban area of Pakis.

LITERATURE REVIEW

Dynamics of Land Use Change

The dynamics of land use change is a phenomenon of changing land use from its original function to a different function, which occurs gradually or rapidly within a certain period of time. Land use change itself, or land conversion, is the change of part or all of an area of land for a purpose other than that previously planned, which causes negative impacts on the environment and the potential of the existing land (Setiawan, 2016). According to Lambin et al. (2001), the conversion of agricultural land or green open spaces into residential areas, industrial areas, or commercial facilities is a response to human needs for space and resources. The process of land use change usually occurs due to the complex interaction of social, economic, political, and environmental factors (Lambin et al., 2001). In addition, spatial planning policies and infrastructure development, such as toll roads and industrial areas, are among the main factors accelerating land conversion (Verburg et al., 2012).

The dynamics of land use change cannot be separated from the complex interaction of social, economic, and environmental factors. According to the Land Change Science theory proposed by Turner et al. (2007), the complex interaction between human and environmental systems influences land use. Changes in land use are influenced by various variables, including government policy, population growth, technological advances, and climate change. Because changes occur in specific spaces and times, this theory emphasizes that spatial and temporal approaches are very important for analyzing land conversion (Turner et al., 2007). From the above theories, it can be concluded that the dynamics of land use change are changes in land use over a certain period of time that are influenced by complex interactions between social, economic, political, and environmental factors, and have a significant impact on the physical, social, and economic structure of an area.

Rural-Urban Areas

Rural-urban areas are transitional areas between urban and regional areas with various services. These areas serve as providers of goods and services for residents, such as agricultural products for the surrounding population (Boccolini & Giobellina, 2018). Pyor (1968) defines rural-urban as a transition zone between areas undergoing continuous development and the outskirts of city centers with rural-urban zoning. Rural-urban areas can also be defined as transitional zones between areas dominated by urban land use and areas dominated by agricultural land use. Rural-urban areas cannot be considered entirely urban or rural areas. These areas have distinctive land use characteristics, such as agricultural land, livestock farming, agriculture-based industries, commercial facilities, and new housing developments. There have been massive changes in land use, especially agricultural land that has been converted into commercial or economic land (Asif, 2011).

Rural-urban areas are characterized by a mixture of urban and regional characteristics. Due to the influence of urban expansion, regional characteristics are gradually or even suddenly replaced by urban characteristics in terms of land use, employment and income, and culture. Along with this transformation process, the need for land increases due to migration from cities or regions and natural population growth. The pressure for land continues to worsen in line with land use for commercial purposes such as the construction of new buildings, new 24 housing, and landfills. The increase in land demand not only changes land use but also causes the degradation of natural resources in the region. Social conditions are also affected by unplanned changes in land use, a lack of civil services, and the inability of policymakers to address the problems caused by these changes (Anbumozhi, 2007).

Previous Studies

Empirical studies in Indonesia highlight varied manifestations of rural-urban change. In Colomadu, Central Java, rapid housing development reduced agricultural land and altered community livelihoods (Pradana et al., 2021). In Sukoharjo, settlement expansion followed the development of industrial estates (Aini et al., 2022). In Purwakarta and Denpasar, peri-urban transformation was strongly correlated with highway infrastructure and tourism development, respectively (Rupini et al., 2017; Murtadho et al., 2018). These studies reinforce

the argument that accessibility and policy decisions are critical in shaping rural-urban areas.

However, there is limited literature focusing on secondary cities like Malang, which, despite being outside the scale of megacities, demonstrate significant rural-urban transformation. This study seeks to address that gap by providing empirical evidence from Pakis as part of the rural-urban fringe of Malang.

METHODOLOGY

This study uses a quantitative, ex post facto, observational survey design to analyze land use changes in the urban-rural area of Pakis, Malang City. The study population covers the entire functional area of Pakis District, while the sample for verification consists of several field points selected purposively for field inspection. This study uses secondary data including multi-temporal satellite imagery (LANDSAT 7 & 8 for 2010 and 2014, Sentinel-2 for 2020 and 2024), Night Time Light (NTL) imagery from NPP-VIIRS, and points of interest (POI) from Ina-Geoportal. Primary data were obtained through direct field observations and documentation at the selected sample locations.

Data analysis was conducted in two stages. First, the Combined Urban-Rural Fringe Index (CUFI) model was applied to identify urban and rural areas by integrating NTL, POI density, and Normalized Difference Vegetation Index (NDVI). Second, the Normalized Difference Building Index (NDBI) was used to analyze the dynamics of land use change by mapping built-up and unbuilt-up land in 2010, 2014, 2020, and 2024. Spatial and temporal analysis was performed using Geographic Information System (GIS) tools, and classification accuracy was tested using confusion matrices, overall accuracy, and kappa coefficients, supported by field validation.

RESULT

Step 1. Data Acquisition and Preprocessing

The research began with the acquisition of Landsat 7 (2010), Landsat 8 (2014), and Sentinel-2 (2020 and 2024) imagery, as well as Nighttime Light (NTL) data from NPP-VIIRS and Point of Interest (POI) data from Ina-Geoportal. The administrative boundary of Pakis Subdistrict was also obtained for spatial reference. All imagery was pre-processed through radiometric and atmospheric correction, cloud masking, reprojection, and resampling into the same grid resolution, so that multi-temporal comparisons could be performed consistently.

Step 2. CUFI Construction and Classification

The Combined Urban–Rural Fringe Index (CUFI) was used to identify rural–urban areas in the study region. Each variable like NTL, POI density, and NDVI was normalized to a 0–1 scale using the following equation:

$$X_{norm} = \frac{X - X_{min}}{X_{max} - X_{min}}$$

To refine the separation between built-up and non-built-up land, NDVI and NTL values were binarized and combined into a vegetation-correction index (NV), where NV = 1 indicated built-up land and NV = 0 indicated non-built-up land. Afterward, CUFI values were calculated through the integration of POI (NP) and NV as:

$$CUFI = NP \times NV$$

The CUFI results were presented in two sets of maps. The first illustrates CUFI values across Malang Raya (Figure 1), showing the regional distribution of rural–urban gradients.

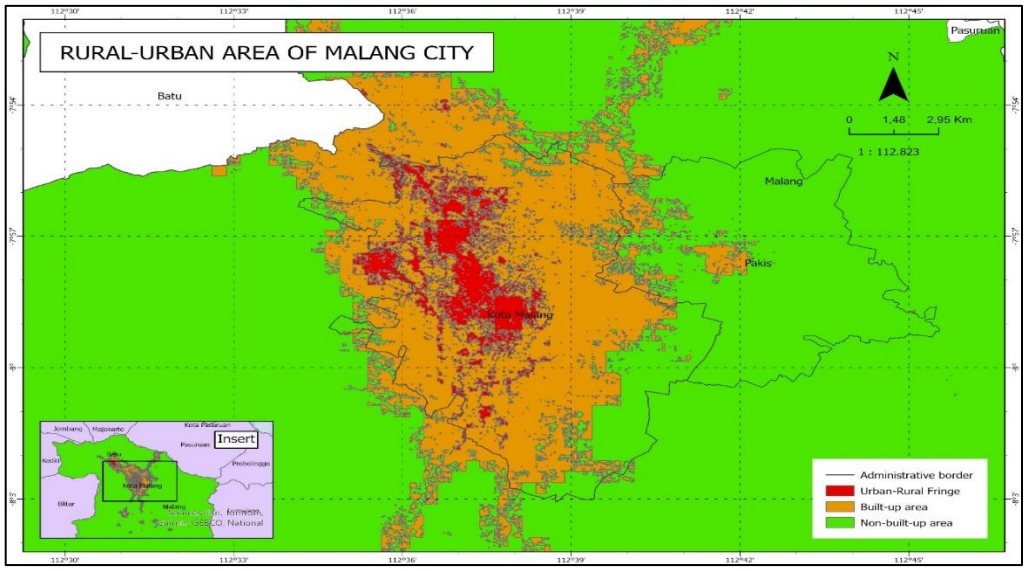

Figure 1. Map of Rural-Urban Areas in Malang City

The second illustrates CUFI classification within Pakis Subdistrict (Figure 2), highlighting localized rural–urban transitions adjacent to Malang City.

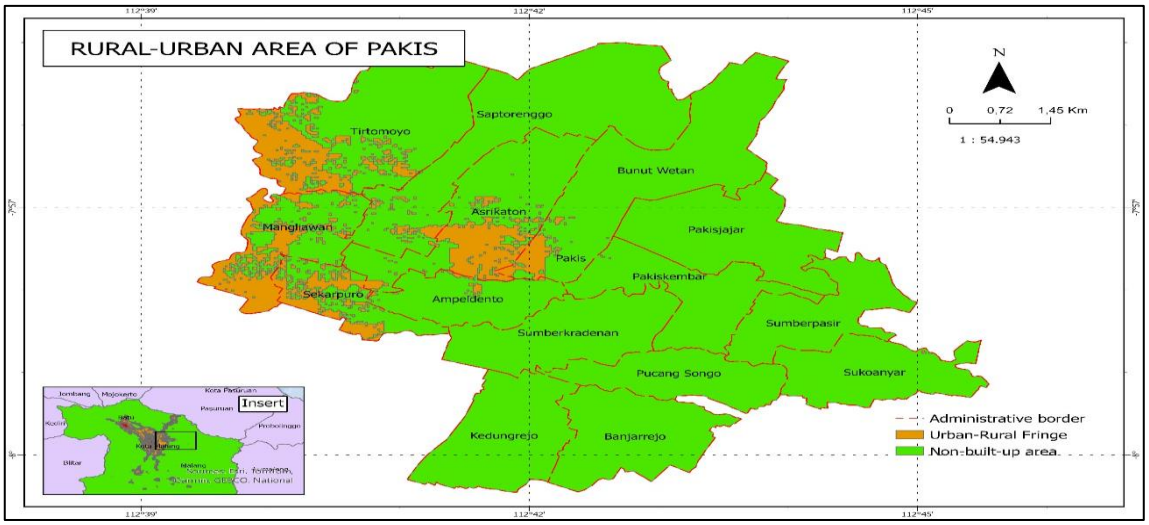

Figure 2. Map of Rural-Urban Areas in Pakis

The CUFI classification in Pakis Subdistrict was further analyzed at the village level. Table 2 presents the distribution of rural–urban areas by village, showing both absolute area (ha) and percentage contribution. The results indicate that the largest rural–urban areas are located in Tirtomoyo (30.72%), Mangliawan (24.37%), and Asrikaton (20.52%), which together account for more than 75% of the total rural–urban area in Pakis.

Table 1. Percentage of Rural-Urban Area in Pakis

Areas	**Rural–Urban Area (ha)**	**Rural-Urban Percentage (%)**
Tirtomoyo	190,93	30,72
Sekarpuro	85,00	13,68
Mangliawan	151,47	24,37
Saptorenggo	20,11	3,24
Ampeldento	8,08	1,30
Bunutwetan	38,13	6,13
Asrikaton	127,54	20,52
Pakiskembar	0,27	0,04
Total	621,53	100,00

Step 3. Built-Up Mapping Using NDBI

Land use classification was conducted using the Normalized Difference Built-Up Index (NDBI), which separates built-up and non-built-up areas. The NDBI is calculated from the shortwave infrared (SWIR) and near-infrared (NIR) bands, as shown in the following formula:

$$NDBI = \frac{(SWIR - NIR)}{(SWIR + NIR)}$$

Pixels with NDBI values greater than zero were classified as built-up land, while those less than or equal to zero were classified as non-built-up land (Hadi & Sadharto, 2011). The classification results are presented in the land cover maps for 2010, 2014, 2020, and 2024 (Figures 3–6). These maps clearly show the expansion of built-up areas in Pakis Subdistrict over time, particularly in the western and central zones adjacent to Malang City.

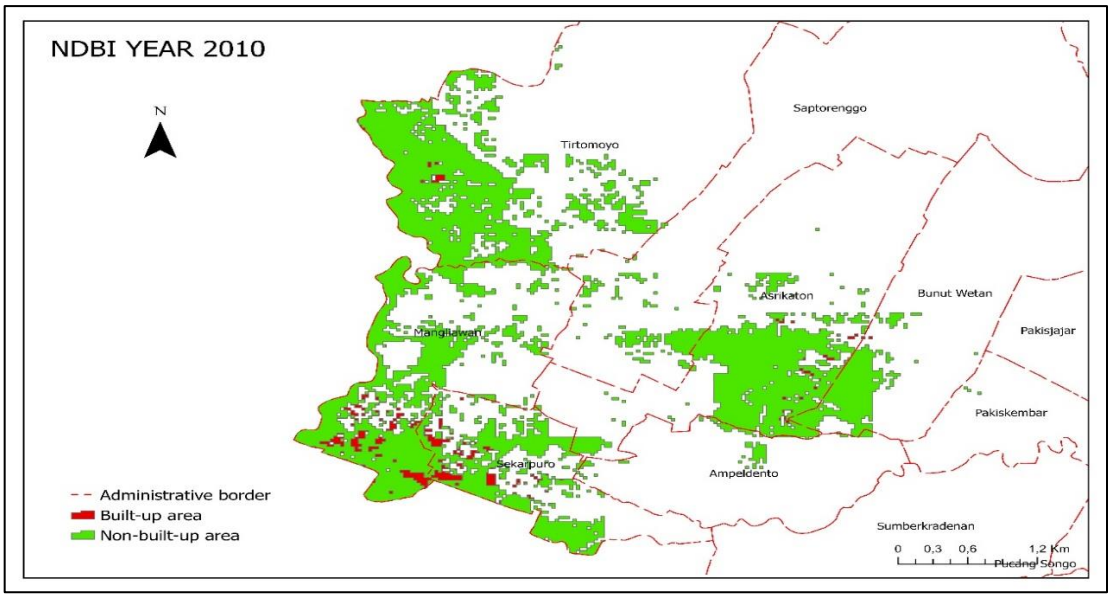

Figure 3. Land Cover Map of the Rural-Urban Pakis Area in 2010

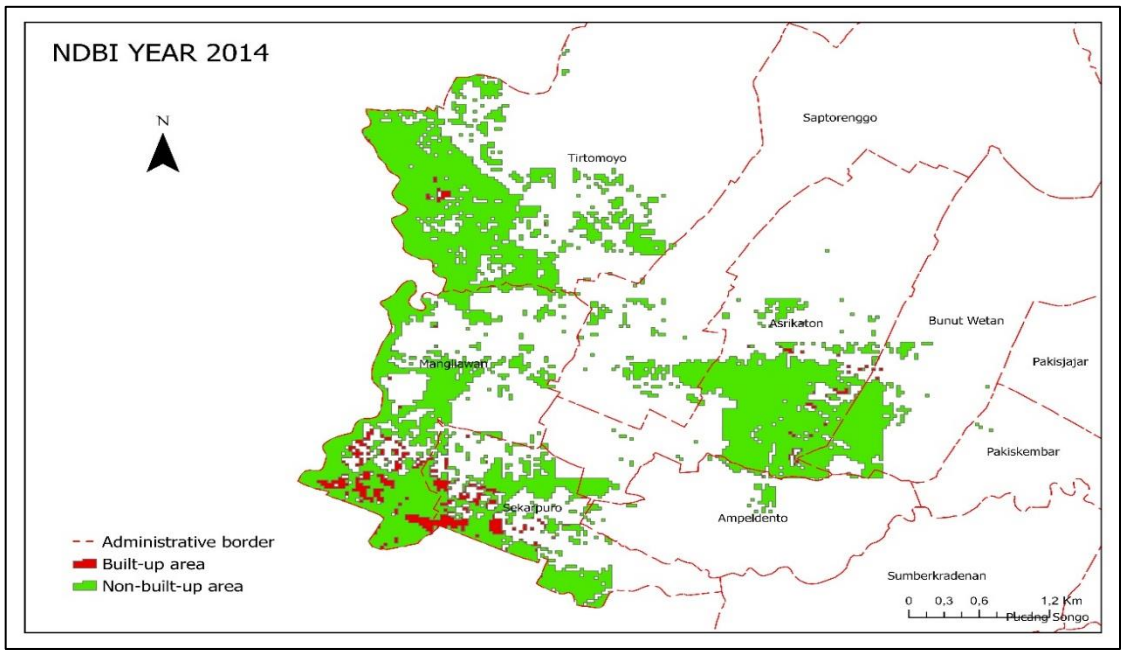

Figure 4. Land Cover Map of the Rural-Urban Pakis Area in 2014

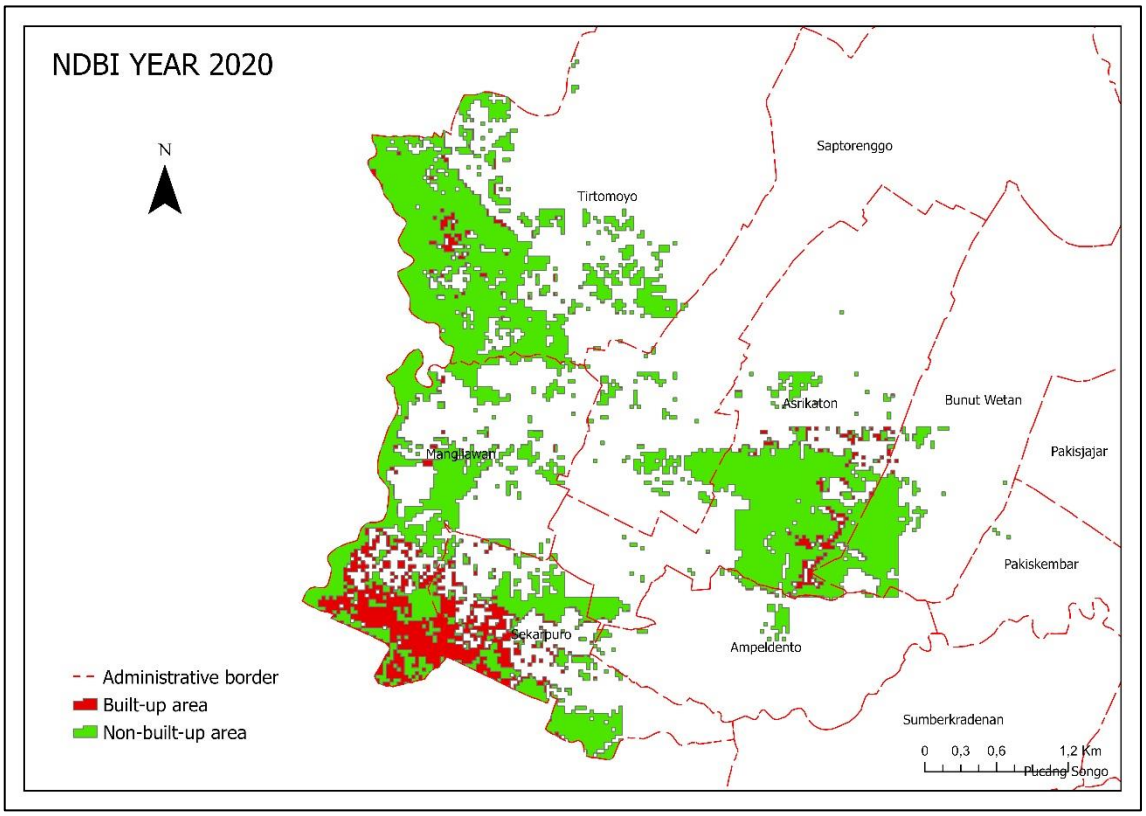

Figure 5. Land Cover Map of the Rural-Urban Pakis Area in 2020

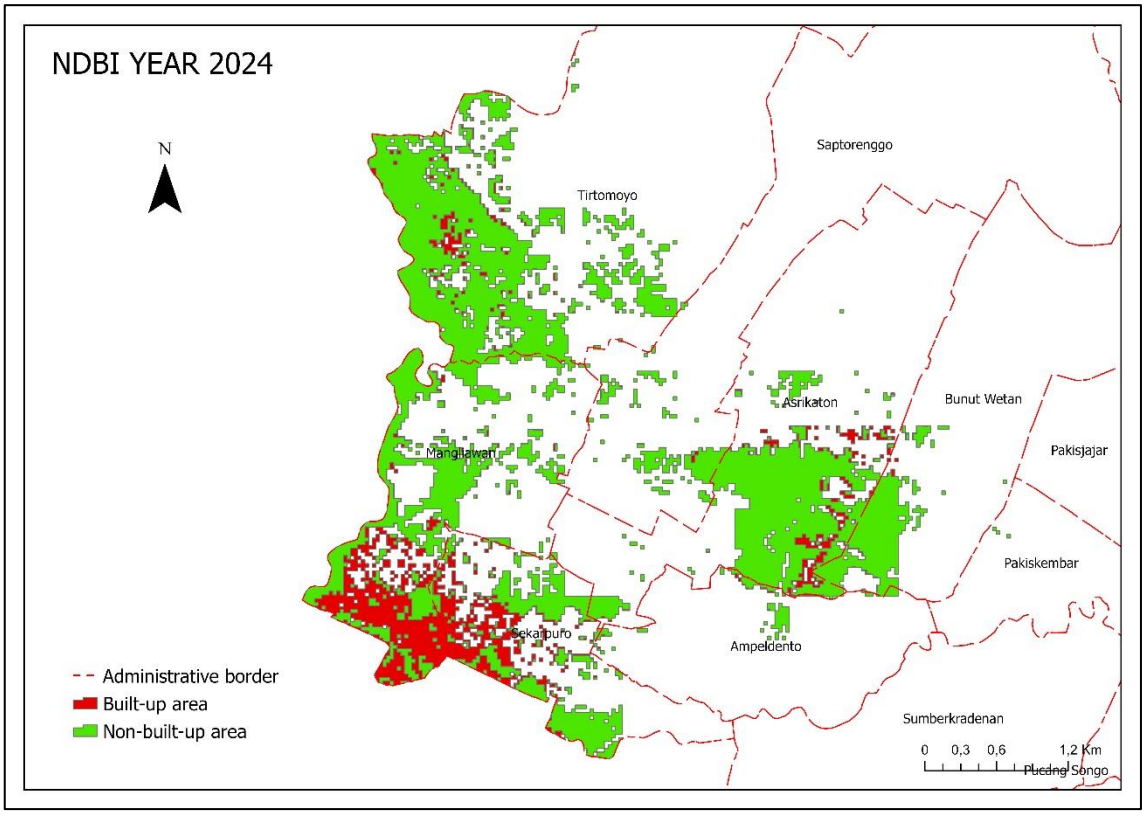

Figure 6. Land Cover Map of the Rural-Urban Pakis Area in 2024

Step 4. Built-Up Mapping Using NDBI

The extent of built-up and non-built-up areas was calculated for each year. Land cover change was measured using:

$$\Delta Area = Area_{\{t2\}} - Area_{\{t1\}}$$

$$\%Change = \left(\frac{\Delta Area}{Area\_\{t1\}}\right) \times 100\%$$

The results are summarized in Table 1. Built-up land increased consistently, with the largest jump occurring between 2014 and 2020.

Table 2. Land Cover Summary of Rural-Urban Pakis (2010–2024)

Year	Non-built-up (ha)	Built-up (ha)	Built-up (%)
2010	599.10	22.43	3.61
2014	587.84	33.69	5.42
2020	525.52	96.00	15.45
2024	510.49	111.03	17.86

Step 5. Accuracy Statement

The classification was validated with 343 ground-truth points. Overall Accuracy and Kappa were calculated as follows:

$$Overall\ Accuracy = \frac{(\Sigma\ correct)}{N}$$

$$\kappa = \frac{(Po - Pe)}{(1 - Pe)}$$

Table 3. Confusion Matrix

Actual/Predicted	Non-built-up	Built-up	Row total
Non-built-up	165	7	172
Built-up	5	166	171
Column total	170	173	343

Based on the results, an overall accuracy of 96.5% was achieved, which indicates a very high level of classification reliability. In addition, the Kappa coefficient reached 0.93, which according to Viera & Anthony J. (2005) falls into the category of almost perfect agreement. These findings confirm that the classification method applied is highly effective in mapping land cover in the rural–urban areas of Pakis. Therefore, the resulting maps can be used as a valid basis for drawing conclusions on land use change dynamics during the period 2010–2024.

DISCUSSION

Rapid urban development has driven urban expansion, causing spatial transformation of areas on the outskirts of cities (Ode et al., 2020). This spatial transformation is characterized by the shift of urban functions to suburban areas, creating an area with a mixture of regional and urban characteristics, known as a rural-urban area (Oktavia, 2010). This phenomenon often occurs in the suburbs of large cities such as Malang. One of the areas experiencing this phenomenon is Pakis, which is geographically adjacent to Malang. As one of the suburbs of Malang, Pakis cannot escape the impact of urbanization and the expansion of Malang.

The rapid process of urbanization and expansion of Malang City has caused areas in Pakis to undergo a transformation from rural to urban or rural-urban areas. Rural-urban areas are areas that are functionally connected to cities (Meisanti et al., 2022). The context of rural-urban areas as functionally important areas is important considering that not all areas are administratively included in rural-urban areas. Therefore, the identification of rural-urban areas in Pakis was carried out to determine the spatial distribution of rural-urban areas in Pakis. 5 The identification of rural-urban areas in Pakis began with mapping the rural-urban areas of Malang City, which covers all areas directly adjacent to Malang City.

The identification was carried out through spatial analysis using nighttime light (NTL) data, public facility density (POI) data, and vegetation density (NDVI) data. This data was used because it provides complete information and accurate locations that can illustrate regional and urban differences. This data is also often used in urban analyses such as urban sprawl analysis, rural-urban dynamics, and rural urban delineation (Xu et al., 2023, Wang et al., 2022, Yu et al., 2023). The collected data was then processed using the Combined Urban-rural Fringe Index (CUFI) method to identify areas that fall into the rural-urban category in Malang City. The CUFI method was chosen to analyze rural-urban areas because satellite imagery is effective in assessing the dynamic conditions of rural-urban areas, both spatially and temporally (Ummah, 2019). The results of the analysis are presented in the form of a map of the rural-urban areas of Malang City.

The rural-urban areas marked in orange on the map are scattered around Malang City as the urban center of Malang City. This pattern shows that the expansion of Malang City occurs radially or spreads outwards from the city center. This pattern is characterized by the expansion of urban areas along the main transportation routes, creating a radial or finger-like pattern from the city center (Carneiro et al., 2021). The pattern of urbanization in Malang City itself tends to be towards the north, south, and east, following strategic routes such as main roads connecting Malang City with the surrounding areas.

On the north side, the rural-urban area extends towards Singosari and Lawang, which are the main corridors connecting Malang City and northern East Java, such as Surabaya. On the south side, the expansion of the rural-urban area spreads to Pakisaji, Bululawang, Gondanglegi, Turen, to Kepanjen, which is the

administrative center of Malang Regency. On the western side, the rural urban area also extends to Wagir, Karangploso, and Dau, both of which are areas that directly border Batu City and are the main connecting routes between Malang City and Batu City. On the eastern side, the rural-urban area extends to part of the Pakis area. It is this rural-urban area of Malang City that extends into the Pakis area that will be the focus of this study. As an area that is geographically adjacent to Malang City and significantly affected by urban expansion and development policies, Pakis is a clear representation of the dynamics of the transition from rural to urban areas.

The spatial distribution of the rural-urban areas of Pakis is not evenly distributed throughout the Pakis region. Instead, it is concentrated in several areas in the western and central parts. The areas included in the rural- -urban Pakis category include several areas such as Tirtomoyo, Mangliawan, Sekarpuro, Saptorenggo, Asrikaton, Ampeldento, Bunut Wetan, and a small part of the Pakiskembar area.

The concentration of rural-urban areas in Pakis is dominated by three main areas, namely Tirtomoyo (30.72%), Mangliawan (24.37%), and Asrikaton (20.52%). These three areas significantly contribute to more than 75% of the total rural-urban area in Pakis District. In contrast, areas such as Pakiskembar and Ampeldento have very small percentages, only 0.04% and 1.30%, respectively. This shows that the rate of urbanization and land use change is not evenly distributed but is concentrated in certain areas.

Geographically, the areas with the highest percentages are directly adjacent to or close to Malang City and are located on the main corridor connecting Malang City with the eastern part of Malang Regency. This strategic location, supported by accessibility and connectivity, is an important element of physical interconnection between areas, which further develops into spatial interconnection between areas (Nurrady et al., 2020). In the context of the rural-urban area of Pakis, this spatial interconnection between regions is reflected in the process of rural-urban sprawl from Malang City towards the Pakis area itself, which indicates a functional interconnection between the two regions.

Based on observations, areas included in rural-urban areas have distinctive characteristics compared to other areas. Areas such as Tirtomoyo and Sekarpuro have been dominated by planned residential areas characterized by the presence of housing in the form of clusters and elite residential areas such as Araya, Sawojajar, and other housing complexes. This condition shows that these areas have become residential choices for people outside Malang City, in line with the concept of urban expansion towards suburban areas due to the increasing demand for residential land in urban areas (Warsono et al., 2009).

The spatial distribution of rural–urban areas in Pakis demonstrates the uneven yet concentrated nature of urban expansion, particularly in subdistricts directly connected to Malang City. This spatial pattern not only reflects the influence of accessibility and connectivity but also indicates the areas most susceptible to further physical transformation. To understand the extent of this transformation more comprehensively, it is important to analyze how land use in these rural–urban zones has changed over time. Therefore, the next stage of

analysis focuses on the dynamics of land use change in Pakis from 2010 to 2024, particularly the shift from non-built-up to built-up land, which provides a clearer picture of the rural–urban transition in this region.

The dynamics of land use change in the rural-urban area of Pakis between 2010 and 2024 show significant changes. This condition can be seen from the increase in the area of built-up land and the decrease in the area of non-built-up land from year to year. The built-up land referred to in includes land use for settlements, industry, public facilities, and other buildings. Meanwhile, non-built-up land includes land use for agriculture, plantations, forests, water bodies, and vacant land (Haikal et al., 2023).

The analysis of land use change dynamics was carried out using the NDBI method utilizing a Geographic Information System. In the NDBI method, there are two categories of values for developed and undeveloped land. Values ranging from -1 to 0 are considered undeveloped land, while values ranging from 0 to 1 are considered developed land. The results of the analysis are in the form of NDBI maps for each year, representing each 5-year period over the last 15 years.

Based on Table 2, it can be seen that there has been a conversion of land use from undeveloped to developed land with varying intensity. In 2010, the area of undeveloped land in the rural-urban area of Pakis was recorded at± 599.50 ha, while the area of developed land was only± 22.43 ha. This proportion shows that in that year, the rural-urban area of Pakis still had predominantly rural characteristics, marked by land cover that was still dominated by undeveloped land. However, several areas began to show changes in land cover that could be marked as the beginning of land use change dynamics leading to the transition of the area towards rural-urban characteristics (Sushanti et al., 2018).

During this period, developed land began to expand in several areas such as Sekarpuro and a small part of Asrikaton and Ampeldento. These areas share similar characteristics, namely their proximity to the city of Malang, which is also supported by good accessibility to the main transportation network. These conditions have encouraged these areas to undergo a faster urbanization process compared to other areas. This period can be indicated as the beginning of the urbanization process, marked by land use change, especially in the main road corridors connecting rural-urban areas with the city center (Webster & Muller, 2002). Although the urbanization process was not yet evenly distributed, the emergence of pockets of development in several of these areas could be the starting point for regional transition as a result of the urbanization process. This phenomenon is in line with the findings of F. Nugroho & Al-Sanjary (2018), which show that the emergence of pockets of development, which tend to be in areas close to cities, is the starting point for the expansion of urban characteristics to suburban areas as part of the urbanization process (F. Nugroho & Al-Sanjary, 2018).

In the subsequent period, namely in 2014, there was a significant increase in the area of built-up land. There was an increase in the area of built-up land from 22.43 ha (±) to 33.69 ha (±). This change in land cover to built-up land

occurred mainly in the southern part, namely most of the Sekarpuro and Mangliawan areas. These areas are located on the connecting route between Pakis and Malang City, such as Jalan Raya Sekarpuro, which connects the Sekarpuro area with the Malang City area. The strategic location with good accessibility is one of the strong drivers of land use change, especially in suburban areas. This is in line with Alonso's (1964) urban economic theory, which states that areas with easy access and proximity to the city center have higher development intensity than areas with the opposite characteristics (Wijaya, 2015).

Although most of the area is still dominated by undeveloped land, this period has seen a growing shift in land use. The emergence of planned settlements, marked by the appearance of new housing estates, is a response to the increasing demand for residential land in Malang City (Miftahur Ridha, 2020). Rural-urban areas began to become an alternative choice for urban communities looking for residential locations outside the city of Malang. This condition shows that this area began to experience urbanization pressure from the city center, which was an early indicator of the beginning of a functional transition towards a more dynamic rural-urban area (Selang et al., 2018).

The following five-year period, from 2014 to 2020, saw the peak of land use conversion in the last 15 years. The area of developed land in 2020 was recorded at± 96 ha, an almost threefold increase compared to 2014, which was only± 33.69 ha. On the other hand, the area of undeveloped land experienced a significant decline from± 588.24 ha in 2014 to± 525.93 ha in 2020. This massive conversion occurred in just a period of 5 years.

As seen on the map, built-up areas began to cover more areas than in previous years. Built-up areas began to expand, especially to the central and western parts of the rural-urban area of Pakis, which was previously dominated by undeveloped land. Despite this significant increase, undeveloped land still dominates the land cover in the rural-urban area of Pakis. During this period, development began to spread to other areas and was not limited to areas directly adjacent to the city of Malang. This condition shows that the development of the Pakis rural-urban area is no longer limited to the fringe zone close to the city center but has begun to spread to other areas (Haikal et al., 2023).

A similar condition was also found in the peri-urban area of Yogyakarta, which showed that there was an expansion of development to areas further away from the city center, triggered by growth from the urban core itself (F. Nugroho & Al-Sanjary, 2018). In line with these research results, Lokantara & Amo (2021) also found a change in land use from undeveloped to developed land in suburban areas, triggered by an increase in the demand for land in cities for residential and commercial purposes (Lokantara & Amo, 2021).

Supported by its proximity to Malang City and adequate accessibility, the rural-urban area of Pakis is increasingly becoming an attractive alternative place to live. The high demand for housing in this suburban area has created significant opportunities for developers in the property sector. This could encourage land conversion for housing purposes. This condition is a response to the high demand for alternative housing in the suburbs of Malang City. This preference

has ultimately led to the concentration of new settlements in several areas such as Asrikaton, Mangliawan, and Sekarpuro (Tara Miftahur Ridha M, 2020).

In the following 5-year period, namely 2020-2024, there will be an increase in the area of built-up land, although not as massive as in previous periods. Built-up land began to dominate the southern rural-urban areas, with a slight increase in the western part, which was previously dominated by non-built-up land. This increase was in line with the pattern of new development that had reached areas previously dominated by non-built-up land, such as Asrikaton and Ampeldento. Conversely, undeveloped land began to decrease and only dominated the northern part. This condition indicates that development pressure has spread evenly to areas that were not previously affected by the urbanization process (Surya et al., 2022).

This change also shows that the spatial attractiveness of Pakis continues to increase as a transitional location between rural and urban life. This phenomenon not only reflects the physical development of the region but also changes in residential preferences, especially among urban communities seeking alternative housing in suburban areas (Cohen, 2017). This trend is in line with the characteristics of urban shadow and commuter zone areas, where residents still carry out activities in the city center but choose to live in quieter and more economically affordable areas, while still maintaining their main activities in the city (Sadewo et al., 2023).

The slowdown in the rate of land conversion compared to the previous period can be understood as an indication of the limited space available for development, increasing land prices, or the implementation of stricter spatial planning regulations (Firman & Fahmi, 2017). In the context of regional planning, this condition emphasizes the need for more selective control of spatial utilization, so that the balance between ecological, social, and economic functions in rural urban areas is maintained (Rustiadi et al., 2021). In addition, this shift also strengthens the role of the Pakis rural-urban area as part of the Malang urban system as a dynamic rural-urban functional area.

After conducting an analysis, it can be seen that the dynamics of land use change in the rural-urban area of Pakis occurred gradually but tended to increase consistently from year to year. It is recorded that in the last 15 years from 2010 to 2024, the rural-urban area of Pakis has experienced land conversion from undeveloped land to developed land by± 88.60 ha. This figure shows an increase of almost 400% compared to 2010, when the area of developed land was only± 22.43 ha. On the other hand, the area of undeveloped land has decreased in inverse proportion to the area of developed land. The distribution of developed land tends to be consistently spread across areas that are spatially and functionally closely related to the city of Malang. This condition reflects the inevitable physical dynamics of a rural-urban area that continues to be affected by the influence of urbanization in the city of Malang (Rustiadi et al., 2021).

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of research on land use change dynamics in the rural-urban area of Pakis, it can be concluded that the rural-urban area of Pakis is concentrated in the western and central parts of Pakis District, especially in areas directly adjacent to the city of Malang. The identification of rural-urban areas using the Combined Urban-Rural Fringe Index (CUFI) model shows a spatial distribution that follows a radial pattern, with strong functional links through major transportation corridors. Analysis of land use change dynamics over the last 15 years using the NDBI method indicates an increase in built-up land area of 88.6 hectares, or nearly 400% compared to the initial condition in 2010, while the area of non-built-up land has decreased significantly. These findings show that there has been a massive spatial transformation in the Pakis area in response to the pressure of urbanization from the city of Malang.

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