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Research article

The Evolution of Madiun City: The Impact of Accessibility on Urban and Economic Transformation

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Abstract

The development of Madiun from 1900 to the 2000s was shaped by political, economic and infrastructure changes that influenced its urban structure. This research examines the city's transformation from the colonial (1990-1945) to the reform era (1998-now), focusing on the relationship between accessibility and the growth of new economic centres. Although previous studies have explored its development, they lack insights into this specific connection. Using a spatial and diachronic approach, the study analyses road networks, economic centres and urban structures using historical maps, together with journals, field surveys and satellite imagery. The data were processed in several stages: (1) georeferencing and digitising of the historical maps to align with contemporary spatial data; (2) mapping of road networks and economic centres using GIS-based network analysis; (3) land use classification and detection of changes from satellite imagery; and (4) validation of the results through field surveys at key locations. These steps, undertaken with the use of ArcGIS Pro, produced diachronic maps detailing urban changes and the spatial relationship between accessibility and economic growth. The findings reveal that accessibility, particularly through transportation networks, has been a key driver of new economic centres. Areas with high accessibility tend to host diverse and intensive economic activities. These centres have a significant influence on Madiun's urban structure, with agricultural land decreasing from 47.01% in 1984 to 34.57% in 2024, while built-up areas, including residential zones, expanded from 52.99% to 65.43%. The expansion of residential areas, which reached 57.5% during the reform era, indicates a major shift in land use, driven by accessibility and economic growth. The centres also have a strong influence on Madiun's urban structure, with a transition from agriculture to residential, commercial and industrial functions. The research highlights the role of transportation infrastructure in shaping economic development and urban adaptation. It contributes valuable insights into the interplay between accessibility and economic centres, offering a reference for future urban planning to help foster sustainable growth in cities such as Madiun.

Keywords: Spatial Analysis; Historical GIS; Urban Planning.

1. Introduction

Research on urban development dynamics is an essential focus in understanding the social, economic and spatial transformations occurring across various regions. Cities, as manifestations of human civilisation, reflect the complexity of societal activities, including economic, social, cultural and political aspects (Bustamam, 2006). One prominent theory in this field is the urban ecology theory proposed by Park and Burgess, which proposes that cities initially developed in fertile areas with strong social and physical connections (Burgess, 2020). This concept emphasises that urban growth is influenced by human ideas, directly reflecting the main interests of a particular period (Setiadi, Yunus, and Purwanto., 2022). Java Island, particularly from the 17th to the 20th century, served as a centre of governance and economy, fostering the creation of many traditional and colonial cities (Setiadi *et al.,* 2022).

Recent research further supports these perspectives, highlighting the role of economic clusters, accessibility and land-use dynamics in urban growth. Franck and Fau (2014) explain that intra-urban dynamics in Southeast Asia, including Java, are shaped by historical urban structures and evolving governance strategies. Similarly, Setiadi *et al.* (2022) emphasise that colonial economic liberalisation played a significant role in shaping the spatial and economic structure of Java's cities, including Madiun. Jones (1984) adds that urbanisation and sectoral shifts in employment continue to drive the economic trajectory of Indonesian cities, where accessibility and governance remain key determinants.

In this context, Madiun City emerges as a particularly interesting case study due to its unique historical development and strategic position. Located between the Madiun and Brantas Valleys, it initially gained prominence as a residential city under the colonial-forced cultivation system. Its fertile lands established it as a key centre for rice and sugarcane production, with Lombard referring to the Madiun Valley as the "second heart" of Java's agricultural production (Lombard, 1996). The city's strategic position as a transit hub connecting three major regions in western East Java further reinforced its importance, supported by an extensive network of arterial roads linking it to Surabaya and Central Java cities (Margana, 2018). Mayang Kusuma and Fikriya (2023)

demonstrate that land-use changes in Madiun are increasingly shaped by transportation infrastructure, where improved accessibility drives new settlement patterns, a process that is further reflected in mappings of Madiun's urban landscape showing how historical sites and digital tourism simultaneously influence spatial planning and local economic development.

Despite its historical importance and strategic advantages, Madiun presents an intriguing development pattern compared to other former colonial cities in East Java. While cities such as Malang, Pasuruan, and Kediri experienced rapid growth, Madiun exhibited a relatively slower development trajectory, as evidenced by a population growth rate of 33.8% and an economic growth rate of 5.80% based on data from the Central Bureau of Statistics (Badan Pusat Statistik) of Madiun City for 2003 and 2023. The city has also undergone significant economic transformation, moving from its traditional agricultural base to focus on trade and tourism sectors (Erdiana, 2023). This shift reflects a long-term trajectory of economic change in Madiun: beginning as an agrarian centre during the colonial period, with rice and sugarcane production; then evolving into an industrial hub with sugar factories and supporting rail transport; transitioning into trade and services during the New Order (1965 - 1998); and finally expanding into tourism and creative economy sectors in the Reform era. Highlight that Ponorogo and surrounding regions, including Madiun, have developed economic centres driven by accessibility and industrial expansion. Similarly, Pusdiktasari (2020) analyse the spatial growth of East Java, demonstrating how regions such as Madiun, Blitar and Banyuwangi exhibit slower than other city yet steady urbanisation trends due to infrastructure constraints and economic diversification. Unlike other East Javanese cities, this staged transformation underscores Madiun's role as a transit-based economy shaped by changes in accessibility and transportation infrastructure.

Previous studies have consistently demonstrated that accessibility and the concentration of economic centres constitute fundamental drivers of urban development and spatial transformation. Myrdal's cumulative causation theory posits that regional economic growth is strongly conditioned by the spatial distribution of resources and the availability of supporting transportation infrastructure, which tend to reinforce existing development advantages. In a similar vein, Boudeville (1975) emphasises that growth poles commonly emerge from geographical agglomerations that are structurally supported by transportation networks, enabling the concentration of economic activities and capital flows. Empirical evidence from contemporary urban contexts further substantiates these theoretical arguments. Zhou and Gao (2020), in their study of Tokyo, reveal that urban morphology and transportation accessibility jointly shape mobility patterns and reinforce the dominance of economic cores, while Liu *et al.* (2019) demonstrate that improved traffic accessibility significantly accelerates land-use change and functional urban expansion in the Pearl River Delta. Malik, Zuhroh and Suliswanto (2021) similarly confirm that economic clustering in East Java, including Madiun, follows clear patterns of accessibility and industrial agglomeration. From a classical economic geography perspective, Marshall (1920) notes that strategically located areas tend to attract complementary industries, generating mutually reinforcing agglomeration economies. This notion aligns with Black's (2018) definition of accessibility as the ease of reaching locations through transportation systems, which plays a decisive role in the formation and sustainability of economic centres. Extending this framework, Rietveld (2006) illustrates how transportation systems and urban structures are closely intertwined, shaping regional economic hierarchies. More recent studies highlight the broader socio-spatial and ecological implications of this process. Wang *et al.* (2022) show that infrastructure-led urbanisation in the North China Plain reshapes ecosystem services, revealing trade-offs between economic growth and environmental sustainability. Lai and Zhang (2016) further demonstrate that redevelopment driven by accessibility and market forces transforms industrial and informal urban spaces, as observed in Shenzhen's "villages in the city." At a larger spatial scale, Luo *et al.* (2023) identify infrastructure connectivity and accessibility as key drivers of urban–rural integration in China, while Tosa *et al.* (2018) document how long-term transport investment and economic growth have catalysed metropolitan transformation in Bucharest, Romania. Collectively, these studies underscore that accessibility is not merely a technical attribute of transportation systems, but a central mechanism through which economic centres emerge, urban space is reorganised, and regional development trajectories are shaped.

Although some studies, such as that of Bustamam (2006) on Madiun's spatial structure, and of Widyantari (2012) on land-use changes, have provided insights, most have focused on specific periods or aspects. Therefore, this research aims to address these gaps by analysing the relationship between accessibility, economic centres, and urban structure in Madiun from 1900 to now. Through a holistic approach examining historical maps, academic literature and modern data sources, the study seeks to understand how Madiun's unique position as a transit hub and its historical legacy have influenced its urban development patterns. It is hoped the findings will not

only contribute to theoretical discussions, but also provide practical insights for sustainable urban planning in similar regional contexts.

2. Research Methods

2.1. Study Area

This study focuses on Madiun City, located in East Java Province, Indonesia, which has had a long history as a governmental centre since the era of the Javanese kingdoms in the 1560s (Hudiyanto, 2020). Administratively, the boundaries of Madiun City were established after regional reorganisation in 1984. It is bordered by Madiun District to the north, Wungu District to the east, Geger and Dagangan Districts to the south, and Jiwan District to the west (BPS Madiun, 2024). The research encompasses all sub-districts within Madiun City, ensuring a comprehensive analysis of urban development dynamics. Physiographically, Madiun City is situated in the lowlands between the Brantas and Madiun Valleys, which offer fertile land that has historically supported significant agricultural activities (Harriyadi *et al.,* 2024). The Madiun River, which flows through the city, has long served as a critical water resource for agricultural and urban uses (Budi, 2024). Geographically, Madiun City lies between coordinates 7°30'2" and 7°51'38" S, and 111°29' to 111°45" E, with an elevation of approximately 65 meters above sea level and an average temperature range of 20°C to 35°C (BPS Madiun, 2024).

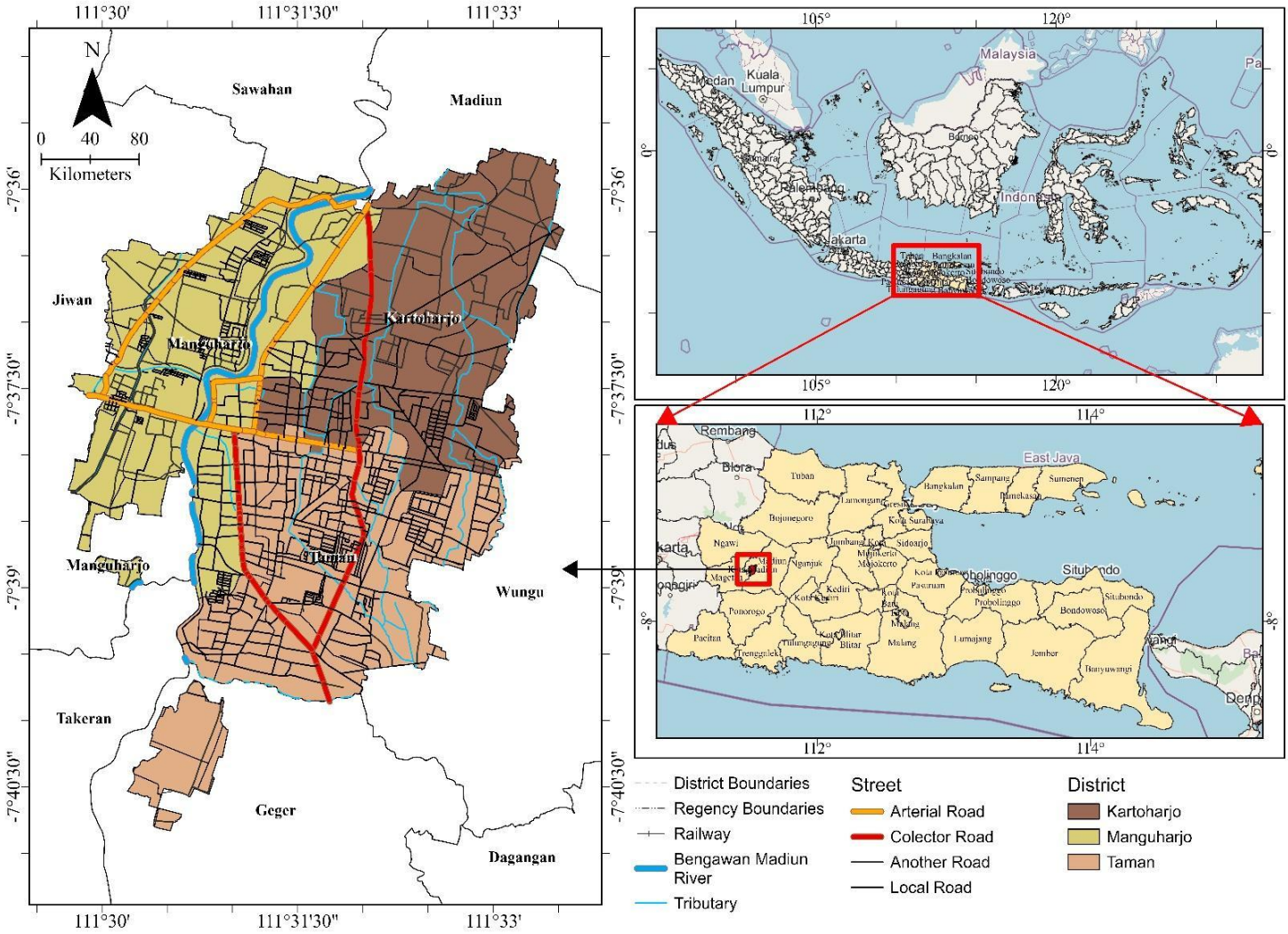

Figure 1. Map depicting the research area, showing the various districts, roads and geographical features within the region. (Source: Administration of Madiun City, 2024).

Historically, Madiun has been a governmental hub since 1568, when its administrative centre, initially named Purabhaya, was established in Sogaten Village (Hanif, 2023). For various reasons, including wars, the centre moved several times: to Wonorejo in 1575, Demangan in 1590, and finally to Pagongangan in 1860, where it remains today (Widyantari, 2012). The city's layout reflects traditional Javanese urban designs, featuring the regent's pavilion, a central square (alun-alun) and a mosque (Sunaryo, 2015; Sunaryo *et al.,* 2014; Wihardyanto & Ikaputra, 2019). During

the Dutch colonial era, Madiun was organised into 12 villages under an autonomous Stadsgemente governed by a Burgementer. After the Japanese occupation, the city was renamed Madiun Shi. Post-independence, it was designated as Kotapraja Madiun under Laws No. 22 of 1948 and No. 16 of 1950, and expanded to 20 villages. In 1982, Government Regulation No. 49 further expanded the city to include 27 villages within three districts: Kartoharjo, Manguharjo and Taman.

In terms of transportation, Madiun City boasts a well-developed network, including arterial roads connecting it to major cities such as Surabaya, Yogyakarta and Ponorogo. The city is also traversed by the public railway network on the southern part of Java Island, linking Surabaya to Bandung and Jakarta via Purwokerto. According to the Madiun City Public Works Department (Binamarga Kota Madiun, 2020), 3.8% of the city's roads are classified as national, while 87.2% are designated as urban, with average daily traffic of 3,170 vehicles. Economically, in recent decades trade and tourism sectors have increasingly replaced agriculture as the city's economic backbone. This shift has been supported by modern infrastructure development, such as ring roads. Figure 1 shows that administratively, the city covers an area of 33.23 km², divided into three subdistricts: Manguharjo (10.04 km²), Kartoharjo (10.73 km²) and Taman (12.46 km²), encompassing a total of 27 urban villages (BPS Kota Madiun, 2024). Its geographic, historical and economic characteristics provide a rich context for this research. By understanding these attributes, the study aims to comprehensively analyse the relationship between accessibility, economic centres and urban structure in Madiun over the past century. This detailed understanding is crucial for identifying the factors that have shaped the city's development and the implications for future urban planning.

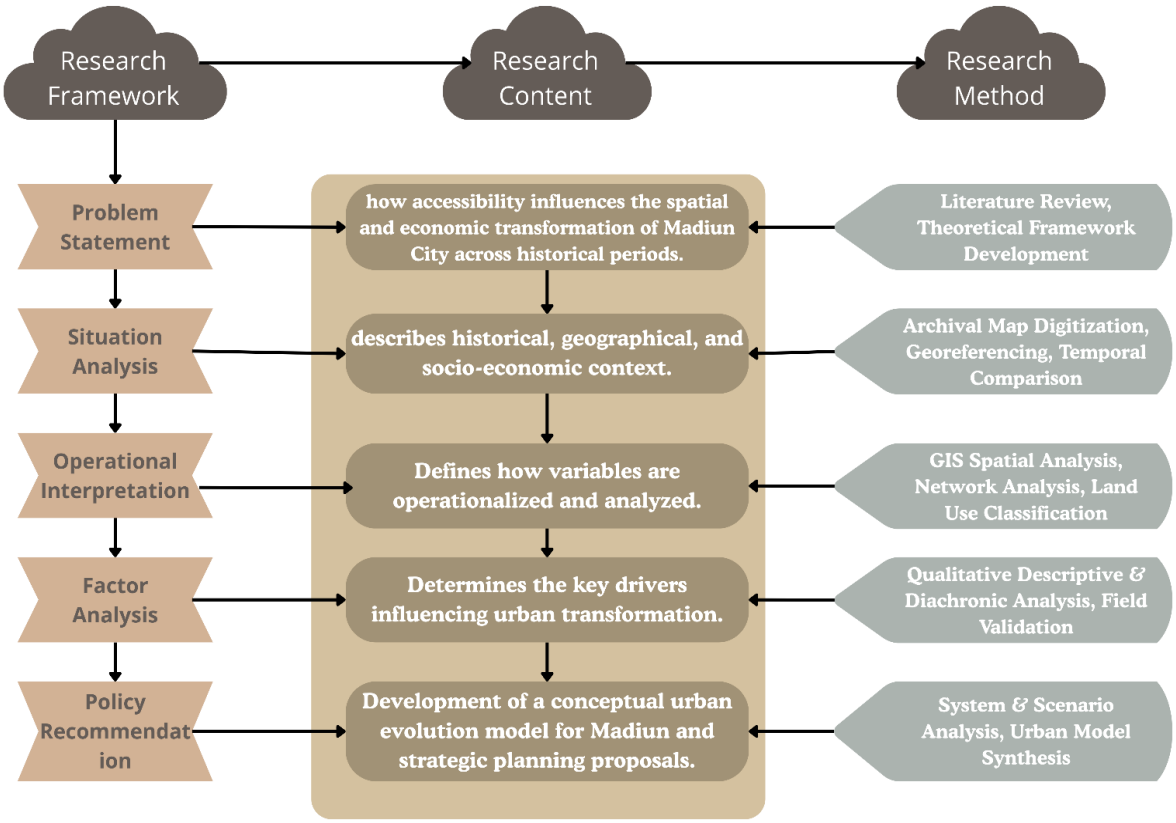

Figure 2. Research Structure. The diagram illustrates the logical relationship between the research framework, content and methods used to analyse how accessibility influences the spatial and economic transformation of Madiun City.

Based on the theoretical foundation and contextual understanding of Madiun City, the overall research framework is illustrated in Figure 2, which presents the logical relationship between the research framework, research content, and research methods. The framework begins with a problem statement focusing on how accessibility influences the spatial and economic transformation of Madiun City across historical periods. The situation analysis describes the city's historical, geographical, and socio-economic context, while the operational interpretation defines how the main variables—accessibility, economic centres, and urban structure—are operationalised and analysed. The factor analysis identifies the key drivers of urban transformation, including transportation infrastructure, economic policy, and historical legacies.

The framework concludes with policy recommendations that lead to the development of a conceptual urban evolution model and strategic planning proposals. Each stage of the framework is aligned with specific research content and analytical methods, including literature review and theoretical framework development, archival map digitisation and georeferencing for temporal comparison, GIS-based spatial, network, and land-use analyses, qualitative descriptive and diachronic analysis with field validation, and system analysis for urban planning synthesis.

2.2. Data Collection

Qualitative data were used for the research, collected from various secondary sources including previous studies, archival information and data, research reports, seminar papers, scientific publications, and historical books. Some of the main literature used in the research included:

1. Madiun dalam Kemelut Sejarah: Priayi dan Petani di Karesidenan Madiun Abad XIX (Madiun in the Turmoil of History: Aristocrats and Peasants in the Madiun Residency in the Nineteenth Century) by Ong Hok Ham, published by Kepustakaan Populer Gramedia in 2019.
2. Madiun: Sejarah Politik & Transformasi Kepemerintahan dari Abad XIV hingga Awal Abad XXI (Political History and the Transformation of Governance from the Fourteenth Century to the Early Twenty-First Century) by Sri Margana, Agus Suwignyo, Baha'Uddin, Abdul Wahid, Uji Nugroho Winardi, published by the Madiun Regency Government in collaboration with the History Department of FIB UGM in 2018.
3. The Process and Patterns of Territorial Political Space in Java Island from the 15th to the 19th Century and Its Implications on Urban Growth, a dissertation by Hafid Setiadi from Gadjah Mada University, 2015.
4. The Development and Urban Planning of Madiun During the Dutch East Indies Administration, a thesis by Yuli Nugroho from the Archaeology Department of Gadjah Mada University, 2017.

In addition to secondary data obtained from the literature, primary sources were also used, in the form of archives. These are an example of what geographical historians refer to as primary sources, consisting of documents, personal letters, diaries, notebooks, maps and photographs. In this research, information and data were obtained from archives in the form of maps, photographs and aerial photographs, sourced from:

1. Digital archives of the Koninklijk Instituut voor Taal-, Land- en Volkenkunde (KITLV).
2. Digital archives of the Universiteitsbibliotheek Leiden.
3. Archives of the Grote Atlas van de Verenigde Oost-Indische Compagnie Comprehensive Atlas of The Dutch United East India Company, which can be consulted from the map room of the National Library of the Republic of Indonesia.
4. Digital Archives of the Army Topographic Directorate.

Table 1 shows that the accessibility variable was obtained from road network and railway data. The economic centre variable was divided into three parts: agricultural and plantation centres, trade centres and industrial centres. In this study, the agricultural and plantation centres comprised rice fields and sugar cane plantations, while the trade centres established in the colonial period were in the form of traditional markets and small shops selling local materials, together with large shops owned by foreigners selling imported products. During the New Order, the form of the trade centres remained the same, although supplemented by several supermarkets that provided various consumer goods.

During the reformation period, trade centre form began to develop, with traditional markets revitalised into modern shopping centres/supermarkets, and with wholesale centres and small and large shops increasingly mushrooming. Industrial centres refer to factories (in four periods) and warehousing (during the reformation period). The city structure variable was obtained from land use data citra satelit. In the collection and processing of the economic centre data, Open Street Map and Google Earth Pro were used to plot economic centre points in order to delineate the economic centre area, assisted by personal experience and field surveys. The three variables were obtained from two map sources: a historical map of 1917 on a scale of 1:5000, and one from 1982 on a scale of 1:50000, which were used to analyse data in the colonial and new order periods. An article on the history of Chinatown in Madiun City by Putro and Hadiwasito (2013), dealing with the development of the structure of the city in 1830-2006, was also used to visualise the results concerning the development of the period after independence. In addition, Open Street Map and

High Resolution Satellite Imagery (CSRT) at a scale of 1:5000 were employed to analyse data from the reformation period through to the current period. In addition, primary data were used to process the land use data previously obtained from Landsat imagery, followed by a field survey to validate the processed data by reviewing several predetermined sample points. The following is attached the data that will be used.

Table 1. Data Collection Summary.

Purpose of Analysis	Variables	Research Data	Data Source	Measurement Methods
To examine the distribution of accessibility development patterns and their relationship to economic centres.	Accessibility	Road and Railway Network	Open Street Map Hoofdplaats Madioen Sheets 1 and 2 from the Leiden Digital Archives 1917 Historical Map of Madiun (1982) from the Digital Archives of the Army Topographic Directorate	Historical map digitisation → GIS spatial analysis → Network analysis → Temporal comparison
	Economic Centre	Traditional and Modern Markets, Factories, Warehousing, Sugarcane Plantations and Rice Farms		Point mapping → Area delineation → Historical data analysis → Field validation
To examine the influence of the development of economic centres on the structure of the city.	Economic Centre	Traditional and Modern Markets, Factories, Warehousing, Sugarcane Plantations and Rice Farms	Hoofdplaats Madioen Sheets 1 and 2 from the Leiden Digital Archives	Economic zone mapping → Temporal analysis → Area calculation → Pattern identification
	City Structure	Land Use	High Resolution Satellite Imagery (CSRT)	Land use classification → Change detection → Spatial pattern analysis → Field verification.

2.3. Data Processing

Data collection was followed by its processing, including data and information obtained from archives in the form of maps and aerial photos, which were also used as references for creating sketches of the visualisation of Madiun's city structure during the colonial period. The processing involved map adaptation by adjusting the old maps with current land use maps using georeferencing techniques, for subsequent digitisation by ArcGIS Pro software. The georeferencing process utilised a second-order polynomial transformation with ground control points (GCPs) carefully selected based on recognisable features in both the historical and contemporary maps. The maps were projected into the Universal Transverse Mercator (UTM) coordinate system, Zone 49S, using the WGS 84 datum, ensuring spatial accuracy across different time periods.

However, the georeferencing process encountered several challenges, particularly due to differences in scale, map symbols and the distortions that commonly occur in old cartographic documents. These discrepancies required careful adjustment, and in some cases resulted in minor spatial shifts that had to be cross-checked with supporting references. To minimise errors, field verification was conducted by comparing key urban features such as roads, rivers and settlement clusters that have remained consistent over time. Field observations not only served to validate the positional accuracy of the georeferenced maps, but also strengthened the reliability of the secondary data sources, ensuring that interpretations of Madiun’s urban structure development were supported by ground realities.

To address the first research question regarding the relationship between accessibility and economic centers, road network data and economic centre points were processed to produce road network and economic area maps. To answer the second question regarding the impact of the emergence of economic centres on the city structure, a descriptive qualitative method with a diachronic approach was then used, supported by field observations. In each predetermined time period, the city's spatial structure was identified based on the urban theories discussed in an earlier section.

3. Results and Discussion

3.1. The Link Between Accessibility and Economic Hubs: Driving Growth and Connectivity

The development of Madiun from the colonial to the reform era shows a distinctive transformation pattern shaped by its role as a strategic transit hub in inland Java. Unlike port cities such as

Surabaya or Semarang, or royal centres such as Yogyakarta and Solo, Madiun's urban growth was not driven by maritime trade or palace politics, but by its position in the fertile Madiun Valley between the Lawu and Wilis mountains, connecting the Brantas Valley and serving as a circulation node between East and Central Java. Due to such geographic factors, during the colonial period the city developed as a centre for plantation production and distribution, driven by the forced cultivation policy and agrarian laws imposed by the Dutch East Indies Government. The fertility of the land in the Madiun region motivated the colonisers to build settlements and develop infrastructure such as railways and sugar factories, in order to optimise the natural resources for the benefit of the European economy (Nugroho, 2020). The exploitation of these natural resources became the foundation for the formation of an organised urban system, with economic centres focused on the agrarian and industrial sectors (Bustamam, 2006). Consequently, Madiun's accessibility was shaped not merely by local economic demand, but by colonial strategy, marking a unique trajectory compared to other Javanese cities.

After independence, the development of the city continued, with the implementation of the national development concept during the New Order era, which focused on improving infrastructure and the industrial sector. This is reflected in the spatial planning that regulates the development of the city into a centre for trade, education and industry, as outlined in the Regional Spatial Planning (RTRW) of Madiun City during the period 1984-2003. During this time, the development of trade areas was aimed at strengthening the city's function as an economic centre, with the establishment of such areas at both city and regional scales. This development, such as the wholesale market located around Jalan Panglima Sudirman and HOS Cokroaminoto, reflects the efforts to enhance trade effectiveness as a driver of the economy in the city (Bustamam, 2006). During the reform era, Madiun City continued its development policies, with a focus on strengthening accessibility and developing economic zones. Since 1998, the city has been designated as a "GADIS" city (trade, education and industry), which has encouraged the development of trade and industrial areas to support its economy (Fathoni, 2017; Hartono *et al.,* 2014).

One of the important policies that has emerged during this period has been the construction of the western ring road, which was initiated in the early 2000s. This road significantly improved accessibility between functional areas and encouraged changes in land use around the corridor. Its presence led to the growth of warehousing industries, particularly in the western part of the city, and accelerated the expansion of residential areas to accommodate the increasing population in the Kartoharjo District. Furthermore, this national route facilitated the movement of large vehicles in and out of the city, making it a strategic zone for logistics and distribution activities (Hermanto, 2017; Widyantari, 2012). As of 2025, Madiun City had a total of 274,41 motorised vehicles, with 78.3% of these being motorcycles (Fadhlurrahman, 2025). The dominance of motorcycles indicates the high reliance on personal transportation, whereas public transportation such as buses remains limited, at only 0.4% of the total vehicles. This highlights a shift in urban mobility patterns, with increased dependence on private vehicles rather than public transit. The changes that have occurred also include the development of new economic centre areas, such as Pahlawan Street Center (PSC) and Bogowonto Culinary Center (BCC), which have become the main focus in the Regional Tourism Development Master Plan (RIPPADA) of Madiun City (Purbadevi & Raidi, 2022). Although the city does not have significant natural resources, the development of man-made tourist areas such as PSC and BCC aims to create attractions for tourists and investors. The Mayor of Madiun, Maidi, revealed that the development of tourist areas and economic centres was a strategy to attract attention to, the city, considering that it does not have distinctive natural attractions such as waterfalls or beaches (Rahmasari, 2024). By utilising its unique city design and improving its infrastructure, Madiun is striving to distinguish itself from other cities in Indonesia, attract visitors, and develop the creative economy sector.

Referring back to the theory proposed by Black (2018), that when a place has land use activities that tend to cluster and are located on a major road network, accessibility will be high and strengthened. In relation to this, referring to infrastructure development since the colonial era, Kota Madiun has created not only three main highway junctions, but also a well-established railway network, which have played a crucial role in shaping its economic landscape. During the colonial period, three railway stations were active in Madiun: Stasiun Madiun, Stasiun Kanigoro and Stasiun Sleko. These supported the transportation of goods, particularly agricultural and plantation products such as sugarcane and rice, which were central to the city's economy. However, as it transitioned through independence and economic shifts, Stasiun Kanigoro and Stasiun Sleko ceased operations, leaving Stasiun Madiun as the only functional railway station serving intercity travel today. Additionally, the Madiun-Ponorogo railway line was decommissioned, and part of its land has now been repurposed into the Bogowonto Culinary Center (BCC), a tourism and commercial hub. This transition reflects the broader shift in Madiun's urban function, from a

plantation-based economy to a commercial and service-oriented city (Wulan & Trilaksana, 2020a).

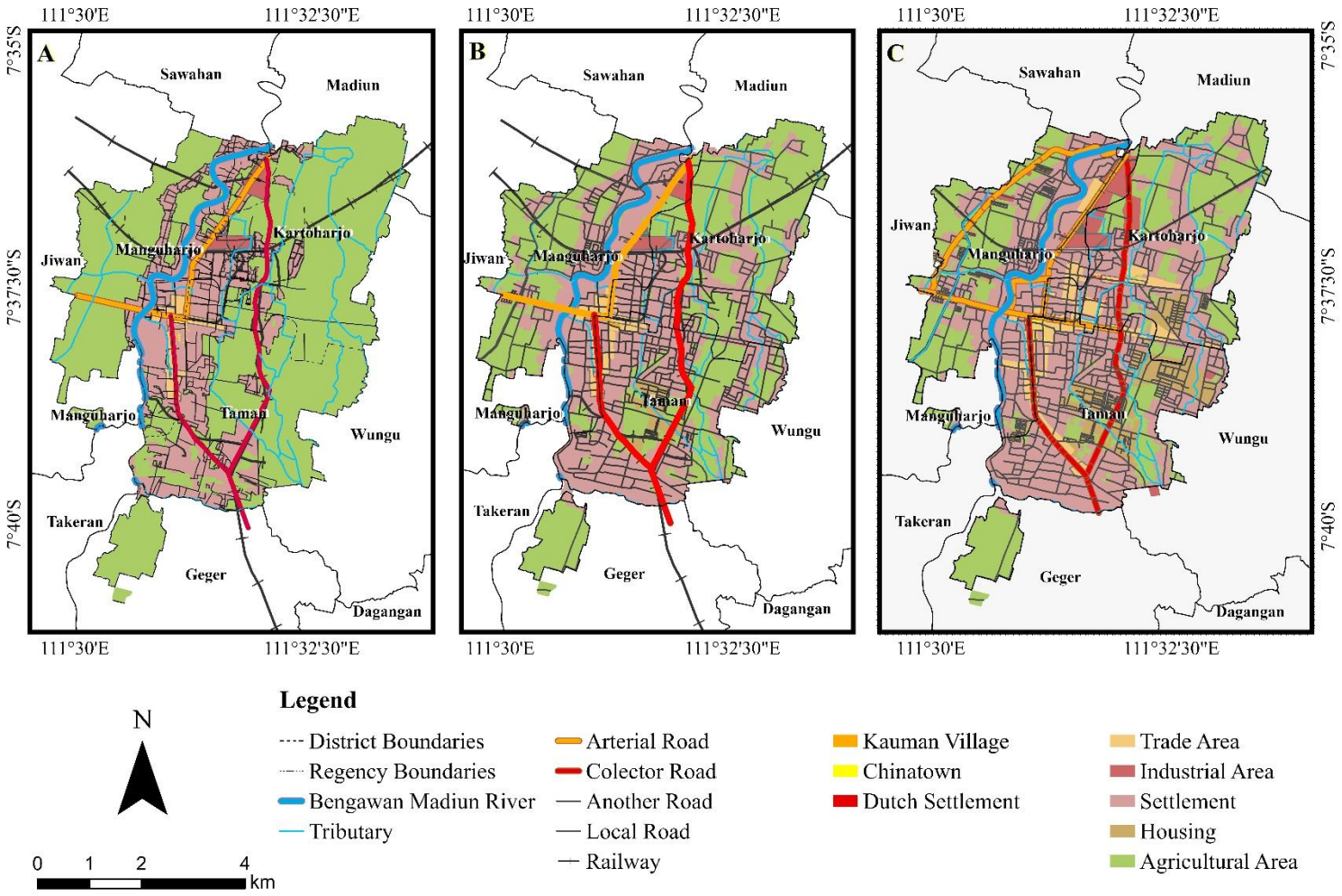

Figure 3. The triptych depicts the evolution of Madiun City from the Colonial to the Reformation Era highlighting the changes in its spatial organisation and land use over time.

Figure 3 shows the development of Madiun City over three periods namely, Colonial (1900-1945), Post Independence (1945-1998), to the Reformation Era (1998-Now). Furthermore, in Figure 4 this development is reflected by square markers in three colours: dark blue, red, and orange. Red indicates the development of trade areas, which during the colonial period were only located in the city centre. Then, during the New Order era, accompanied by the implementation of long-term development programmes focused on infrastructure development, the red areas indicating trade areas began to spread eastward. By the Reformation era, the locations showing Dutch settlements with red polygons had already transitioned into trade areas. Meanwhile, the blue box indicates the development of the industrial area, which during the colonial period was located only in the northern part of the city or along the main road junction in northern Madiun. After independence, there was no significant development in this area, as the only change was the nationalisation of sugar factories (Wulan & Trilaksana, 2020a). However, during the reform era, the industrial area in the northern part of the city began to spread, with the establishment of new factories such as tobacco factories and energy sector industries. In the western part of the city, after the construction of the western ring road, warehousing industries began to emerge, in line with the city's policy direction that the road be designated as a national route used by many large vehicles coming in and out of the city. Similarly, the orange colour indicates the development of residential areas in the eastern and southern parts of Madiun City, which during the colonial period were still dominated by agricultural land. After independence, with the implementation of housing development programmes for employees in the southern part of the city, the area was eventually transformed into residential or organised settlement areas. By the reform era, the area showed an increasing spread of new settlements, leading to a further reduction in agricultural land.

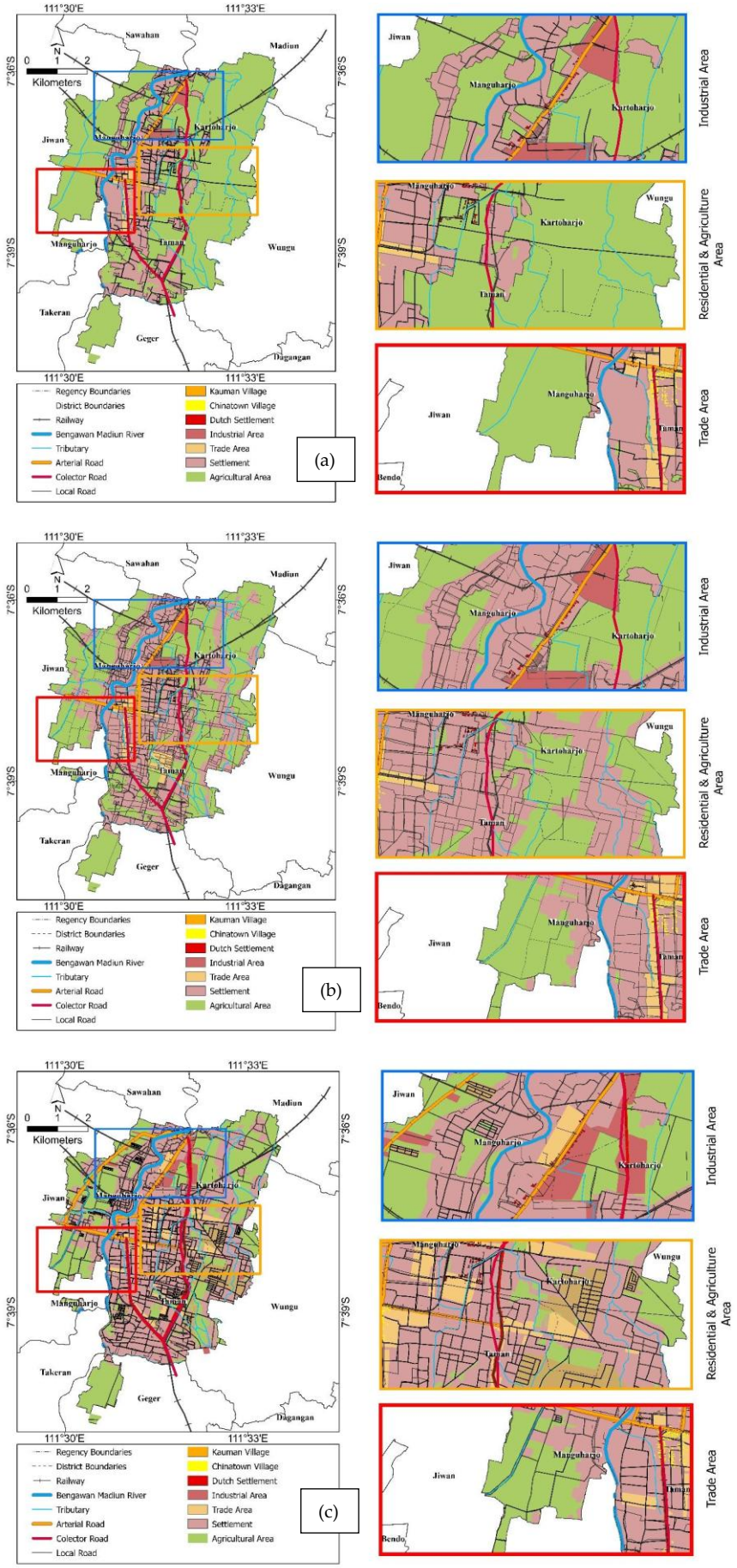

Figure 4. Details of the Development of Industrial, Trade, Residential and Agricultural Areas in Madiun City: (a) Colonial Era, (b) Post-Independence Era, (c) Reform Era. Source: Modified Description based on Figure 3, 2024.

The above explanation shows that the expansion of transportation networks has strongly shaped the spatial and economic transformation of Madiun. However, the city's trajectory diverges from the general models of urban development. While Burgess's concentric zone theory assumes radial outward growth, Madiun developed linearly along colonial railway lines and arterial roads, resembling Hoyt's sector theory. Over time, the city also reflected Harris and Ullman's multiple nuclei model, with the *alun-alun* (indigenous government and market) and the colonial quarter (plantation economy and railway hub) functioning as dual centres. Furthermore, the logic of accessibility in Madiun differed from Gauthier's (1970) and Hansen's (1959) general notion of accessibility as a market-driven determinant of land value (Levinson & Wu, 2020). In Madiun, accessibility was initially imposed by colonial strategy—railways, sugar factories and military logistics—rather than by endogenous urban demand. This explains why the city gradually shifted from an agrarian base to a colonial industrial sugar hub, and eventually into a modern trade- and service-oriented city known as *Kota Gadis*. Therefore, Madiun represents a hybrid case in which accessibility, rooted in colonial imperatives, restructured its economy and spatial form in ways that both confirm and nuance classical urban theories. This trajectory demonstrates that the city's economy underwent successive transformations, from an agrarian base to a colonial industrial hub, then to a trade and service city, and most recently a tourism-oriented urban centre. This staged economic shift, driven by evolving accessibility, highlights the uniqueness of Madiun compared to other Indonesian cities (Habib *et al.,* 2010; Hermanto, 2017; Wulan & Trilaksana, 2020b; Yoga & Pd, 2016). Consequently, roads remain the dominant element driving the expansion of urban space towards the outskirts and the intensification of economic activities along major corridors. The construction of the western ring road in the early 2000s, combined with improvements in road infrastructure, has played a key role in reshaping Madiun's spatial structure. Similarly, while rail transportation was once an essential part of the city's economy, the decline in rail-based freight transport and the closing of two out of three railway stations indicate a shift toward road-based mobility. The presence of 274,41 motorized vehicles in 2025, of which 78.3% were motorcycles and only 0.4% buses, further emphasizes this trend. These changes illustrate how accessibility influences economic transformations, supporting new business clusters and urban development along major road networks (Wulan & Trilaksana, 2020b). The better the accessibility offered by the road network, the greater the opportunities for the emergence of new economic centres in the surrounding areas. The research findings show that the pattern of accessibility development around the centre of Madiun City encourages higher economic activity compared to other cities due to the high volume of movement in and towards the area, which opens up opportunities for the region to develop. These movements are facilitated by clustered land use activity patterns with a high density of road networks, reflecting the level of connectivity between various areas within a region. The denser the road network, the easier the access between various locations, and thus the greater the accessibility.

3.2. Shaping Urban Form: The Impact of Accessibility on City Structure and Expansion

The role of the economic centre in a city's structure is inseparable from its growth process and its various models. The stages of development of the city of Madiun over several periods show a process of urban spatial development. The development of its spatial structure illustrates an urban spatial structure consisting of the distribution of the city's main functions and its circulation network, forming areas with dominant physical-spatial development. The main functions of Madiun include the emergence of economic centres, followed by residential, governmental and educational areas.

The spatial structure of the city of Madiun has undergone significant development from the colonial era to the reform era, with noticeable changes in settlement patterns, trade centres and urban infrastructure. During the colonial period, a trade centre was located in the middle of the city, with the Main Market (Pasar Besar) and Old Market (Pasar Lama) serving as the primary commercial hubs (marked with line graphs). These markets were strategically located near the Chinatown district, which played a significant role in trade and commerce. The Chinese community in Madiun, known for its dominance in trade, had a strong presence in this area, making it a key economic zone for the city. Around this central trade district, residential areas were distinctly divided by ethnicity, with the Dutch settlement marked in turquoise green in the northern part of the city, the Chinatown area in orange-red in the southern part of the city centre, and the Kauman area in yellow-orange in the western part of the city. The indigenous settlement, marked by navy blue, was located on the outskirts of the city near the river.

In the post-independence period, the urban structure of Madiun began to change, as former colonial facilities were adapted for national governance and public use. The central square (alun-alun)

remained the symbolic and functional core of the city, but residential development expanded towards the east and south, driven by growing population needs. Markets and small-scale trade continued to flourish, while the construction of public housing, schools and governmental offices created a more integrated spatial pattern compared to the segregated colonial structure. Road networks were improved, enabling better connections between the city centre and peripheral areas, reflecting the transition of Madiun from a colonial town into a developing national city.

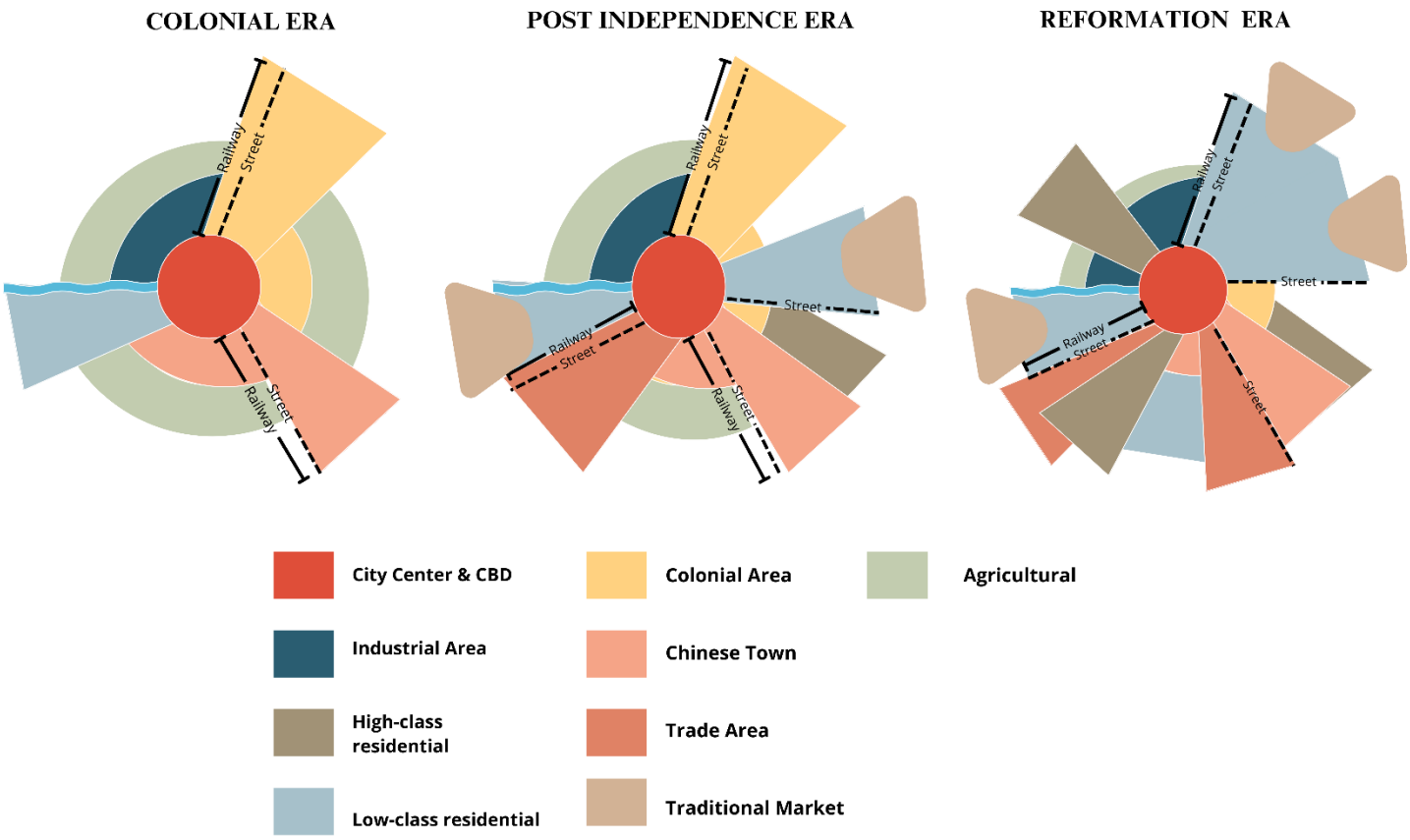

Figure 5. This series of diagrams illustrates the model structure of Madiun City, highlighting the different land use and infrastructure elements that have characterised the city's development across the Colonial, Post-Independence and Reformation eras. (Source: Data Processing, 2024).

By the reform era, the structure of Madiun had evolved into a more polycentric model. Trade activities were no longer concentrated solely around the old markets; instead, new commercial areas, shopping centres and modern trade facilities emerged along major transportation corridors and at suburban nodes. Industrial zones developed on the outskirts, while residential areas expanded significantly into peri-urban regions, supported by improved infrastructure such as the construction of the western ring road and later toll road connections. Educational institutions and health facilities also expanded, reinforcing Madiun's role as a regional service centre. This transformation illustrates a shift from a rigid, colonial spatial order towards a dynamic, multi-nodal urban structure adapted to modern economic and social demands.

As urban development progressed, the role of traditional markets began to change. During the post-independence period, new traditional markets emerged, such as Pasar Mangunhardjo, Pasar Sleko, Pasar Spoor, and Pasar Kliwon, which were located along major transportation routes connecting Madiun City with surrounding districts (see Figure 6). These markets expanded trade activity beyond the colonial trade centre, leading to a more dispersed commercial pattern. Entering the reform era, commercial transformation became more pronounced, with many traditional markets transitioning into modern shopping centres. Plaza Madiun, Samudra, Suncity Mall and Furniture Mall replaced or complemented the role of traditional markets, introducing one-stop shopping concepts and shifting the concentration of trade towards strategic commercial zones (see Figure 6). This change was further accelerated by infrastructure improvements, particularly the expansion of road networks and the construction of the western ring road, which facilitated greater commercial mobility. Despite these changes, some traditional markets, such as Big Market and Old Market, have continued to operate, preserving their historical role in the city's economy. The

spatial distribution of trade centres now follows a concentric development pattern, with traditional markets and modern shopping malls coexisting in different areas of the city.

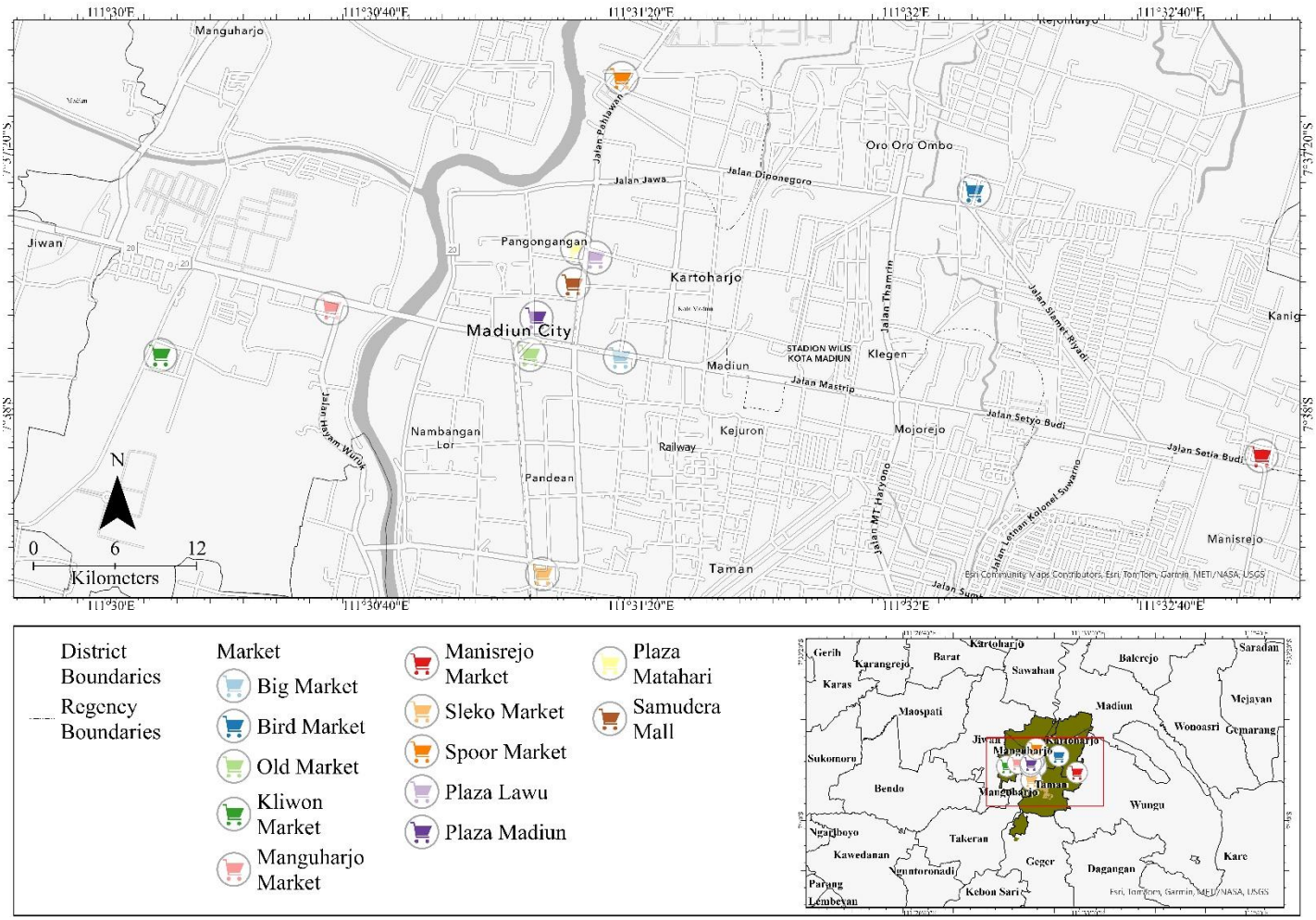

Figure 6. Distribution of markets in Madiun City (Source: Data Processing based on Open Street Map and Personal Analysis, 2024).

The transformation of Madiun's urban structure, trade and infrastructure over time reflects a shift from a centralised colonial-era city to a more dispersed and modernised urban system (see Table 2). During the colonial period, Madiun's spatial structure was highly centralised, with trade activities concentrated in the city centre, particularly around Main Market (Pasar Besar) and Old Market (Pasar Lama). The ethnic-based residential pattern, with Dutch settlements in the north, Chinatown in the south, and indigenous communities on the outskirts, reflected colonial segregation policies. At this stage, the railway network played a dominant role in trade and logistics, facilitating the transport of plantation products such as sugarcane and rice. After independence (1945–1998), the city saw a gradual expansion beyond the core, with new road networks connecting it to surrounding districts. This led to the establishment of new traditional markets such as Pasar Mangunhardjo, Pasar Sleko and Pasar Kliwon, which allowed commercial activities to spread towards the eastern outskirts of the city. During the reform era (1998–now), Madiun underwent rapid infrastructure development, including the construction of the western ring road in the early 2000s, which spurred the growth of industrial and residential areas along the major transport routes. The trade sector also experienced a major transformation, with the emergence of modern shopping centres such as Plaza Madiun, Samudra and Suncity Mall, marking a shift towards a more centralised commercial district in high-traffic zones. The city's reliance on motorised vehicles increased significantly, with 273,132 registered vehicles by 2024, predominantly motorcycles, reflecting changing mobility patterns. This evolution illustrates how Madiun's urban development has been shaped by accessibility, economic policies and infrastructure expansion, with a transition from a railway-dependent trade hub to a modern road-based commercial city.

After independence, the city's structure underwent a change, with the construction of better road infrastructure. The government began building new roads connecting the city with Madiun Regency, where new traditional markets started to emerge in the outskirts of the city, especially to

the east, towards Madiun Regency. This encouraged more dispersed economic activities, with the mobility of goods from Madiun Regency to Madiun City increasing. In addition, new housing emerged in the southern part of the city to accommodate government employees.

Table 2. Timeline of Major Changes in Madiun (Colonial – Reform Era).

Period	Key Developments in Urban Structure	Trade & Economic Centres	Infrastructure & Transportation
Colonial Era (1900–1945)	- Centralised urban structure with trade and settlement based on ethnicity. - Dutch, Chinese and indigenous settlements distinctly separated. - Limited urban expansion, focused around the city centre.	- Main Market (Pasar Besar) and Old Market (Pasar Lama) were the main trade hubs. - Chinatown played a major role in commerce. - Sugarcane and plantation products were key exports.	- Three railway stations: Madiun, Kanigoro and Sleko. - Major roads connected Madiun to Surabaya and Ponorogo. - Rail transport dominated trade and logistics.
Post-Independence (1945–1998)	- Urban expansion began, driven by new government policies. - New residential areas developed in the southern part of the city for government employees. - More decentralised city structure with emerging trade districts.	- New traditional markets: Pasar Mangunhardjo, Pasar Sleko, Pasar Spoor, Pasar Kliwon. - Trade expanded beyond the city centre to the eastern outskirts (towards Madiun Regency).	- Expansion of road networks connecting Madiun with surrounding districts. - Decline of railway transport for goods, replaced by road-based logistics.
Reform Era (1998–now)	- Increased urban density and land conversion for commercial use. - Western ring road construction (early 2000s) spurred industrial growth. - Shift from centralised to more evenly distributed urban functions.	- Modern shopping centres: Plaza Madiun, Samudra, Suncity Mall, Furniture Mall. - Traditional markets continued but some transitioned into modern trade hubs.	- Western ring road completed, supporting industrial expansion. - Only Madiun Railway Station remains operational (Kanigoro and Sleko closed). - Significant increase in motorised vehicles (273,132 units by 2024), with motorcycles dominating (78.3%).

Urban development during this period tended to follow the direction of the main roads, with the commercial centre beginning to move to the outskirts of the city. Entering the reform era, Madiun underwent a massive transformation. Infrastructure was rapidly developed, with an increasing density of road networks. This led to the emergence of organised housing and new commercial areas, which are increasingly spreading throughout the city. The existing traditional markets began to develop into malls and modern markets, which expanded the trading centres to the southern areas of the city and along the main roads. The construction of the western ring road accelerated the development of industrial areas extending along the road corridor, together with the construction of new housing along the route. In addition, the Dutch area, once used for European settlement, has now been transformed into a commercial area, indicating that land use has become more equitable and is no longer limited to certain ethnicities. Overall, Madiun is now following a concentric development pattern, with residential and commercial areas evenly distributed throughout the city. The area of residential land has rapidly increased to 57.5%, resulting in a decrease in agricultural land.

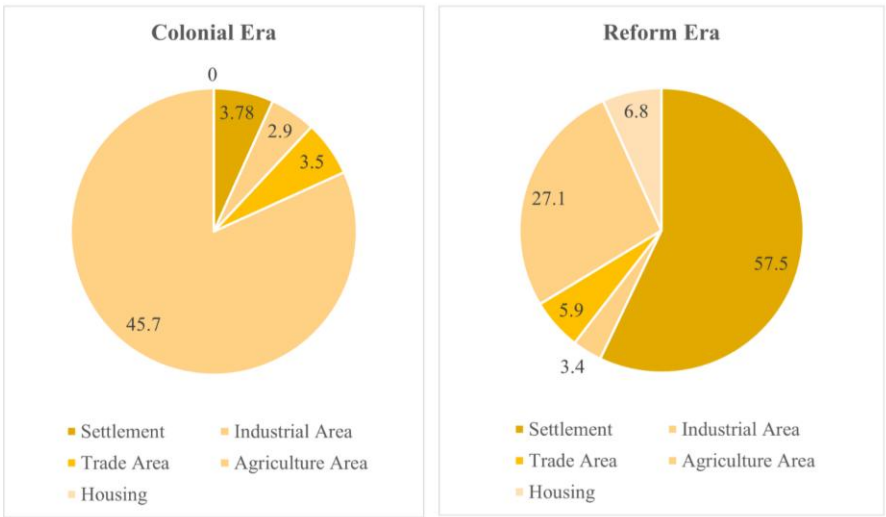

Figure 7. Diagram Chart of Percentage of Sectoral Areas in Madiun City in 2024 (Source: Data processing results based on Google Earth and Open Street Map, 2024).

Figure 7 illustrates the comparative analysis of sectoral area percentages in Madiun City between the colonial era (1917) and the reform era (2024). Significant land use transformations are evident during this period. The settlement sector shows a dramatic increase, from approximately 5% in 1917 to nearly 60% in 2024, indicating rapid growth in residential development. Conversely, the agricultural area experienced a significant decline, from about 40% in the colonial era to around 30% in the reform era, suggesting the conversion of agricultural land into built-up areas. Trade and industrial areas show relatively minor changes, with slight increases in 2024. Meanwhile, the housing sector, distinct from settlements, represents a relatively small percentage in both periods.

Based on the discussion above, the generalised results of land use in Madiun in 1917 and 2024 through percentage diagrams of the city's sectoral areas show that the city centre remains the dominant area, consisting of trade and industry zones that have started to develop alongside an increase in residential areas (Figure 7). Therefore, it can be said that the centres of the agricultural and plantation economy, which expanded during the colonial era, have now begun to decline due to Madiun's function as a GADIS City (Trade, Education and Industry). This transformation reflects the city's evolution from a predominantly agricultural area in the colonial era to an urban region dominated by residential areas in the reform era. The shift aligns with the city's modern identity as a GADIS City, emphasising its role as a hub for trade, education, and industry, moving away from its historical agricultural foundation.

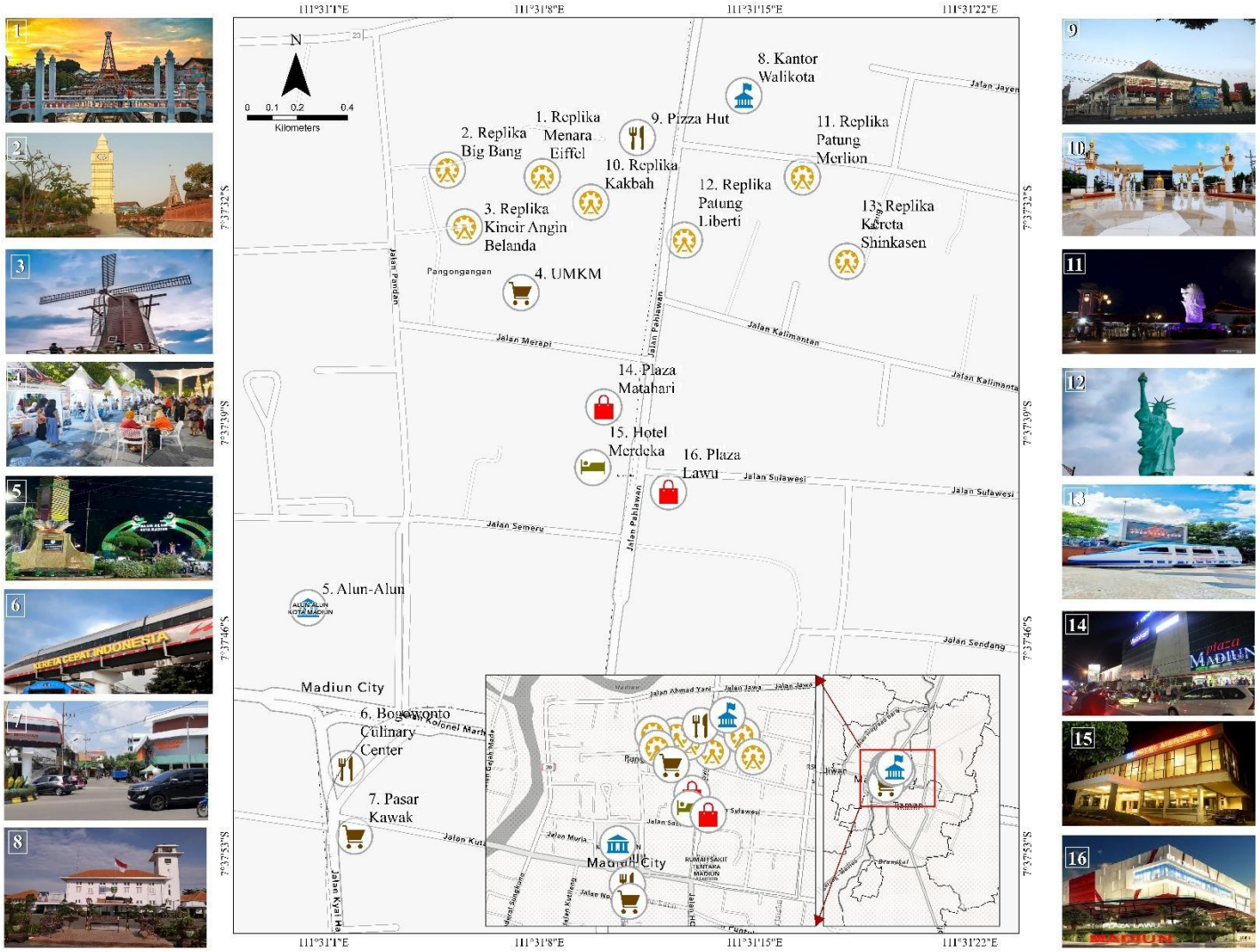

Figure 8. This composite image provides an overview of the Pahwalan Street Center and Bogowonto Culinary Center, key landmarks in the city of Madiun. It includes a location map, together with various photographs highlighting the architecture, street life and cultural attractions of the area (Source : Data Processing, 2024).

The Madiun City government is also striving to enhance the tourism sector by building new economic centres such as the Pahlawan Street Center (PSC) and the Bogowonto Culinary Center (BCC) in the city centre (see Figure 8) (Ahsani, 2023). The development of these two areas aligns

with Boudeville (1966) theory of agglomeration, which emphasises the importance of strategically locating economic hubs to generate cumulative effects that drive economic growth in surrounding areas. By concentrating trade and tourism-related activities in these central locations, the city government aims to create a spillover effect, by which surrounding businesses, such as shops, hotels and service industries, also benefit from increased visitor flow and investment. This development mirrors the principle that economic centres function as growth poles, attracting labour, capital and services to enhance urban economic integration. The establishment of PSC and BCC reflects a deliberate effort to create man-made tourist attractions that differentiate Madiun from other cities. These developments act as nodes in a multi-nodal urban structure, in which multiple economic activity centres interact and reinforce each other. The synergy between culinary hubs, retail zones and industrial areas fosters an interconnected economy, aligning with Boudeville's idea that agglomeration economies arise when businesses and industries cluster in a specific area, leading to cost reductions, increased productivity and overall economic expansion. Therefore, the development of Madiun's urban structure during the reform era reflects how agglomeration dynamics influence spatial patterns, with economic centres serving both basic functions (primary economic activities such as industry and trade) and non-basic functions (such as tourism and services). The interaction between these, coupled with the strategic location of trade and culinary hubs, contributes to the formation of a dynamic and continuously evolving urban structure, meeting both the economic and social needs of the urban community.

3.3. Discussion

The study makes a significant contribution to understanding of urban development dynamics by using Madiun City as a case study to examine the transformation of urban structures over a century (1900–2000). By integrating spatial and diachronic approaches, the analysis underscores the critical interplay between accessibility, economic centres and urban growth, thereby enriching the broader field of urban geography (Kaplan & Holloway, 2024). The historical trajectory of Madiun, shifting from an agrarian economy based on rice and sugarcane production to a trade- and tourism-oriented urban system, demonstrates how transportation infrastructure functions as a long-term structuring force in urban evolution. This finding is consistent with classical regional development theories, particularly (Myrdal, 1967) cumulative causation framework and Boudeville's (1975) growth pole theory, which emphasise that economic expansion tends to concentrate in accessible locations supported by transport networks. Empirically, the case of Madiun aligns with broader international evidence showing that accessibility reshapes urban form and economic concentration, as observed in metropolitan Tokyo (Zhou & Gao, 2020), the Pearl River Delta (Liu *et al.,* 2019), and Bucharest's metropolitan transformation over a quarter of a century (Tosa *et al.,* 2018).

By extending earlier works, such as Nugroho's (2017) examination of Madiun's colonial-era physical development and Widyantari's (2012) analysis of land-use change, the study contributes a comprehensive diachronic perspective that spans multiple political and economic regimes. The findings are also consistent with (Purbadevi & Raidi, 2022), who demonstrate that contemporary urban transformation in Madiun—particularly along Jalan Pahlawan, cannot be detached from historical urban activities and spatial legacies. Their study highlights how streetscape revitalisation, through the integration of physical elements and socio-economic activities, reinforces urban identity, structure, and meaning, thereby shaping the city image of Madiun as a governmental, commercial, and service-oriented centre. This reinforces the argument that historical urban corridors continue to play a strategic role in guiding present-day urban planning and spatial restructuring (Pratama *et al.,* 2023). Similar patterns of infrastructure-led land conversion and redevelopment have been widely documented in rapidly urbanising contexts, including the redevelopment of industrial sites in Shenzhen's "villages in the city," where accessibility improvements catalysed functional and spatial restructuring (Lai & Zhang, 2016). On a broader scale, Luo *et al.* (2023) similarly highlight infrastructure connectivity as a key driver of urban–rural integration in China, reinforcing the argument that transport networks redefine spatial hierarchies beyond city boundaries.

Our study further refines urban ecology theories (Burgess, 2020) by demonstrating that accessibility and economic agglomeration in Madiun operate beyond the classical monocentric city model. Rather than following a strictly concentric pattern of expansion, Madiun exhibits a multi-nodal urban structure in which infrastructure investments, particularly the railway network and the western ring road, have stimulated distributed economic growth across several nodes. This empirical pattern supports Rietveld (2006) argument that transportation systems and urban structures are closely intertwined, with accessibility functioning as a dynamic force that reshapes economic geography and regional hierarchies. Comparable outcomes have been observed in other

urban systems where transport accessibility directly influences land-use transformation and economic clustering (Liu *et al.,* 2019; Zhou & Gao, 2020).

The novelty of this research lies in its ability to connect historical legacies with contemporary infrastructure development, demonstrating that Madiun's transformation is being shaped not only by colonial and post-colonial political economies, but also by the evolving role of accessibility in generating new economic clusters. Unlike studies that have focused on specific periods, this century-long diachronic analysis reveals how accessibility-driven transformations have progressively transformed Madiun from a monocentric structure to a multi-nodal urban system. This interpretation extends beyond classical ecological models (Park & Burgess, 2019) and is consistent with Marshall's agglomeration theory (Marshall,1920) which posits that strategic locations attract complementary industries and generate mutually reinforcing growth dynamics.

Methodologically, the study contributes an innovative and replicable framework by combining historical maps, satellite imagery and GIS-based spatial analysis to trace long-term urban change. The integration of traditional archival sources with contemporary tools such as Google Street View enhances spatial accuracy and temporal validation, aligning with best practices in historical urban geography. This approach enables a deeper understanding of how socio-economic and infrastructural forces interact over time, offering methodological value for studies of cities with similar colonial and post-colonial trajectories.

The findings also substantively engage with Black's (2018) theory of strategic locations, which emphasises the role of transit cities in shaping regional economies. Madiun's position as a railway junction and a node along major arterial roads exemplifies how transit-oriented accessibility fosters cycles of infrastructure-led economic transformation. During the colonial period, railways facilitated plantation-based commodity flows; in the post-independence era, road networks supported trade and service-oriented growth; and during the reform era, the western ring road has reinforced Madiun's role as a regional transit hub, stimulating industrial expansion along its corridor. This trajectory strongly corroborates Black's assertion that transportation accessibility is a primary driver of economic clustering and land-use change, while also reflecting Myrdal (1967) cumulative causation process, whereby accessible regions continue to attract investment and growth.

Beyond economic restructuring, the study has significant social and environmental implications for Madiun's urban transformation. The decline of agricultural land, from nearly half of the urban area in the 1980s to approximately one-third today, has resulted in the displacement of farming communities, the erosion of agrarian livelihoods, and increasing dependence on surrounding rural hinterlands for food supply. These dynamics raise critical food security concerns and mirror broader trends observed in infrastructure-led urbanisation, where economic growth is often achieved at the expense of ecosystem services (Wang *et al.,* 2022). The reduction in green spaces and expansion of built-up areas have also contributed to urban heat island effects, increased energy consumption, and declining ecological resilience, challenges that are widely documented in rapidly urbanising regions.

Socially, the emergence of new economic hubs such as the Pahlawan Street Center (PSC) and Bogowonto Culinary Center (BCC) has created opportunities in tourism and services, while simultaneously moving employment away from traditional agricultural and informal sectors. Although these changes support economic diversification, they also risk exacerbating socio-spatial inequalities between communities integrated into new growth nodes and those marginalised in declining agrarian zones. Similar patterns of uneven development and accessibility-driven disparity have been reported in other East Javanese cities and international urban contexts (Pusdiktasari *et al.,* 2020; Tosa *et al.,* 2018).

Concrete evidence of accessibility-driven restructuring is particularly evident along the western ring road corridor, where industrial warehouses and new housing estates rapidly emerged following its completion in the early 2000s. Likewise, the conversion of the former Madiun–Ponorogo railway into the Bogowonto Culinary Center illustrates how infrastructure decline and adaptive reuse can reconfigure urban functions, transforming transport corridors into commercial and tourism spaces. Comparable adaptive redevelopment processes have been documented in Chinese and European cities undergoing post-industrial transformation (Lai & Zhang, 2016; Tosa *et al.,* 2018), reinforcing the argument that infrastructure projects act as direct catalysts of urban restructuring.

Despite its contributions, this study has several limitations. While the diachronic approach effectively captures long-term spatial change, reliance on archival and spatial data may underrepresent everyday social experiences and lived urban realities. The incorporation of oral histories,

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Author Contributions

Conceptualization: Muafiroh, S., Setiadi, H.; **methodology:** Muafiroh, S., Setiadi, H.; **investigation:** Muafiroh, S., Setiadi, H.; **writing—original draft preparation:** Muafiroh, S.; **writing—review and editing:** Setiadi, H.; **visualization:** Muafiroh, S. Salsa Muafiroh contributed as a student researcher, while Hafid Setiadi provided guidance and supervision throughout the research process. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

All authors declare that they have no conflicts of interest.

Data availability

Data is available upon Request.

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ethnographic methods or participatory mapping could enrich future analyses. Additionally, although environmental impacts are addressed conceptually, more detailed assessments of ecosystem services, ecological carrying capacity and climate risks, such as those made by Wang *et al.* (2022), would strengthen sustainability evaluations. Future research could therefore adopt a mixed-methods approach that integrates spatial-historical analysis with social surveys and environmental modeling to provide a more holistic understanding of urban transformation processes. One of the most innovative aspects of this research is its methodological rigour, with the combination of historical maps, satellite imagery and GIS technology to trace the spatial and temporal evolution of Madiun's urban landscape. This integration of traditional and modern tools not only bridges historical documentation with contemporary urban planning, but also provides a replicable framework for other studies of cities with similar colonial and post-colonial trajectories. The use of tools such as Google Street View enhances the accuracy of spatial analysis, facilitating the validation of historical data. This approach establishes a new standard for examining long-term urban transformations, enabling a deeper understanding of the socio-economic and spatial dynamics that drive city development.

4. Conclusion

It is concluded that accessibility has been a key driver of Madiun's urban and economic transformation, shaping its spatial structure and fostering economic diversification. The findings refine classical urban ecology models (such as those of Park and Burgess) by showing that the city's expansion has not taken place concentrically, but rather has followed a multi-nodal pattern shaped by transport infrastructure, in line with Hoyt's sectoral theory and Boudeville's agglomeration dynamics. While the analysis provides important insights, it is limited by reliance on secondary data and partial field validation. Future research could therefore focus on exploring the role of digital technology and smart city initiatives in strengthening accessibility and economic resilience, as well as investigating sustainable urban growth strategies to address the city's declining agricultural land and ecological pressures. These directions would complement the historical-spatial perspective of this study and offer more comprehensive recommendations for urban policy and planning.

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