Analysis of Building Distribution and Accessibility of Kanigoro Urban Roads

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ABSTRACT
The Kanigoro Settlement Area's land is mostly utilized for residential and agricultural purposes. Modifications to the city's construction and development are necessary to turn Kanigoro into a sustainable urban region, particularly in the field of urban morphological pattern development. City or area morphology may be analyzed using three primary components: building density, land use patterns, and road network patterns. This research aims to investigate the urban morphology pattern in Kanigoro Urban Area, focusing on road accessibility and building dispersion. In order to accomplish this goal, land use and building distribution were identified using satellite image data from 2011, 2015, 2019 and 2023, along with questionnaire data on residential location selection. The findings demonstrate that elongated patterns dominate settlement patterns in Kanigoro, with group patterns and the main road network following closely behind. Kinship and historical factors also play a role in this pattern. During the study, there was a notable increase in settlement growth, particularly on main transportation routes. The population density analysis shows that there is a concentration of population in the city center and some rapidly developing residential areas as a result of this rapid settlement growth. According to the road accessibility analysis, most areas are served by arterial roads, but there are still some areas with limited accessibility, especially with regard to collector roads. Based on the research results, there is a need for sustainable integrated spatial planning, adequate infrastructure, improving the quality of the collector road network and developing integrated public transportation.

1. Introduction

The growth of cities since the early 20th century has faced a very rapid growth with the complexity of urban elements and cases that arise. This growth has led to an increase in demand for human needs, resulting in a rate of urban growth that is difficult to stop. The city as the center of human activity is growing rapidly due to the condition of the city that can provide a variety of human life facilities more than the countryside. The increase in urban population is not only caused by births but also by population migration due to the urbanization process. This urbanization causes urban population growth to develop rapidly and the movement of people to urban areas to increase, causing densification of the population in urban areas (urban densification) and areas around urban areas that grow into buffer areas (urban sprawling) (Suweda, 2011).

The various dynamics and problems of urbanization are an integral part of the ideas of modernity in a city. The progress of a city will always coincide with the rapid growth of the urban population (Makkelo, 2017). This urban development occurs along with an increase in the number of people in urban areas (urbanization) which causes a decrease in the quality of the urban environment so that it brings various consequential problems in Indonesia, including an increase in urban poverty, traffic congestion, rising sea levels, uneven fulfillment of infrastructure needs, more slum environments, and flooding. According to Aithal & Ramachandra (2020), urban growth and development is the transformation of cities that is influenced by many things, such as urbanization, increased economic, social, and cultural activities in the city center, and the increase in the area of built-up land. This land conversion is caused by land growth and population activities, leading to the emergence of new settlements in the suburbs that have an impact on the morphology and spatial structure of the city (Cheng, Liu, He, & Shaw, 2017). In peripheral areas, land use is built up for residential, service, and industrial purposes (Yunus, 2008). With less land in the city, peripheral areas experience physical changes, especially in terms of land use (Pratama & Ariastita, 2016; Putra & Pradoto, 2016). The growth of new settlements will inevitably increase land demand.

Residential areas in Kanigoro Urban Area are developed by considering existing land functions, namely open and built-up land area, as well as the distribution of population and urban facilities. Land use refers to the way one uses or exploits land. Land can be used for a variety of purposes, including agriculture, residential, commercial, industrial, nature conservation, and recreation. Regulating and optimizing the use of natural

resources and available land for human needs and environmental sustainability is important in land use planning. Good land use planning can prevent disputes, support sustainable development, and maintain ecological balance. When demand for new dwellings is high and land availability is limited, housing density is generally lower. This is seen in almost all urban areas (Broitman & Koomen, 2015). Most of the land in Kanigoro Urban Area is used for residences and agriculture. Transforming Kanigoro into a sustainable district capital requires a major change in the city's building and development methods. To achieve this, a prioritized approach to development is needed that considers the community's need for a comfortable place to live.

The arrangement or formation of urban states as objects and systems that can be examined visually, structurally and functionally is known as urban morphology (Zahnd, 2006). Three main components can be used to analyze the morphology of a city or region: land use patterns, road network patterns, and building density. Land use patterns show how land is used and allocated for various purposes, and road network patterns affect the circulation and accessibility of an area. The morphology of a city is different for each area, so its characteristics are shaped by its morphology. The data analysis method used to identify urban morphology is position-based data processing or geographic information systems (Basworo G.P., 2019).

According to James & Bound (2009), morphology comes from the word “morph”, which means “shape” so it can also be interpreted as the shape of the physical appearance of the area. The physical appearance of the area in urban morphology is viewed from the structure that forms a certain appearance that includes the relationship between areas and the shape itself (Dahal, Benner, and Lindquist, 2017). Urban spatial structure is how various elements are organized in a city, including land use, road networks, and building density in a city (Chen et al., 2019). Urban spatial structure refers to the economic, social, and physical activities distributed in urban areas. To see the physical condition of an area, morphology looks at three things: the land use of the area that reflects its activities, building patterns and their functions, and circulation patterns or road networks that connect between areas (Soetomo, 2009). Land use, building patterns and road network patterns, are the three components used in morphological shape analysis (Putri, M. A., Rahayu, M. J., & Putri, R. A., 2017).

By referring to the research gap and previous findings, this study is expected to produce a comprehensive review that combines the technical factors of land use change with the distribution of buildings and road availability to determine changes in urban morphological patterns. Thus, the aim of this research is to formulate urban morphological patterns that are in accordance with physical land and social factors.

2. Method

The research method used in this study is a mixed approach that combines quantitative and qualitative analysis to provide a more comprehensive understanding of the interdisciplinary topic under study. In this study, data analysis of land use conditions and initial identification of urban areas formed by identifying the distribution of buildings using secondary image data in 2011, 2015, 2019 and 2023 supplemented by questionnaire data with resident respondents in the research location. The map results are used to see the pattern of land use development and spatial distribution in a growing urban area, the distribution of buildings and road accessibility. This was done using the Kanigoro Urban Area as the study area.

3. Results and Discussion

Building Distribution Analysis

Buildings, especially settlements, in the morphological component of the city consist of three patterns, namely: homogeneous, heterogeneous, and dispersed (Zahnd, 2008). Urban development that is dominant in meeting housing and infrastructure needs is a determining factor in increasing accessibility, land use change, and conversion of productive agricultural land (Xing et al. 2020). Settlement development in various regions has undergone a significant transformation, including Kanigoro Urban, which has experienced settlement development over the past ten years. Settlement development in Kanigoro Urban can be seen in the structure and pattern of settlements on the map as shown in the following figure:

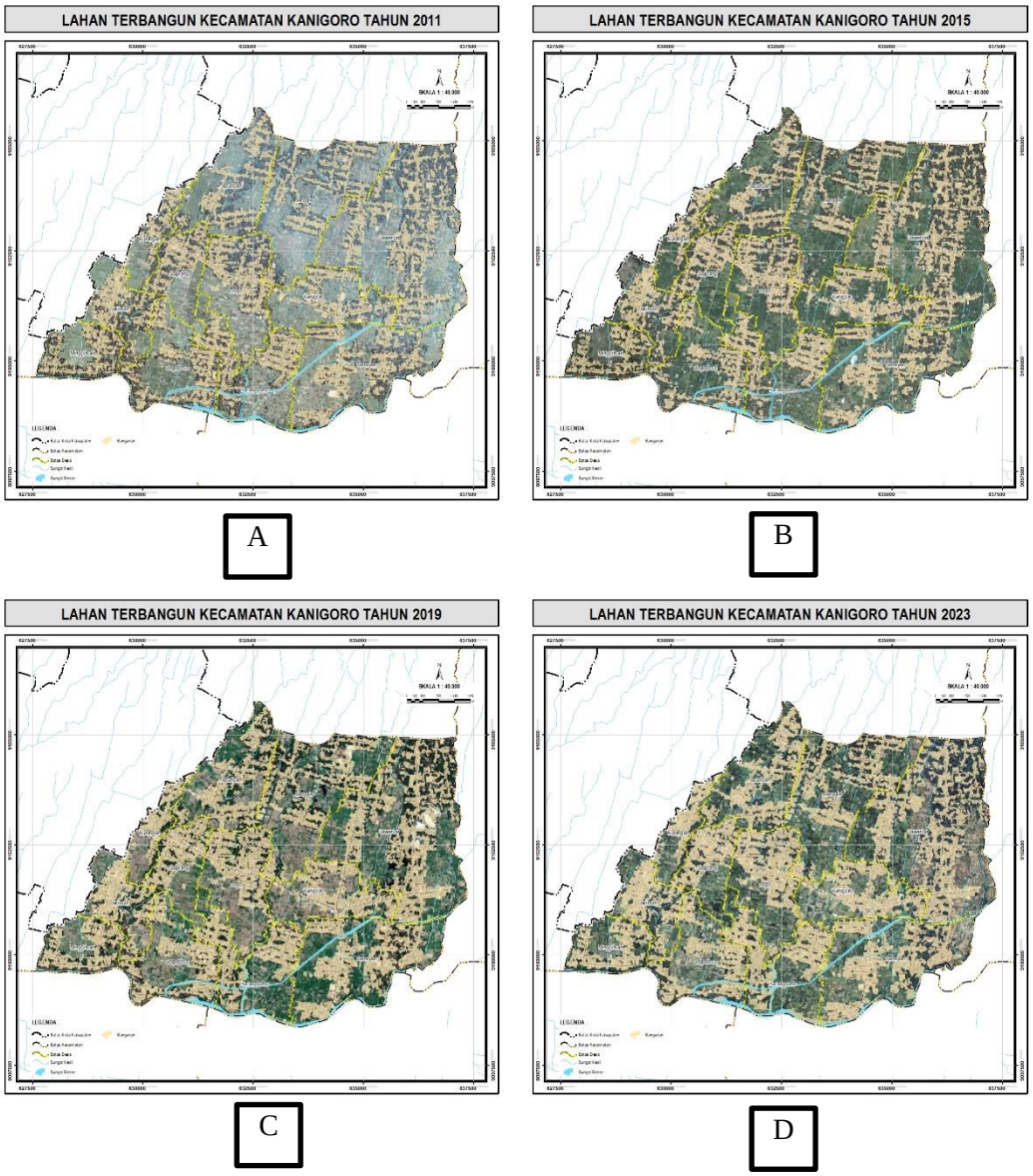

Figure 1. Map of Kanigoro Urban Settlement in 2011, 2015, 2019 and 2023

The figure shows the difference in the distribution of settlements on the map of built-up land in Kanigoro Urban Area in 2011, 2015, 2019 and 2023. This difference is due to an increase in the number of residents or population in the area. According to Surya et al. (2020), population pressure on space tends to increase due to urbanization, migration, and suburban suburbanization, causing land use change, conversion of productive agricultural land, open land use, and other ecologies. Figure 1.A shows that settlements in Kanigoro Urban Area in 2011 had a linear urban form due to the elongated urban spatial model following transportation routes. As seen on the map in Figure 1.A, Kanigoro Urban in 2011 experienced urban development centered along the road with the center of government located in Kanigoro Urban Village. The linear city form has several advantages such as land use efficiency by concentrating development along the main route, ease of mobility of population and economic activities along the main route, and ease of integration between functional zones and public services. However, the linear city form in Kanigoro Urban Village has disadvantages such as high dependency on the main route which can cause congestion.

Furthermore, based on the analysis of land cover change conducted, settlements in Kanigoro Urban Area in 2015, 2019 and 2023 also have a linear city form because they have similar characteristics to the city form in 2011 with an increase in land area used as settlements, namely:

Table 1. Building Area of Kanigoro Urban Settlement in 2011, 2015, 2019 and 2023

No	Year	Area (Km^2)	Changes (Km^2)	Change Ratio (%)
1	2011	15,57		
2	2015	16,17	0,6	3,85%

3	2019	20,75	4,58	28,32%
4	2023	21,92	1,17	5,64%

The building area from 15.57 km^2 in 2011 to 21.92 km^2 in 2023. As seen in Figure 1, Kanigoro Urban settlement experienced a fairly rapid growth for eight years, from 2011 to 2023, covering an area of 6.35 km^2 with a ratio of 3.40% increase in building land area per year.

Limited land for settlements, especially in cities, causes rural areas to develop (Qomar, N., & Harudu, L., 2019). The increase in buildings for new settlements will shape or change the pattern of settlements that have existed before. According to Rifai R. (2011) there are 3 patterns of distribution of residential buildings, namely the elongated pattern, concentric pattern and leapfrog pattern as shown below:

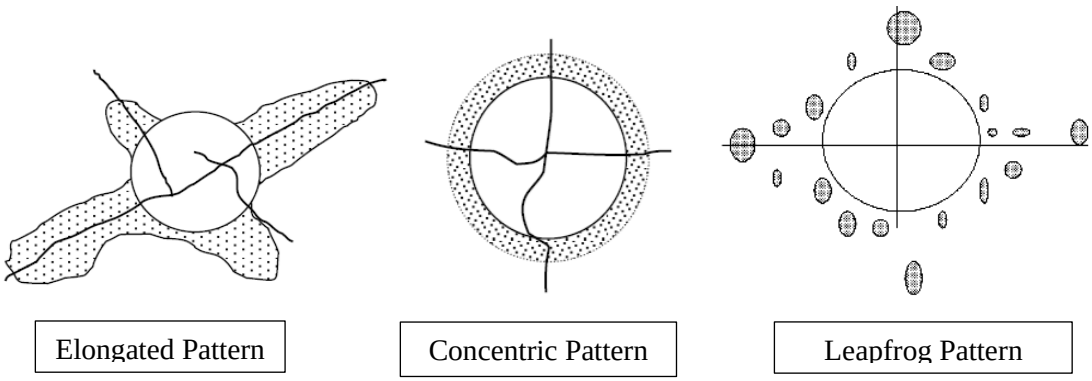

Figure 2. Settlement Distribution Pattern

Source: Rifai R., 2011

Based on the 2023 land cover map, it can be seen that there are 2 (two) patterns of distribution of buildings, especially settlements in Kanigoro Urban Area, namely:

a. Elongated Pattern

In Kanigoro Urban Area, an elongated settlement pattern dominates, following the roads to the right and left of the highway. Settlements in this area develop fastest along road networks and transportation routes, especially radial routes that run through the city center (Roziqin, A., & Kusumawati, N. I., 2017). This pattern is generally found in low-lying areas with gentle morphology, which facilitates the construction of roads around it. This pattern is naturally created to make transportation easier. Areas close to transportation routes experience rapid growth. Outside the city center, this development pattern is uneven (Rifai R., 2011). A map of the elongated settlement distribution pattern is depicted in the following map:

Figure 3. Map of the Distribution of Elongated Pattern Settlements in Kanigoro Urban Area

b. Concentric Pattern

Kanigoro township has a number of areas that have a group settlement pattern. In this settlement pattern, most of the residents are still of the same descent or work, and houses are usually inherited. These historical factors and close kinship structures influence clustered settlement patterns. Marriages between the same ethnic group and intermarriage affect the density of each settlement block. This is caused by the conversion of land used for community members in that part of the village (Agustian, E., Rachmawati, R., Rijanta, R., & Pitoyo, A. J., 2021). Based on the results of the questionnaire, most respondents answered that they chose a place to live because of inheritance, namely 76% of respondents as shown in the following table:

Table 2. Questionnaire Results Reasons for Choosing a Place to Live

Village	Reasons for Choosing Current Residence:					
	Easy Access	Near Public Facilities	Near Work/School	Low Price	Legacy	Total
Kanigoro	3	2		1	4	10
Satreyan	3	2	1		4	10
Minggirsari	3				8	11
Gogodeso			1		11	12
Karangsono	1		1		8	10
Tlogo	1			1	8	10
Gaprang	2				9	11
Jatinom	1				9	10
Kuningan					10	10
Papungan	1			1	8	10
Bangle	2			3	4	9
Sawentar					12	12
Grand Total	17	4	3	6	95	125
%	14%	3%	2%	5%	76%	100%

In addition, places that are fertile and close to water sources are usually chosen as places of settlement. The even nature of growth will form a relatively compact urban morphology. Transportation routes have a less obvious role in this development pattern (Rifai R., 2011). The map of the distribution pattern of settlements in groups is depicted as the following map:

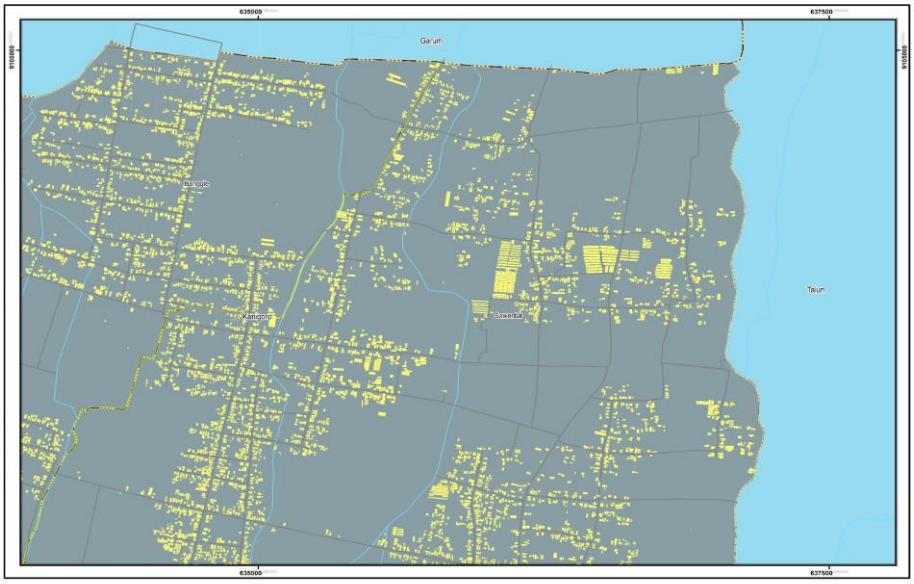

Figure 4. Map of Distribution of Clustered Settlement Patterns in Kanigoro Urban Area

Urban areas continue to develop in cities and surrounding areas, changing the appearance of rural areas into urban areas. Periurban areas continue to experience physical, social and economic development. In general, the layout and population composition of each urban settlement in Indonesia has a different layout and population composition (Estoque et al. 2017; Biegańska et al. 2018). To gain an understanding of the distribution pattern of activities in the area of interest, density or density maps can be used to determine the level of population or activity density in different parts of the city.

According to the kernel density data, activities are spread across Kanigoro Urban Area. On the map, the color

or intensity indicates the level of activity density, with the legend showing the variation from very low to very high. The following figure shows the density of buildings as activity centers in Kanigoro Urban Area

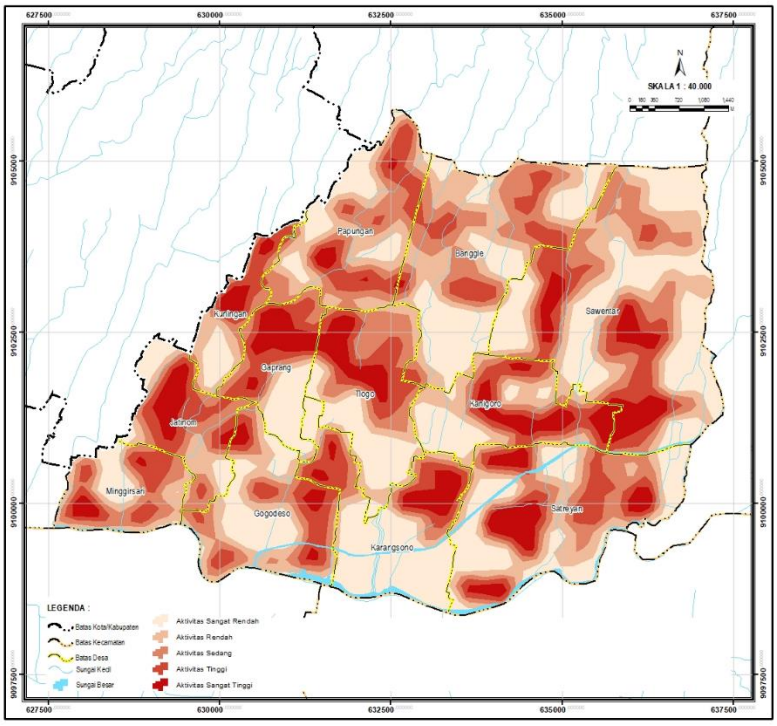

Figure 5. Kernel Density Map of Kanigoro Urban Area

The figure shows that Kelurahan Kanigoro and Desa Sawentar have high activity centers, which are the government centers of Kanigoro Urban Area with various public facilities. They function as city centers morphologically. In addition, Sawentar Village shows a high level of activity as it has developed into a sub-center with supporting facilities such as schools. The villages of Banggle, Satreyan, Tlogo, Papungan, Gogodeso, Karangsono, Jatinom, Gaprang, Minggirsari, and Kuningan fall into the transition area with moderate to low activity. These areas have activity levels that vary from moderate to low, indicating a transition zone with a combination of housing, agricultural land and some small commercial activities. Furthermore, the peripheral zone with very low activity consists of the Kanigoro Urban boundary, indicating an area that is more focused on agricultural land, green open spaces, or low-density housing.

Road Network Accessibility Analysis

Settlement areas in Kanigoro Urban Area develop following a combination of grid and linear patterns, by spreading along the existing road network. On main roads, settlements develop centrally because they follow well-organized road access and have many trade and service centers. Road accessibility is also a factor in determining potential settlement land. According to Curtis, C., & Scheurer, J. (2010) accessibility is the ease with which a person or individual can perform a desired activity, in a desired place, by a desired method, and at a desired time. Road accessibility is defined as a state in which people can travel comfortably and aims to fulfill basic community needs, such as education, health, administration, and culture, as well as commercial needs, such as the use of business facilities, services, and craftsmen. Roads to transport people from rural to urban areas are increasingly needed. To meet daily travel needs, “more roads with high accessibility are needed” as urbanization progresses (Ng, C. P., Law, T. H., Wong, S. V., & Kulanthayan, S., 2017).

The road accessibility assessment is taken from arterial and collector roads, where the closer the land is to the buffer circle, the more potential the land is using the buffer analysis as follows:

a. Arterial Road Accessibility

Based on the results of the buffer analysis, it can be concluded that arterial road accessibility in Kanigoro Urban Area has been fulfilled, with arterial road services covering all land in the entire Kanigoro Urban Area. Areas that have received this service can be considered as potential areas as shown in the following map:

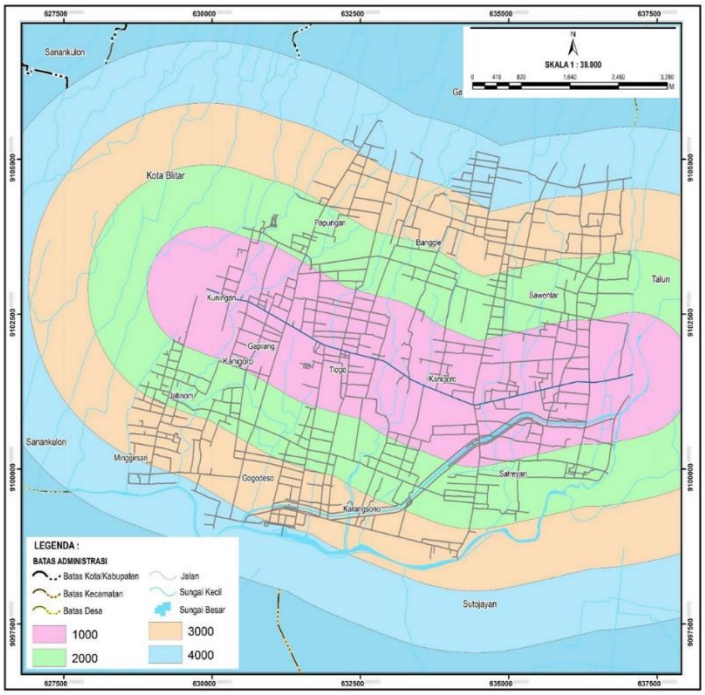

Figure 6. Accessibility Radius Map of Kanigoro Urban Arterial Road

b. Collector Road Accessibility

The results of the buffer analysis show that collector road accessibility in Kanigoro Urban Area is still lacking, with several villages and sub-villages such as Minggirsari, Gogodeso, Jatinom, Gaprang, Tlogo, Papungan, Karangsono, Sawentar, Kanigoro Urban Village, and Satreyan not yet fully served. Places that have not received this service are considered to have less potential, as shown in the following figure:

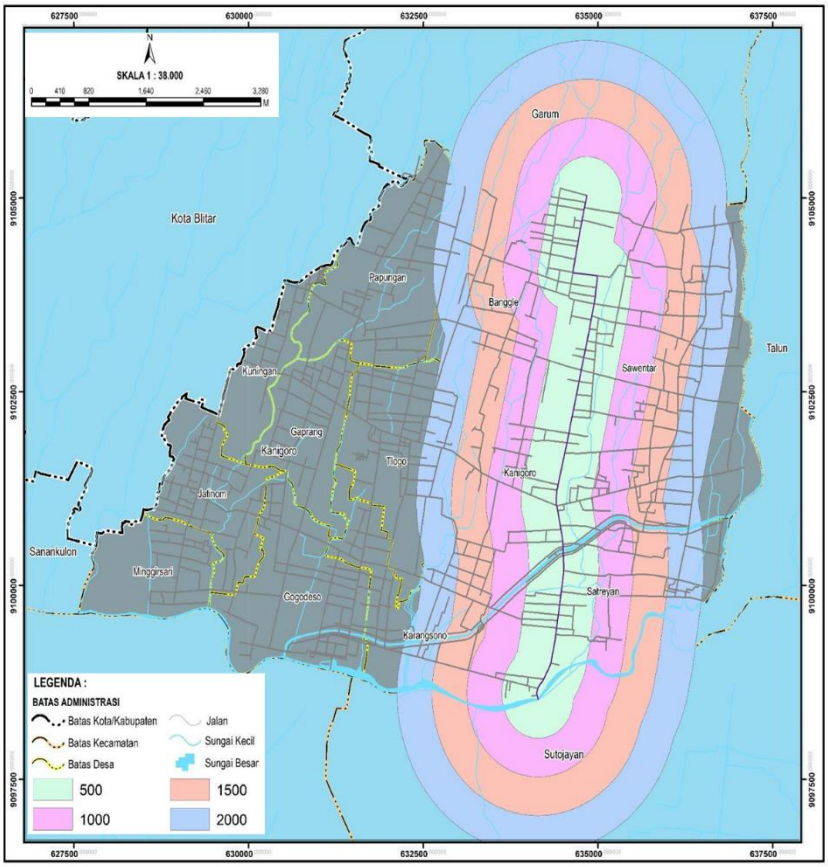

Figure 7. Accessibility Radius Map of Kanigoro Urban Collector Roads

Some of the less potential settlement areas can be improved by developing and upgrading existing roads so that all settlements in Kanigoro Urban Area are better accessed. According to Welch (2013), good accessibility is essential for developing sustainable settlements because accessibility is calculated using connectivity measures, which consider several characteristics of transportation connections such as frequency, speed, distance, capacity, required transfers, and activity density. Sustainable transportation is essential to ensure that everyone has access to the economic and social opportunities necessary to live a good life (Richardson, B. C., 2005). Sustainable transportation connections rely heavily on the availability and affordability of road access.

Accessibility plays an important role in the economic development of any region (Basworo, G. P., 2019). Urban and rural communities strive to build sustainable transportation systems, especially road networks, that will enable them to achieve successful economic, social, and environmental growth (Wolny, A., Ogryzek, M., & Źróbek, R., 2019). To improve accessibility in Kanigoro Urban Village, there are four road development plans in the Kanigoro Urban Detailed Spatial Plan shown on the transportation network plan map, namely primary collector roads, primary neighborhood roads, primary local roads, and secondary local roads as shown below:

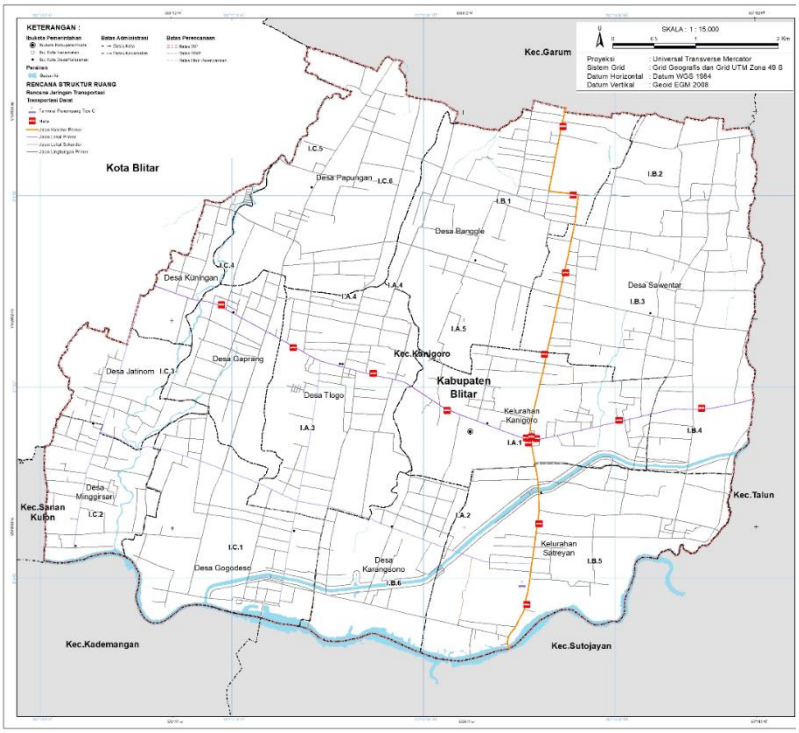

Figure 8. Transportation Network Plan Map of Kanigoro WP RDTR

Source: RDTR WP Kanigoro 2022-2042, 2022

The figure shows that in the morphological pattern of Kanigoro Urban, the road network is spinal, with one main road (like a spine) running through the city. Smaller roads branch off to the left and right from this main road. The layout of the main roads spreading out from the city center forming arms supports the road network pattern of Kanigoro Urban. A transportation route is available in multiple directions out of the city, rather than just one. In cities that grow concentrically, transportation routes are concentrated in one area. Concentric growth is the term used to describe city growth that follows this linear and grid. Kanigoro is a small concentric city, far from the big city and far from the arterial lines. The mix of urban and rural with a very agrarian feel is typical of small towns that are still developing. However, land use is changing along with the city's population and economy.

4. Conclussion

Several important findings emerged from the research conducted on building distribution and road accessibility in Kanigoro Urban Area. First, settlement patterns in Kanigoro are dominated by elongated patterns that follow the main road network and clustered patterns that are influenced by historical and kinship factors. Second, settlement growth experienced a significant increase during the period of this study, especially along the main transportation routes. Third, the accessibility of arterial roads in Kanigoro is quite good, but the accessibility of collector roads still needs to be improved, especially in some villages and to the city center. The results of the

analysis show that there are several suggestions for the future development of Kanigoro City, namely integrated spatial planning that allows for sustainable settlement growth and ensures the availability of adequate infrastructure; improvement of the quality of the collector road network to improve accessibility and connectivity between areas; and development of integrated public transportation to reduce dependence on private vehicles.

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