Spatial Analysis of Road Network Integration Using Space Syntax And In Residential Area

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Abstract. The development of an area begins with a variety of activities which then influence the formation of the spatial structure, so that a spatial configuration that is integrated with the road network is needed so that it can be interconnected with the scope of public facility services. Spatial analysis of road network integration and public facility service coverage using space syntax in the case study location in housing area. It is Bumi Tamalanrea Permai (BTP). BTP near the arterial road, one of the largest housing areas and the complexity of road and street in the sub residential in BTP. BTP residential area of Makassar City was carried out to identify the influence of connectivity, integration, intelligibility values on road space and radius of public facility services with the nearest area and travel area. The space syntax analysis was used to solve the problem about road network integration. Then a space syntax analysis was carried out regarding the correlation between the integration of road space and existing public facilities through the level of accessibility of the road network as a link to public facilities in BTP housing. the results of the service coverage analysis which shows the service area coverage of a public facility has a correlation with the results of the space syntax analysis with the coverage of these service areas via roads

Keywords: Integration, Space Syntax, Road

1 Introduction

The road network system is an abstract representation of transportation infrastructure that plays a crucial role in land use. It influences the structure and pattern of land use, while also serving as a means of facilitating the movement of people and vehicles. Therefore, road connectivity is a vital element in regional development. By identifying which roads connect to specific areas, we can understand their impact on local activities [1], [2]. Although several roads exist, there are still issues with the network. As a result, the connections between road sections, which should provide access to public facilities,

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do not function as expected. This limits the ability of residents to fully utilize public facilities within their community. As noted by [2], [3], [4], due to rapid urban growth and constant changes in city spaces, there is a need for careful planning and simulation of urban spaces. In the BTP housing area, where many public facilities exist, the road network is still disjointed, and its configuration is suboptimal. This research aims to assess the level of connectivity and integration within the road network of a residential area. The movement of people is heavily influenced by the road system, which shapes daily activity patterns and the efficiency of circulation. To understand movement patterns and access to public facilities in the BTP residential area, the space syntax method is applied. This will help evaluate the effectiveness and efficiency of interactions and the depth of movement within the space and the road network [5].

2 Literature Review

The development of an area begins with various activities which then influence the formation of the spatial structure contained therein. According to the elements forming the spatial structure consist of activity centers, functional areas, and road networks. Cities or urban areas can basically be viewed as a spatial system that uses elements that form and are related to each other (Putra, 2021). These diverse activities require effective and efficient spatial planning, where this relationship can be realized when there is an interaction that can be identified in a movement from one space to another. The road space configuration system is created by including road space as an open space which is an important part of the arrangement of an area that connects one road to another (Jiang et al., 2000; Muadzin, 2023). The road network system and service coverage are abstract representations of transportation facilities that have an important relationship with land use that will change the structure of the pattern of a particular land use and its use as a means of transportation that accommodates the movement of people and vehicles (Adhitya & Nurdini, 2022; Jiang et al., 2000; Muadzin, 2023). Therefore, the role of road connectivity and service coverage becomes an important element that is closely related to public areas or public facilities in the development of a region. By observing precisely which roads are connected to a particular region that will have an impact on the activities in it. Space Syntax analysis is one of a method used in urban planning to analyze the spatial configuration of urban environments [6], [7]. It focuses on understanding how the layout and structure of spaces, such as streets, buildings, and public areas, influence social, economic, and environmental outcomes. Key concepts in space syntax analysis are connectivity and integration. It is a Space syntax evaluates how well spaces are connected and integrated with one another. For example, it looks at how easily people can move between different parts of a city [8], [9], [10], [11]. Highly connected streets are likely to see more movement, while poorly connected ones might be more isolated. Axial Maps aspect represent the longest straight lines that can be drawn through a network of streets or spaces. The more intersections an axial line has, the higher its "connectivity," and this correlates with higher pedestrian or vehicle flow. Accessibility is space syntax aspect helps planners assess how accessible key locations (like parks, schools, and shops) are to residents based on the spatial layout. The accesibilty parameters are connectivity, choice, integration, nodes, and depth [6], [12], [13], [14], [15]. Therefore, the space syntax analysis can be

one of the solution to solve some problems interconnectivity between street configuration and land use.

3 Method

3.1 Location

This research was conducted at Bumi Tamalanrea Permai Housing. The location of this research covers the residential area of BTP and its surroundings.

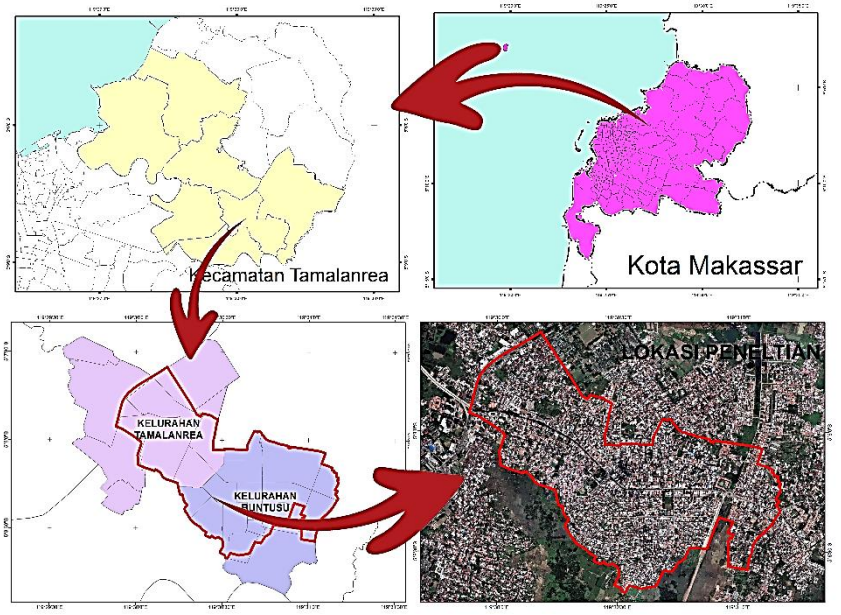


Fig 1. Research Location Map

3.2 Space Syntax Analysis

In the initial stage of analysis, road network data in .dxf format is needed. After that, import the file into the DepthmapX application (the space syntax apps). After the road network data file has been imported. Then create an axial map. The next stage is the stage of starting to run the analysis using the run graph analysis tool and then entering the radius with the numbers 3 (local) and -n (global). The final stage is selecting the results of the existing road network analysis such as connectivity, HH integration (Global), HH R3 integration (local) [1], [2], [3], [4], [5], [16], [17], [18]. The step is from survey data, space syntax analysis by using connectivity, integrity and integibility parameters. The output is global and local integration.

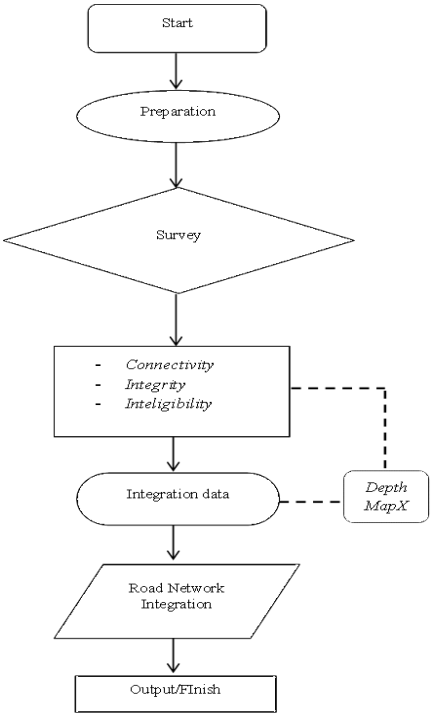


Fig 2. The Step of Analysis

4 Results and Discussion

4.1 Global Integration (Rad-N)

The road network structure in the BTP housing complex, from a morphological perspective, has seen little development since 2010. The progression of road construction is illustrated in Figure 2, where new roads are highlighted in red. The high integration of residential roads stems from the main BTP residential road corridor, which is influenced by the presence of public service facilities.

In the road network maps from 2010 and 2015, roads in the outer residential areas with low integration levels are impacted by the limited accessibility, as these roads are less frequently used by drivers. However, the growing number of public facilities is shifting the area's function from primarily residential to a mix of commerce and services. This shift is expected to further enhance the road network's integration by 2023, extending it across almost all areas of BTP housing.

As shown in Figure 3, the axial map analysis of road integration within the BTP housing complex reveals that the core of road integration is concentrated in the center of the residential area and has gradually expanded toward the outskirts. Several roads on the periphery, marked in blue, indicate low integration values, suggesting limited accessibility. In contrast, roads highlighted in red and yellow show high integration

values, signifying better connectivity. The axial map integration analysis indicates that the spatial configuration is well integrated overall, reflecting a high level of accessibility throughout the road network.

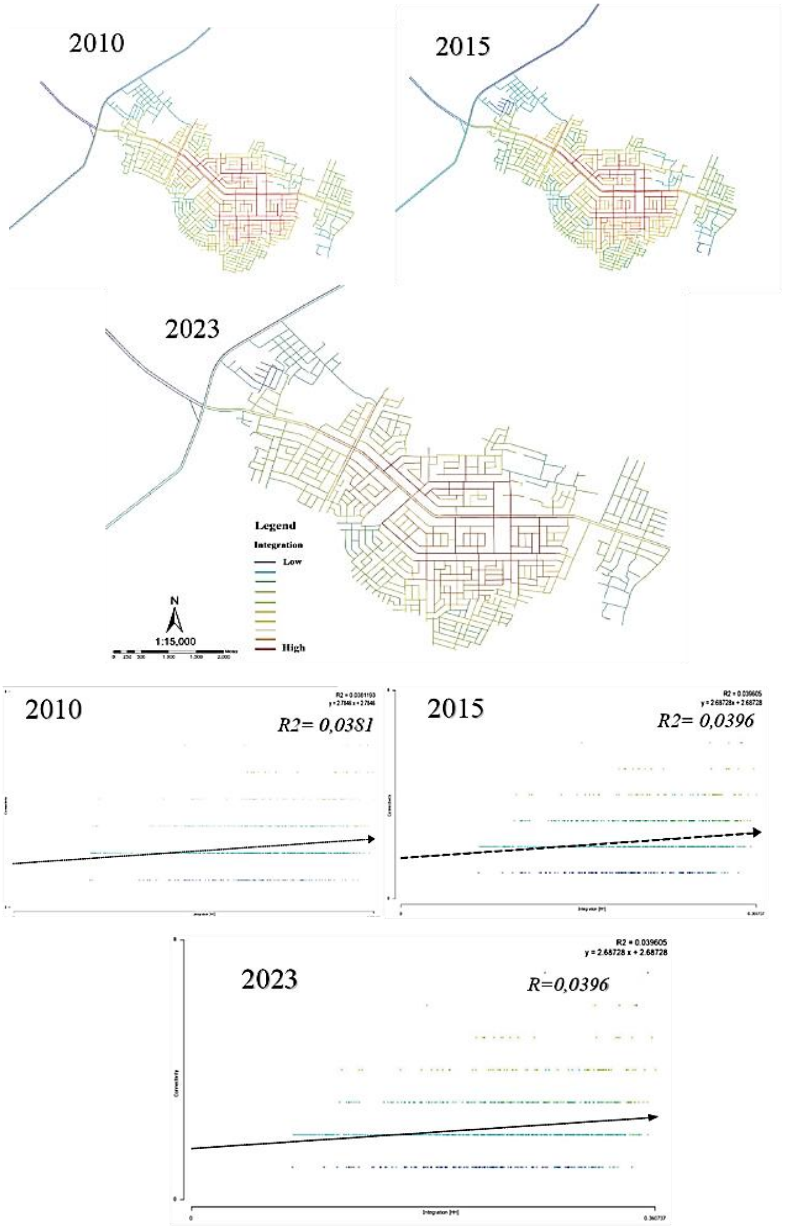


Fig 3. Scatter plots of global integration showing the Intelligibility value of BTP residential roads

The scattergram in Figure 3 illustrates the correlation between connectivity and integration. The analysis results from DepthMapX show a distribution of points forming an upward straight line at a 30-degree angle from the bottom left to the top right. The straighter the line or the steeper the slope, the stronger the correlation between connectivity and integration. This indicates a road network structure that is easier to navigate and understand.

4.2 Local Integration (Rad-3)

The radius (or level) is determined by the center coordinates in the DepthMapX application. For the BTP housing case study, the map's center coordinates are set at level 3 (Rad-3). In the axial map analysis results, which use local integration up to level 3 (shown in Figure 4), the quality of integration improves over time. This improvement becomes evident when comparing access to different areas with pedestrian movement versus vehicle movement.

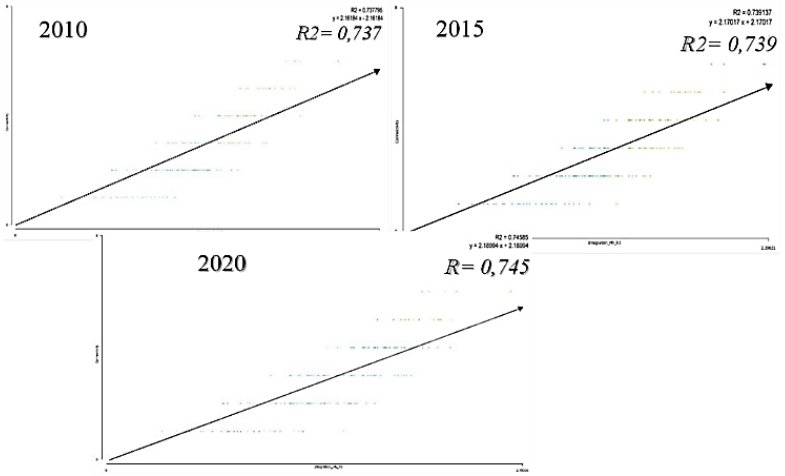
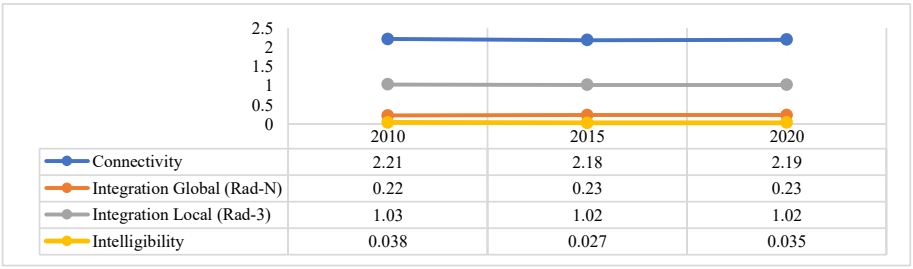


Fig 4. Scatter plots of local integration showing the Intelligibility value of BTP residential roads



	2010	2015	2020
Connectivity	2.21	2.18	2.19
Integration Global (Rad-N)	0.22	0.23	0.23
Integration Local (Rad-3)	1.03	1.02	1.02
Intelligibility	0.038	0.027	0.035

Fig 5. Topology variable value

In terms of connectivity development, the road network in 2010 had the highest connectivity quality, while the 2015 network showed the poorest. The main residential road corridors in BTP for 2015 and 2023 maintained a high average integration value of 0.23, with 2010 showing the lowest. The grid network pattern in BTP housing reflects this, indicating a high degree of road integration within the system. The integration value of BTP residential roads has consistently increased from 2010 to 2023, in line with the growing number of public facilities in the area.

However, based on the intelligibility value (R2), the road network in BTP housing is still far from achieving the optimal value of 1. In 2010, the highest intelligibility value was 0.038, which decreased slightly to 0.037 in 2015 and further to 0.035 in 2023. The integration and connectivity values are directly linked and influence the overall intelligibility (R2).

The local integration analysis (Rad-3) reveals that the quality of integration has been gradually improving, largely due to road construction at various points. The local

integration value is significantly higher compared to the global integration level, indicating that the growth of public facilities has had a substantial positive effect on local connectivity and integration. However, on a global scale, the decrease in integration quality has resulted in reduced accessibility. This decline can be attributed to the uncoordinated road construction, which has been driven by the need to access public facilities rather than following a planned development approach.

4.3 Level of Road Network Connectivity

The connectivity analysis of the axial map for the road network in BTP Housing, conducted using the DepthmapX application, calculates the value and number of direct connections each road has to surrounding roads. In the results, the map reveals many blue road points, indicating low connectivity, while red roads show high connectivity values. This suggests that the overall connectivity of the road network is not optimal, as the number of interconnecting roads remains limited.

The findings emphasize that spatial planning policies are closely tied to transportation and road infrastructure strategies. A well-connected road network links different activity spaces, directly influencing socio-economic development and population changes in the area. Therefore, creating a well-designed and interconnected road plan is crucial to the successful development of a region.

Fig 6. Analysis results connectivity axial map

5 Conclusion

The scope of public facility services and the integration of existing road space in the BTP housing area are closely related. The service coverage analysis, which shows the extent of a public facility's service area, is correlated with the space syntax analysis.

This reveals that these service areas are accessible via roads with high accessibility, often referred to as the "red line." This demonstrates strong connectivity between the road network and public facilities within the BTP housing complex.

However, the global integration in BTP shows a low correlation. This is because global integration primarily refers to arterial or secondary roads, which are not well connected to the local roads. On the other hand, local integration shows a high correlation, as it refers to the integration and connectivity of pedestrian pathways.

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