International Journal of Architecture and Urbanism Vol. 09, No. 01 (2025) 43 – 52

International Journal of Architecture and Urbanism

Journal homepage: https://talenta.usu.ac.id/ijau

The Influence of Transportation Network Connectivity on Spatial Structure in West Medan District

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ARTICLE INFO

Article history:
Received 14-11-2024
Revised 15-3-2025
Accepted 17-3-2025
Available online 31-03-2025

E-ISSN: 2622-1640
P-ISSN: 2622-0008

How to cite:
Sitepu M. K. C. The Influence of Transportation Network Connectivity on Spatial Structure in West Medan District. International Journal of Architecture and Urbanism. 2025. 9(1):43-52.

http://doi.org 10.32734/ijau.v9i1.18867

ABSTRACT

West Medan District, as the center of various activities such as education, industry, economy, and transportation, experienced significant population growth. Transportation is a very important and strategic means of shaping the structure of a region, where the transportation network contributes to the formation of a crowded urban space and becomes the center of community activities. This study aims to investigate how transportation network connectivity affects the spatial structure of urban areas, with a focus on the role of transportation infrastructure in shaping commercial land use patterns and urban activities in West Medan District. Result This study is expected to identify changes in the structure of urban space caused by transportation network activities, as well as negative impacts on the development process. This research is expected to have a positive impact on efforts to improve accessibility patterns in the future. In addition, the results of this research are expected to be relevant to support urban planning and transportation, especially in realizing sustainable urban areas and have spatial integration.

Keywords: accessibility, spatial structure, transportation

1. Introduction

The development of a city continues to increase along with the development of the population so that the community's activities are more diverse. Therefore, the increasing mobility between regional spaces affects the spatial structure of the city According to [1], defining the meaning of a city is interpreted as a form of government in which the majority of areas are urban areas. A city can be seen as a complex network system consisting of various elements such as transportation and its infrastructure [2].

Differences in resource ownership and limited areas require transportation facilities, such as public transportation, buses, and others, to support community mobility [3]. One of the roles of activities in the central area of West Medan is the transportation network, which is one of the important roles in supporting humans in carrying out their activities. The transportation network consists of infrastructure (roads) and service networks (modes), and the transportation infrastructure network consists of transportation traffic spaces. The integration of infrastructure networks and modes of transportation aims to implement intermodal transportation in providing sustainable transportation services [4].

Transportation according to [5], is a derivative need of economic activities, so the economic growth of a country or region is reflected in the increase in its transportation intensity. Transportation is also needed because the sources of human needs are different, so there is a gap in distance between the source and production locations to create a distance gap, this is the reason for the existence of transportation elements [6].

There are several theories and analyses of transportation networks that include several aspects that are the basic foundation, namely the function of transportation in its development, the national transportation system, policies in the transportation sector, development planning, transportation patterns in the development of a region, traffic consolidation and land use in transportation planning.

The interaction between regions can be seen in the existence of transportation facilities and the movement of people, goods, and services. Transportation is the main indicator in spatial relations between regions and has a very important role in supporting the development of a region [7]. Transportation networks are networks that can connect various regions and determine accessibility between regions [8]. The realization of effective and efficient transportation supports and drives the dynamics of development, increasing the mobility of people, goods, and services and supporting regional development [9].

Like Hurst's theory about the state of transportation which is a benchmark in spatial interaction between regions, in West Medan itself which is the CBD (Central Business District) area due to its strategic location and its function as the center of economy, trade, and administrative activities in the city of Medan, the formation of several additional transportation network connectivity affects the spatial structure of urban areas, focusing on the role of transportation infrastructure in shaping the pattern of commercial land use and urban activities in West Medan District. There is a connection between transportation networks and spatial structures, where spatial structures have infrastructure that includes roads, railways, public transportation lines, and bus lines that can connect various regions. With the availability of infrastructure that affects the distribution of activities in an area, the spatial structure reflects an area organized to meet human needs in activities in a region, thus affecting the quality of life, regional activities, transportation efficiency, and economic growth.

Currently, the increase in movement in West Medan District certainly needs to be balanced with adequate road capacity. According to the survey results, in this sub-district area, alternative road space is added to accommodate the dense transportation network and activities in the city center. The addition of a bus stop in the middle of Jl. City Hall, which at any time at a certain hour, causes the load on the road to no longer be able to accommodate the density of movement, resulting in congestion.

This condition is undoubtedly a big challenge for the local government to consider, recreate a better spatial layout, and provide better transportation support spaces such as pilot stops on Jl. The City Hall must pay more attention and examine how the potential problems will arise from changes in the area of road space that are narrowed by congested transportation activities.

2. Method

2.1 Type of Research

This study uses a qualitative approach with a descriptive method. A qualitative approach is carried out through the collection of data in a certain environment to understand and interpret the events that take place, where this research will later play the role of the main instrument [10]. Meanwhile, according to [11], descriptive research aims to provide an overview of phenomena that take place in a real, realistic and in accordance with current conditions. This research is focused on depicting, explaining, and analyzing the relationship between the transportation network and the spatial structure in West Medan. This approach aims to produce in-depth descriptions and analyses of certain characteristics, conditions, activities, or events.

The data in this study was collected through observation methods, literature review, and data and information collection related to the issues that are the focus of this research. The literature study was carried out by reviewing the RDTR policy of West Medan District. Observation was also carried out by identifying road conditions and movements and changes in space utilization. There is also the use of data collection using documentation obtained from Google Maps and the publication of articles or journals relevant to the problem

to be discussed and combine secondary data analysis of transportation networks and land use maps sourced from government publications. Data analysis includes identifying connectivity patterns and their correlations in this study.

3. Results and Discussion

3.1 Location and Geography of West Medan District

Medan City has an area of 26,510 hectares, which is equivalent to 3.6% of the total area of North Sumatra Province. As the capital of North Sumatra Province, the city is the center of various social and economic activities, covering the fields of government, industry, trade, transportation, and education. The city of Medan is divided into 21 sub-districts, as shown in figure 1. One of the sub-districts is West Medan District, which is bordered by Medan Deli District to the north, Medan Petisah District to the south, Medan Helvetia District to the west, and East Medan District to the east.

Figure 1. Map of the West Medan Area

Based on data from the Central Statistics Agency (BPS) of Medan City in 2021, West Medan District has an area of 5.33 km² with a population of 88,602 people. Medan, as one of the sub-districts located in the city center, has a strategic role in supporting educational, industrial, economic, and transportation activities. This contributes to the growth of the population in the region.

West Medan is also known as one of the service and trade areas in Medan City. Some of the public facilities in this area include Kesawan Square, TVRI North Sumatra, JW Marriott Hotel, Lonsum Building, Medan Post Office, Titi Gantung, Merdeka Square, Tjong A Fie House, Medan Railway Station, Gang Bangkok Old Mosque Medan, Bank Indonesia Region IX Office (North Sumatra & Aceh), PT Telekomunikasi Cellular Office (Telkomsel), Graha Merah Putih Building, and other facilities.

Figure 2. West Medan area as CBD

The West Medan area becomes the CBD (Central Business District) area, as seen in Figure 2, due to its strategic location and function as the center of economic, trade, and administrative activities in Medan City. The Business Center is a key area for commercial activity in a city, characterized by a high concentration of commercial buildings, optimal accessibility, and its role in supporting the regional economy.

3.2 Road and Transportasi Network

A. Road Network

The road network will form a transportation system in a particular area. The existence of a road network that is also formed allows for changes in land use. The transfer of land change functions can occur because of transportation that supports the movement and growth of people in an area.

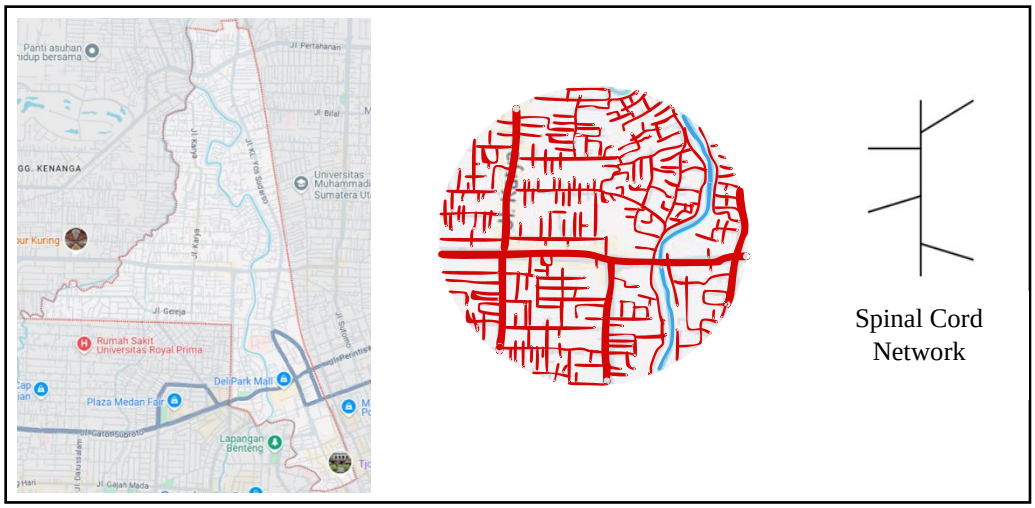

Figure 3. Road Network Pattern

The road pattern resembles a branched system with a hierarchy, the main road is in the middle, and the secondary roads branch into various areas (Figure 3), as a pattern of the leading road network, namely Secondary Arterial Lines, Secondary Collector Roads, and Local Roads.

B. Transportation Network

Transportation affects the distribution of activities in the area, which forms an urban structure where transportation helps move between modes from one area to another. Major transportation networks such as terminals and public transportation lines determine the location of the center of economic and social activities. Integrated Area: Transportation connectivity allows the integration of spatial functions between settlements, businesses, and public facilities, creating a more effective spatial pattern.

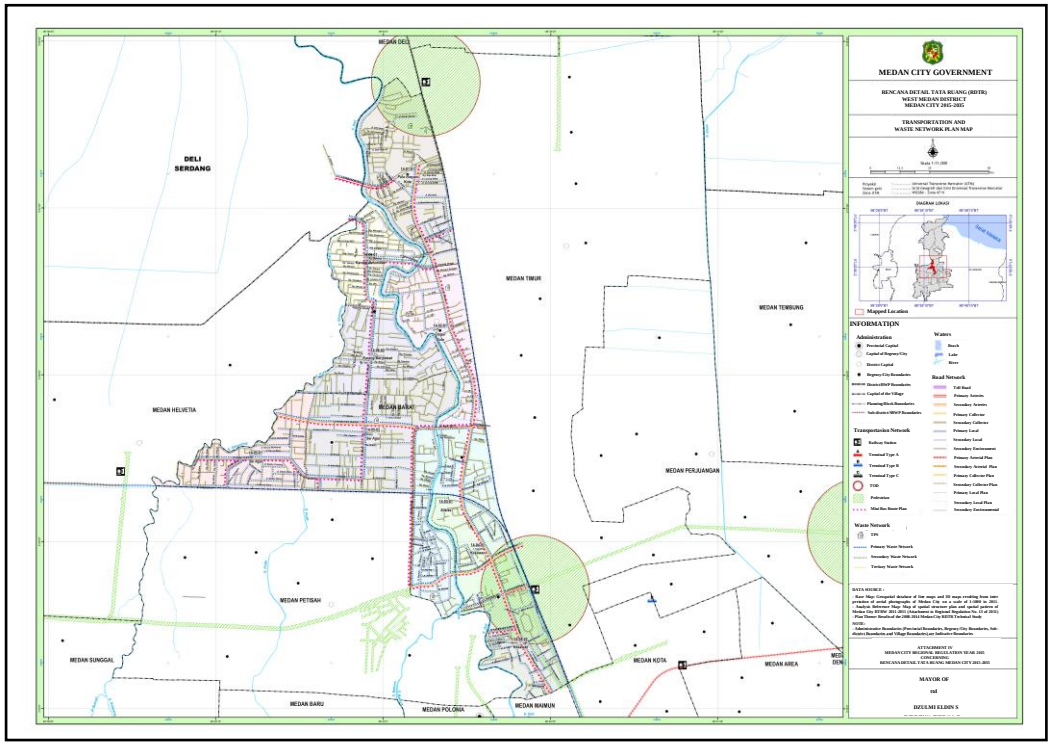

Figure 4. West Medan Transportation Network Plan Map

Transportation systems and space utilization in urban environments will affect each other. Transportation in the West Medan area plays a considerable role in the use of space. The developed and adequate transportation network system in this area provides a relatively high volume of movement, as shown in figure 4 which shows the transportation network system in West Medan. To form a high pattern of urban activity so that spaces are improved to complement the transportation network in the Medan Baru Area. Thus, the correlation between space utilization and movement volume is positive.

C. Road Network System to Transportation System

The Transportation System of West Medan District is an urban transportation system that functions as a chain of transportation that connects one activity or area to another, consisting of an arterial road network, collector roads [12], where there are main bus stop points, one train station and a large number of city transportation modes with various travel routes as urban transportation services.

The transportation system in the West Medan District consists of an infrastructure network or road network in the West Medan Area. The arterial road in the West Medan area functions to connect the West Medan area with the Helvetia Field Area, Medan Maimun. As a secondary artery in the West Medan Area, namely Secondary Arteries, namely, Amir Hamzah Street, Adam Malik Street, Putri Hijau Street, Perintis Kemerdekaan Street, Prof. HM. Yamin Street, City Hall Street, and Yos Sudarso Street. Meanwhile, collector road, a Collector road that functions to connect the West Medan area with several areas in Medan as a collector route in the West Medan area, namely Kapten Maulana Lubis Street, Danau Singkarak Street and Karya Street. In West Medan District, there are several bus halls as a place to pick up and drop off passengers, which are

often also city transportation stops. The main points of the Bus Stop in the West Medan section are Kesawan, Merdeka Field Hall, City Hall, Glugur, Methodist 8, Maju Bersama, Simpang Brayan, Padar Palapa Brayan, Merak Jingga, Gaharu and Taman Budaya and several other bus stops. In addition, Srasiun train on Jalan Station No.1, Kesawan, West Medan. Serves as a departure and arrival hub for long-distance routes between cities or local routes.

The existence of a road network in the West Medan area, which is the center of community activities in urban areas with the existence of other office or commercial areas, leads to the growth of transportation in West Medan with the existence of Transdeli Medan buses and electric buses to support the Medan government to make several stop points, especially in West Medan, to make it easier for people who are active in the area.

Transportation lines such as Railways and Bus Main Lines are in the middle of the city, namely Kesawan and City Hall Street. The shape of the spinal road network can be seen in the pattern of the road network in West Medan so that it provides transportation services such as public transportation and bus transportation on the main road where there is a commercial spatial layout that supports community activities to form the transportation needed by many people.

3.3 Land Use

Land use is one of the main components in spatial planning. This is in line with the concept of Spatial Planning which explains that spatial planning involves the arrangement of residential centers along with a network of infrastructure and facilities that support the socio-economic activities of the community, with hierarchical functional relationships [13].

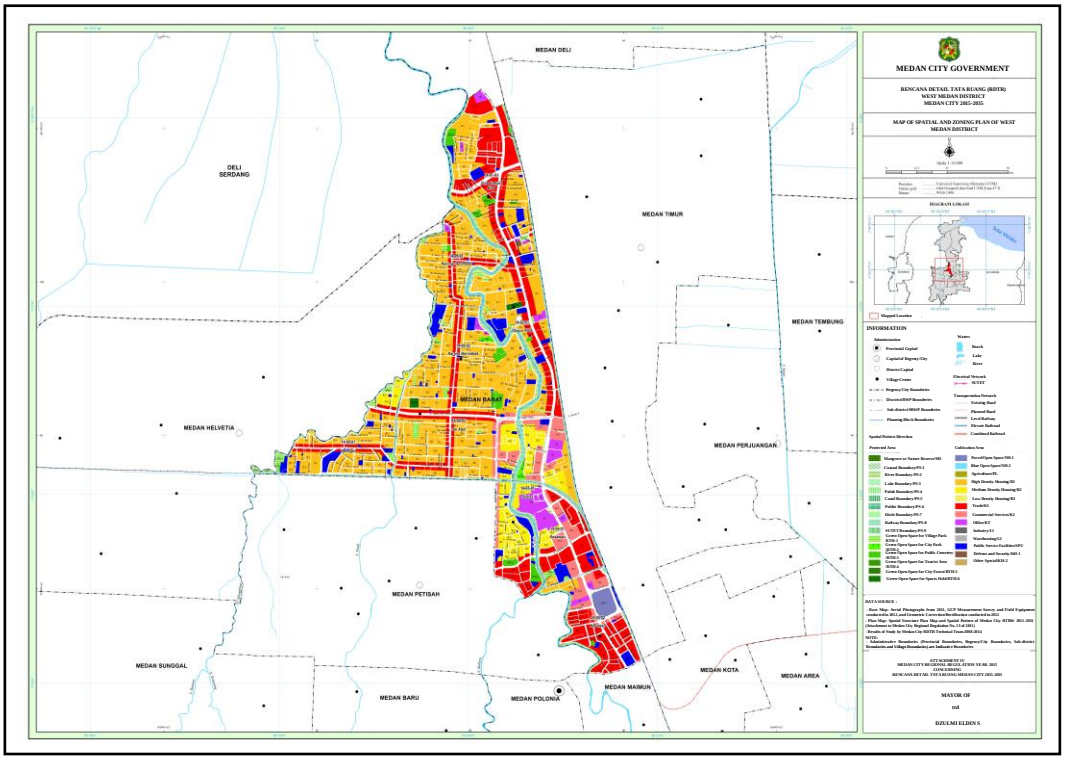

Figure 5. Map of the Spatial Pattern Map of West Medan District

Figure 5 of the Spatial Pattern Map of West Medan District shows that secondary arterial roads are more dominant in commercial areas; this is one reason for forming community activities that support the density of the transportation network. Land use is one of the reasons for forming a transportation network that is directly related to the spatial structure that forms several bus stop points and public transportation lines in Medan, especially in West Medan.

Land use in a city is influenced by transportation, which increases land use. Transportation is significantly related to accessibility, where accessibility is a factor that dramatically affects spatial planning in urban areas. The road network is a collection of road segments that are interconnected and integrate growth centers with areas within the scope of their service through hierarchical relationships [14]. The road network will also form a transportation system in certain areas. The existence of a road network that is also formed allows for changes in land use. The transfer of land change functions can occur because of transportation that supports the movement and growth of people in an area.

1. Transportation System to Land Use Change

   a. Deli Park Bus Stop

Figure 6. (a) Existing Land of Deli Park Bus Stop (2015); (b) Existing Deli Park Bus Stop Land (2024)

In 2015 (Figure 6a), during the construction of Podomoro or previously, there was no bus stop for the bus or public transportation stops. However, in 2024 (Figure 6b), around Podomoro, there were bus stops for the bus or public transportation stops. The bus stop, one of the supporters of the transportation system, has changed part of the pedestrian layout in urban areas into waiting areas for bus stops or public transportation.

   b. Construction of Pilot Bus Stop

The existence of bus stops in Medan City should be able to discipline public transportation to be able to board/drop off passengers at bus stops. Many public transportation options still pick up/drop off passengers anywhere. The bus stops that are built should be able to be used as they should so that public transportation such as Trans Mebidang and Public Transportation (Angkot) stop arbitrarily; it becomes one of the factors causing congestion. This can be seen during peak hours, such as morning, afternoon, and evening, when the hours are gone, rest, and return from work or school.

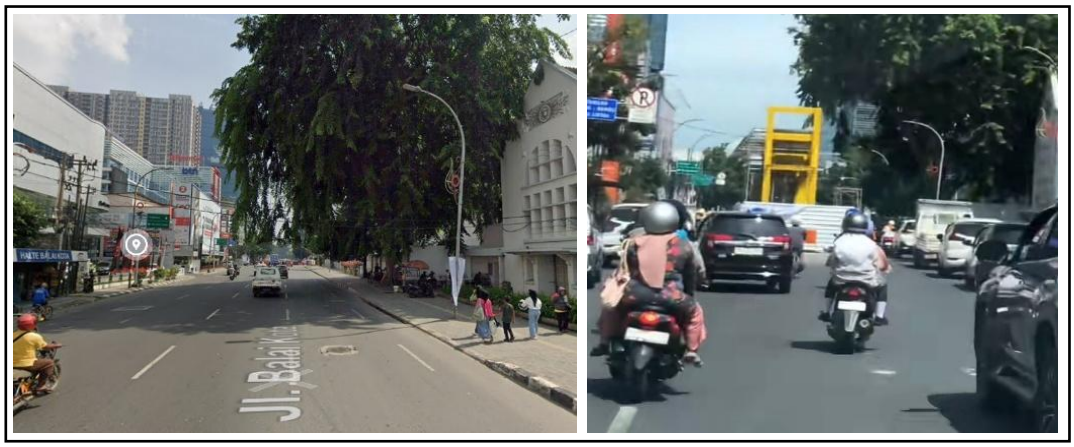

Figure 7. (a) Existing City Hall Road (2022); (b) Existing City Hall Road (2024)

Figure 7a is the area of Jalan Balai Kota before the construction of the pilot bus stop, where there are many commercial areas, offices, and economic areas. Many community activities are carried out using public and private transportation. In August 2024, as seen in Figure 7b, the Medan City Transportation Agency again narrowed the lane on Jalan Balai Kota, West Medan District. The construction of the BRT Pilot Stop is on City Hall Street; therefore, the road is narrowed. As a result, there is congestion on the City Hall road due to the road's narrowing, so transportation activities become more congested. This is one of the land changes in the road sector that resulted in the narrowing of the arterial road, namely the City Hall road.

c. Overpass Project

Figure 8. (a) Overpass Planning Design; (b) Existing Overpass Development

The construction of the overpass on Jalan Station is still ongoing. The overpass will be built along 232 m with a width of approximately 12.5 m, as shown in Figure 8a. The overpass construction before the Medan Railway Station began on October 5, 2023. This overpass is expected to overcome congestion around Jalan Stesen and support Transit Oriented Development (TOD) at the Medan Railway Station. At this time, as shown in Figure 8b, the road in front of the railway station is still experiencing traffic jams due to the construction of an overpass, but it is hoped that the effect of the completion of this overpass can reduce congestion. This will positively impact the future because it will provide a separate path between transportation and the station. However, there is also a negative where the road land is used again, narrowing the road land during this development period and causing congestion.

3.4 Connectivity of Transportation Networks and Spatial Structure

Land use is related to travel – the need for transportation – transportation facilities – accessibility – and land value. The urban spatial structure consists of occupancy, land use, and road/transportation network [15]. So, with the existence of a transportation system in the West Medan sub-district as a chain of transportation

consists of a network that connects the centers of activity and activities of city residents with a system of road networks in the form of a spinal shape with characteristics where the route follows the road section through the city center. With the support of spatial planning with various commercial areas such as offices, shopping centers, and even green open spaces, it supports the many community activities, forming a mobility and transportation mode needed to support activities in this city center.

The existence of a transportation network system that affects the spatial structure where this finding emphasizes the role of arterial roads in forming urban spatial structures. Future research may explore the socio-economic impact of this connectivity on marginalized communities. The construction of experimental stop points and overpass roads will improve the area, and the transportation network system supporting development in West Medan will become a CBD area supporting TOD. However, attention must continue to be paid to the capacity of the road area with the mobility of transportation passing through Lalang, and the existence of an overpass can reduce congestion and form a better spatial structure in West Medan.

4 Conclusion

This study shows that urban development has the consequence of increasing the need for mass transportation facilities [16]. Therefore, the transportation network in the West Medan District plays an important role in shaping the city's spatial structure. The existence of transportation infrastructure, such as roads, bus stops, and train stations, not only supports the community's activities but will also change its land use, especially in commercial areas.

The construction of pilot stops and overpasses is one of the shaping changes in the structure of urban space, which is expected to increase accessibility and reduce congestion. However, there are still challenges in the form of narrow roads that add congestion during the construction period and require serious attention from the government to create more efficient and sustainable urban spaces.

This study underlines the important role of transportation networks in shaping urban spatial structures. It is also recommended that more opportunities be provided and that the development of a comprehensive transportation system that not only improves accessibility but also supports fair and sustainable urban development be prioritized.

In addition, this study is also expected to evaluate the environmental and social impacts of increased commercial activities in highly connected areas in the future to provide more complete data to support better spatial planning and transportation policies.

5 Acknowledgment

This study discusses the influence of transportation network connectivity on spatial structure in West Medan District, to identify the impact of transportation network on spatial structure dominated by land use for commercial activities. This condition supports the increase in various community activities in the West Medan area, which is supported by transportation networks such as public transportation, buses, trains, and population mobility. The author expresses his gratitude to PT. Makmur Dekorindo Lestari, The Ap Group, the Architecture Study Program, Faculty of Engineering, University of North Sumatra, and all parties and colleagues who have assisted in the implementation of this research.

6 Conflict of Interest

In this study, there was no potential conflict of interest between the parties involved. All data and information used are obtained from reliable sources, including observations, literature studies and other secondary data. The authors ensure that the preparation of this research is carried out objectively and independently, without pressure or influence from certain parties that can affect the results of the interpretation of this research.

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