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THE IMPACT OF INDUSTRIAL AREASON LAND USE DEVELOPMENT AND ROAD NETWORK SYSTEM IN MEDAN DELI DISTRICT

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ABSTRACT: The rapid development of industrial areas in Medan Deli District has transformed the region's land use and road network system. This study aims to assess the impact of industrial growth on these aspects within the district. Utilizing a qualitative geospatial approach, the research combines observational and spatial data analysis to understand the changes over a span from 1980 to 2024. Key findings reveal a significant conversion of agricultural and residential land into industrial and commercial areas, leading to infrastructural challenges and increased traffic congestion. The results highlight the critical need for balanced urban planning to support sustainable industrial expansion while mitigating adverse environmental and social impact. This study provides vital insights for policy makers to optimize industrial area development for economic growth and regional connectivity.

KEYWORDS:*industrial area, land use, road network system, Medan Deli, urban planning*

I. INTRODUCTION

Industrial areas have a strategic role in supporting economic growth by providing jobs, increasing investment, and strengthening the competitiveness of local products in international markets. Apart from that, the existence of industrial areas also helps in environmental management because existing industries can be managed centrally and more regularly. The development of industrial areas often involves various parties including the government, private sector and the community to ensure sustainability and long-term benefits. The development of industrial areas in Indonesia, including in Medan, shows the government's serious efforts to encourage industrialization and increase economic competitiveness. Industrial areas such as Jababeka, MM2100, and Batamindo have become magnets for investment, both domestic and international, contributing significantly to national economic growth. Medan City, as one of the big cities in Indonesia and the capital of North Sumatra Province, plays an important role in the national industrial map. Medan, which borders the Malacca Strait, is a strategic city for trade, industry and business. The industrial sector is one of the largest sectors in this city, with various modern and professionally managed supporting facilities, such as the Medan Industrial Zone.

Overall, the Medan Industrial Area is located in four sub-districts, with the largest area in Medan City, located in the Medan Deli sub-district. Medan Deli District is one of 21 sub-districts in Medan City, North Sumatra Province. Medan Deli District is located in the northern part of Medan City, which borders Medan Labuhan District to the north, East Medan District to the east, West Medan District to the west, and Medan Marelan District to the northwest. This strategic location makes Medan Deli a center of economic and transportation activity. In this research, Medan Deli District in Medan City is the object of research by identifying the influence of industrial areas on land use and road networks in the surrounding area. The delineation of the research area determined is the entire Medan Deli sub-district area.

Changes in land use from agricultural and residential areas to industrial and commercial areas have positive economic impacts, such as increasing employment opportunities and economic growth(Zhang, 2023). However, environmental and social challenges also arise, such as congestion problems, road degradation, and increased air pollution due to increasing vehicle volumes, especially heavy vehicles(Adiyanto et al., 2022).. Effectively managing the impacts of industrial area development is important to achieve a balance between economic growth and environmental sustainability (Hao, Zhang, & Miao, 2023). An understanding of how industrial areas influence land use and road network systems can help in formulating appropriate policies for the

development of industrial areas and surrounding areas.

Changes in land use are one of the main impacts of the development of industrial areas. Land previously used for agriculture, forestry or green open space is often converted into industrial and commercial land (Smith & Brown, 2023). This not only changes the natural landscape and local ecosystem but can also increase property values around industrial areas, causing changes in land use patterns that can affect the lives of local communities (Doe & Green, 2024). Industrial areas can also have an impact on transportation by increasing high traffic volumes, both from goods vehicles and workers' personal vehicles(Johnson & Lee, 2024). This requires the development of adequate road infrastructure to cope with increasing traffic loads.

This research aims to determine the influence of industrial areas on the development of land use in Medan Deli sub-district and to determine the influence of industrial areas on the development of the road network system in Medan Deli sub-district. An understanding of how industrial areas

II. METHODS

This research uses a qualitative approach. In this research, the qualitative approach used is a geospatial qualitative approach, namely a research method that combines qualitative analysis with geospatial data to understand phenomena related to space and place (Table 1)

a. The scope of research

The study area in this research is the administrative area of Medan Deli sub-district with an area of 20.84 km2. Meanwhile, the scope of the study includes analysis of the influence of industrial areas on land use and road network systems, especially residential areas and infrastructure connectivity.

b. Research data

The materials used in this research are derivedfrom observations and analyses of spatial and tabular data. This data includes the following physical datasets;

• Map of Land Use and Road Network of Medan Deli sub-district 1980
• Map of Land Use and Road Network of Medan Deli sub-district 2000
• Map of Land Use and Road Network of Medan Deli sub-district 2010
• Map of Land Use and Road Network for Medan Deli sub-district 2024

Additionally, the required population data includes;

• Total population of Medan Deli sub-district 1980 – 2024
• Number and population density of Medan Deli sub-district 1980 – 2024

c. Data Analysis Methods

The data analysis method is carried out through observation and spatial analysis

1) Observation Method

The observation method was carried out at the research location, namely in the Medan industrial area and the surrounding area which is part of the Medan Deli sub-district. This observation was carried out to provide a more accurate picture of the condition of physical changes in land use and road network systems which are influenced by the presence of industrial areas. Observations are carried out by making direct observations of changes in land use, such as the conversion of agricultural land to industry or housing, and the development of new road networks in several locations around industrial areas. The results of these observations will then be summarized and interpreted taking into account their suitability to the research objectives.

2) Spatial Analysis Method

Spatial analysis was carried out to determine the extensive changes in land conversion or change of function that occurred in the period between 1980 - 2024 in the Medan Deli sub-district area. Next, spatial analysis is carried out using Arc GIS software and tabular data will be obtained in the form of land use data from 1980 to 2024, as well as the area of land use change/change in the Medan Deli sub-district area. The land use conversion conversion map for 1980 - 2024 was produced through an overlay process between land use satellite image maps starting from 1980 to 2024. For the road network system analysis, the road network system map data for both 1980 and 2024 was carried out by digitizing the map.

d. Determination of Research Variables

By following the procedures for carrying out observations in the field, researchers can collect accurate and valid data about the influence of industrial areas on the development of land use and road network systems in the Medan Deli sub-district. This is reinforced by spatial data analysis of changes in land use and road network systems that occurred in Medan Deli sub-district, both before the existence of the Medan industrial area and after.

The variables used in this research are expected to provide comprehensive insight into how industrial areas influence the development of land use and road network systems in Medan Deli District, as well as provide useful information for planning and managing the spatial layout of the area.Determination of variables in this research was carried out through a comprehensive approach, combining qualitative and

quantitative data to ensure that all relevant variables were properly identified. This research uses the following variables.

Table 1. Research Variables

Variable	Data Required	Data Collection Technique
Population	Population number in Medan Deli district Population density in Medan Deli district	Secondary Data from Medan City Statistics Bureau
Residential Area	Development of Built-up Areas Development of residential activities around industrial areas	Satellite Imagery Analysis, Observation, Medan City Spatial Plan, Medan City Detailed Spatial Plan
Connectivity	Development of road network length Access connection between industrial areas and surrounding areas, and access to other infrastructure areas	Satellite Imagery Analysis, Observation, Medan City Spatial Plan, Medan City Detailed Spatial Plan

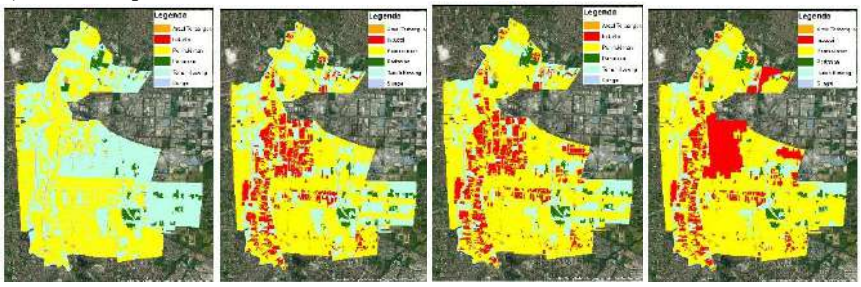
III. RESULTS AND DISCUSSION

Industrial areas are areas dedicated to production and manufacturing activities. The establishment of industrial areas is often designed to improve a region's economy through job creation and increased economic output. However, the development of industrial areas also has a significant impact on land use and the surrounding road network system. In general, the results of this research show how changes in land use and road network systems occur as a result of the existence of industrial areas.

a. Conversion of Agricultural Land: One of the main impacts of the development of industrial areas is the conversion of agricultural land to industrial land. Land previously used for agricultural, plantation or livestock activities is often diverted to build factories, warehouses and other industrial facilities (Williams, J., 2021).. This can reduce the available area of productive agricultural land.
b. Spatial Planning Changes: The development of industrial areas also affects the spatial planning of surrounding cities and villages. Land previously used for residential or green open space may be converted into commercial or office areas to support industrial activities. In addition, supporting infrastructure such as roads, railways and other transportation facilities were built to connect industrial areas with markets and distribution centers (Fig. 1)
c. Increase in Settlements Around Industrial Areas: The establishment of industrial areas often attracts migration of workers from various regions, which in turn triggers the development of new settlements around these areas. These new settlements require land that was previously used for other uses such as agriculture
d. Road Infrastructure Development by improving road surfaces, widening roads, and building new roads and improving special access roads for heavy vehicles or industrial toll roads are often carried out to reduce the impact of traffic on public roads and increase logistics efficiency (Fig. 2)

This establishment and growth of industrial areas bring about notable transformations in both land use and the road network systems of surroundings regions. This section delves into the specific impacts that industrial areas have on these two crucial aspects of urban development:

1) The impact of industrial areas on land use.

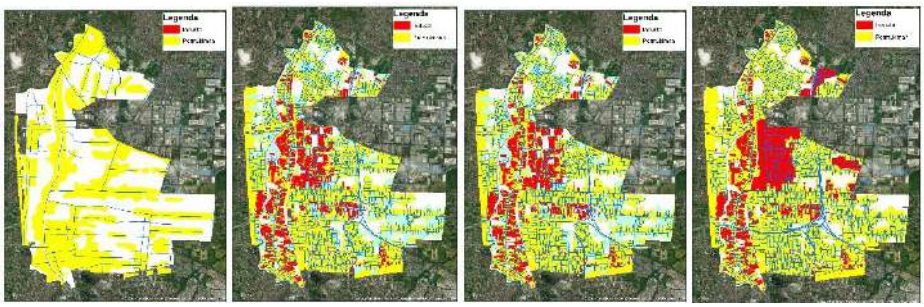


1980 2000 2010 2024

Fig 1. Land Use changes

- In 1980: The image map shows that the location of Medan Deli sub-district is still dominated by settlements, agriculture and empty land
- In 2000: This year the Medan Industrial Area has been built and developed since 1988, most of which is in the Medan Deli sub-district. The increasing development of industrial areas and residential areas has an impact on reducing the area of agricultural land and increasing the area of built-up areas.
- In 2010: In this period, industrial areas increased and encouraged the growth of residential areas including housing, educational facilities, health facilities, trade and others around industrial areas.
- In 2024: This year, residential area activities will increase and agricultural space allocation will become smaller. This is also in line with the promotion of the Medan Deli sub-district as one of the growth centers of Medan City, especially in the northern part of Medan City

2) The impact of industrial areas on road network system.



1980 2000 2010 2024

Fig. 2. Road network system

- In 1980: The main roads in Medan Deli sub-district in the 1980s were still limited in number and most of them connected residential areas with agricultural/plantation areas at that time
- In 2000: After the development of the Medan Industrial Zone in 1988, the condition of the road network system has developed so rapidly. This development is driven by the intensity of industrial and residential activities for industrial workers and communities around industrial areas which creates corridors for the movement of people and goods between industrial areas and surrounding areas. To strengthen connectivity access to industrial areas, the Belawan to Tanjung Morawa toll road has been built, which connects the Medan industrial area with warehouses and other industrial areas in the North Sumatra region.
- In 2010: During this period, several more well-organized residential areas began to grow in several sub-districts and had good connectivity to industrial areas. Access to industrial areas is starting to cause problems because the capacity and quality of access roads between industrial areas and surrounding areas is inadequate.
- In 2024: This year, regional connectivity will be even higher, with the Sumatra toll road corridor connected to the toll road network in industrial areas. Access to housing/settlement facilities is also increasing, especially strengthening the carrying capacity of roads for industrial activities and area intensity.

IV. CONCLUSION

The establishment of industrial area development in Medan Deli district has had several impacts. This study indicates that the development of industrial areas in Medan Deli District has led to significant changes in land use. Agricultural land that previously dominated the area has been converted into industrial and commercial land. Additionally, there has been an increase in the amount of land used for housing to accommodate industrial workers. The study shows that one of the most significant changes in land use in Medan Deli District is the conversion of agricultural land into industrial land. Areas previously used for agriculture are now used for the construction of factories, warehouses, and other industrial facilities(Verburg, Neumann& Nol, 2011). This is due to the increased demand for land for industrial purposes in line with the development of industrial areas in the region(Chen, Gao& Chen, 2016). Besides the conversion of agricultural land, previously vacant or residential land has also been transformed into commercial areas(Lambin, &Meyfroidt, 2011)..

Besides that, the growth of industrial areas requires adequate infrastructure support, especially in the road network system. This study found an increase in the construction of new roads as well as the improvement and expansion of existing roads to accommodate the increased traffic volume. However, this has also caused traffic congestion in several areas, which requires further handling. The study shows that the development of industrial areas in Medan Deli District has led to a significant increase in traffic volume. Intensive industrial activities necessitate more frequent and large-scale transportation of goods for both production and distribution purposes

(Gerling, H., & Stead, D., 2003). Additionally, the increase in the number of workers commuting to the industrial area daily also contributes to the increased traffic volume.

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