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Analysis of the Role of Infrastructure and Transportation in the Development of Batam City

Pramono Adi[1], Yuanita FD Sidabutar[1], Herlina Suciati[2]

[1]Master of Regional Planning Study Program, Batam University, Indonesia
[2]Civil Study Programs, Batam University, Batam City, Indonesia
Email: 102623002@univbatam.ac.id

Abstract. *Batam City is a city known as the gateway to free trade in Indonesia, continuing to improve itself from time to time. A number of strategic infrastructure projects were then worked on to encourage economic growth, and increase Batam's competitiveness with regions in Indonesia and other countries such as Malaysia and Singapore. Historically, various supporting infrastructures have been built since this area was developed as an industrial area. Starting from highways, ports, to airports that were deliberately built to attract investment. However, the massive development of Batam now also demands development according to the times. The results of this study are used to analyze how infrastructure and transportation can contribute to the development of Batam City from an economic, social, and environmental perspective. With a qualitative approach and SWOT analysis, this study evaluates the influence of government policies, private investment, and the influence of infrastructure development on the competitiveness of Batam City. The results of the study show that investment in road, port, and airport infrastructure has increased connectivity that can drive the city's economic growth globally. The sustainable and competitive growth of Batam City requires a more targeted strategy in the development of infrastructure and transportation. The use of data-based technology such as GIS can help in more accurate planning, while the integration of public transportation systems will increase efficiency and comfort for the community.*

Keywords: *Infrastructure, Transportation, Urban Development, Batam, Regional Planning*

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INTRODUCTION

The development of Batam City as an industrial and investment center in Indonesia is inseparable from the dynamics of economic policies, starting from the implementation of *Free Trade Zone* (FTZ) status to its transformation into a Special Economic Zone (KEK). With its strategic geographical conditions on the border of Indonesia and Singapore, Batam has great potential in supporting national economic growth. The advantages of this location have attracted investment in the manufacturing, logistics, and services sectors, which have driven rapid urbanization and expansion of industrial areas.

However, this rapid development also presents complex challenges, especially in the management of infrastructure and transportation systems (Zaenudin & Riyan, 2024). Due to the limited capacity of road infrastructure, and public transportation that is not yet optimal, as well as the less integrated regional development pattern, it results in an imbalance between economic growth and environmental carrying capacity. Traffic congestion, increased carbon emissions, and pressure on ecosystems are impacts that need attention in sustainable city planning (Zhang et al., 2020). In addition, the growth of residential areas as a consequence of the increasing number of residents and migrant workers requires a more comprehensive planning approach.

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The gap between the economic center and settlements in the suburbs also contributes to the increasingly obvious socio-economic inequality (br et al., 2023). Therefore, an in-depth analysis is needed on how infrastructure and transportation can support the sustainable development of Batam City, as well as how regional planning policies can accommodate economic growth without sacrificing social and ecological balance. This study aims to examine the contribution of infrastructure and transportation to the development of Batam City by highlighting the challenges faced and alternative solutions that can be implemented to realize more sustainable urban development.

Literature Review

Expert Theory

Rapid urban growth demands systematic spatial planning to accommodate infrastructure and transportation needs without causing negative impacts such as congestion and environmental degradation (Blanco et al., 2009). According to Putri (2024), expert Theory An effective transportation system plays a role in improving logistics efficiency, reducing congestion, and supporting regional economic growth. According to the urban transportation theory by Wihasti & Praono (2025), a good transportation system must consider aspects of accessibility, affordability, and sustainability. Expert Theory Urban infrastructure includes various physical elements that support community activities, including roads, bridges, ports, and public utilities such as clean water and electricity (Agustin & Hariyani, 2023). According to the infrastructure development theory proposed by Sapthu (2023), investment in public infrastructure has a positive impact on economic growth by increasing the productivity of the industrial and service sectors.

Government Policy

The Indonesian government has implemented a spatial planning policy through Law Number 26 of 2007 concerning Spatial Planning, which emphasizes the importance of integration between infrastructure and transportation development (Fajarida, 2024). Government Policy In Indonesia, transportation development is regulated in the National Transportation Master Plan (RITN) which aims to create an integrated and sustainable transportation system to increase regional competitiveness. Government Policy The Indonesian Government through Law Number 38 of 2004 concerning Roads emphasizes that road infrastructure is an important part of the national transportation system to support population mobility and distribution of goods.

Previous Case Study

Latue et al. (2023) shows that the development of road infrastructure in big cities in Indonesia contributes to increasing economic accessibility, but also raises challenges in terms of environmental sustainability. Kadarisman et al. (2016) found that an integrated transportation system can reduce travel time by up to 30% in big cities. Sofaniadi et al. (2022) shows that spatial planning that is not integrated with the transportation system can increase congestion levels by up to 40%.

METHODS

Descriptive-Qualitative Approach

This study uses a descriptive-qualitative approach with the aim of deeply understanding the role of infrastructure and transportation in the development of Batam City. This approach was chosen because it allows a more comprehensive exploration of the dynamics of development occurring in the city. The data used in this study come from primary and secondary sources, including government reports, academic studies, statistical data, and relevant previous research. Data analysis was carried out using a qualitative approach to explore various aspects that influence the effectiveness of infrastructure and transportation development in Batam City.

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Type of Research

This study uses a case study method, which allows for in-depth exploration of the specific conditions of Batam City. This approach aims to provide a more holistic understanding of the relationship between infrastructure, transportation, and their impacts on the city's economic and social development. Thus, this study is expected to provide insights that can be used as a basis for formulating more effective and sustainable development policies.

Research Location

This research was conducted in Batam City, Riau Islands Province. This city was chosen because it has significant infrastructure development dynamics but also faces various challenges, including social and environmental impacts due to its rapid development. Batam is one of the cities with a high economic growth rate, but also faces problems of development inequality that need to be analyzed in depth.

Data Collection

The data used in this study consists of primary and secondary data: (1) Secondary Data: This data includes statistics from related agencies such as the Central Bureau of Statistics (BPS), the Department of Transportation, and relevant city planning documents. In addition, this study also uses literature studies from academics and previous research to strengthen the analysis; (2) Primary Data: Primary data was collected through in-depth interviews with stakeholders, including local governments, developers, and the community. In addition, direct observation was conducted to understand the condition of infrastructure and transportation in Batam City more realistically. Field documentation was also used as additional material in the analysis.

Data Analysis

The data obtained will be analyzed using content analysis and thematic analysis methods. This approach allows the identification of patterns and themes that emerge from the data that has been collected. Furthermore, the results of the analysis will be arranged in a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis framework to identify internal and external factors that influence the development of infrastructure and transportation in Batam City. This analysis will provide an overview of the strengths and weaknesses in the infrastructure system as well as the opportunities and threats that can affect future city development.

Expected Results

This research is expected to produce several main findings, including: (1) Comprehensive Analysis: A deeper understanding of the role of infrastructure and transportation in the development of Batam City, including its impact on the economic, social and environmental sectors; (2) Identification of Determining Factors: Revealing various factors that influence the effectiveness of infrastructure and transportation development, both in terms of policy, investment, and community response; (3) Policy Recommendations: Develop policy recommendations that can support more effective and sustainable infrastructure and transportation development, based on the results of the SWOT analysis. Thus, this research is expected to contribute to the development planning of Batam City, especially in optimizing the role of infrastructure and transportation to support inclusive and sustainable growth.

RESULTS AND DISCUSSION

Development of Infrastructure and Transportation in Batam

Based on data analysis, infrastructure in Batam city has experienced extraordinary growth, especially in the construction and procurement of roads, ports, and other transportation facilities. Batam city continues to develop as a center of industrial and trade activities, so that the need for adequate infrastructure is increasing. The increase in investment in this sector can be seen from strategic projects carried out by the government and private sector, such as widening the main road into five lanes, building flyovers in several places, also changing intersections with

park roundabouts without using traffic lights and modernizing Batu Ampar Port as one of the largest logistics centers in the region. However, there is still an imbalance in the distribution of infrastructure between the city center and the suburbs in particular.

With areas in the economic center, such as Batam Center, Nagoya, and Batu Ampar, tending to have better transportation access compared to suburbs such as Rempang, Galang, or some parts of Belakang Padang District that still cross the sea by boat. This causes a disparity in accessibility and economic growth opportunities for people living in the suburbs (Farida & Andalas, 2019). This imbalance also results in increased urbanization in the city center, which ultimately has an impact on congestion and pressure on public facilities. From a transportation perspective, Batam has a fairly extensive road system with a main network connecting industrial areas, ports, and economic centers. However, rapid economic growth has resulted in the number of private vehicles that are not balanced with the development of public transportation, which has resulted in congestion on several main roads, especially during peak hours (St & Said, 2021). Several locations that often experience high levels of traffic congestion include Jalan Yos Sudarso, Jalan Sudirman, and the Muka Kuning industrial area. Align with research from Mary et al. (2017), to realize this problem, the government has tried to develop mass transportation projects, but until now effective facts are still a challenge.

In addition to highways, the port and airport sectors also play a crucial role in supporting Batam's economic growth. Batu Ampar Port is the main logistics port in the city, this port has undergone modernization with increased loading and unloading capacity and adequate logistics facilities. According to Soegiri (2008), this port is the center of export-import activities, especially for the manufacturing and electronics industries that are export-oriented. However, when compared to ports in Singapore and Johor, the operational efficiency of Batu Ampar Port still needs to be improved in order to compete at the regional level. In terms of air transportation, Hang Nadim International Airport is the main gateway for tourists and business people coming to Batam. This airport has the longest runway compared to other airports in Indonesia, so it has the potential to be developed into an air cargo center. However, until now additional investment is still needed to improve and expand terminal facilities, passenger services, and connectivity with other modes of transportation such as airport buses and taxis.

Although there has been progress in infrastructure and transportation development in Batam, there are still several issues that need to be considered. Align with research from Umam & Nafiah (2024), one of the main challenges is infrastructure planning that has not been fully integrated into various sectors. For example, every new road construction is not always accompanied by adequate drainage system improvements (Lubis et al., 2023). In addition, there is no well-organized public transportation system so that people's mobility is still very dependent on private vehicles or online transportation. Considering these conditions, a more planned and sustainable development strategy is needed so that infrastructure and transportation in Batam can support the city's growth efficiently and optimally. The integration of each road system, public transportation, and logistics facilities must be strengthened so that Batam can compete as an efficient and environmentally friendly economic center.

Impact of Infrastructure on City Development

Economic Impact

The escalation of infrastructure and transportation in Batam City has a special impact on the economic sector. With a better road network, facilities to industrial areas, ports, and trade centers become more organized. This affects the efficiency of shipping goods and raw materials, which ultimately can raise the competitiveness of industry in Batam. As one of the cities that is directed at export activities, adequate transportation infrastructure may mean that manufactured products produced in Batam will be sent faster to international markets, especially to Singapore and Malaysia. In addition, infrastructure escalation can also attract more investment, both from within and outside the country. Investors are more inclined to locations with good accessibility and cheap logistics costs.

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The modernization projects of Batu Ampar Port and the development of the Hang Nadim Airport area are important variables in attracting the interest of multinational companies to operate in Batam. It is hoped that with the increase in investment, the availability of jobs will also increase, so that local people get more opportunities to work in the industrial, trade and service sectors. Although infrastructure has experienced rapid development, there are still challenges in the distribution of economic development that need attention. Several areas in Batam are still lagging behind in terms of basic infrastructure such as decent roads and public transportation networks. This causes an economic gap between the city center and the outskirts. If not addressed immediately, this condition can hamper inclusive and sustainable economic growth (Nasution, 2016).

Social Impact

From a social perspective, good infrastructure and transportation development will increase population mobility and provide more access to economic opportunities for the community. With better road facilities, people can more easily move around to work, go to school, or access health services. The provision of new roads and improvements to transportation networks will help connect previously isolated areas, to improve social interaction and access to public services. In addition, the existence of more appropriate transportation can also support the growth of the informal sector, such as small and medium enterprises (SMEs). Traders and informal sector workers can access a wider market, both in selling products and obtaining raw materials at more competitive prices (Sari & Nurhuda, 2023).

Thus, adequate infrastructure and transportation can play a role in improving the welfare of society as a whole. Meanwhile, infrastructure growth can result in social challenges, especially in terms of urbanization and pressure on public facilities. Batam City has experienced a significant increase in population due to migration from various regions in Indonesia. This has resulted in a rapid increase in demand for housing and social services. If this problem is not balanced with good planning, rapid growth can cause problems such as slums, congestion, and pressure on health and education facilities (Musida, 2024). Therefore, infrastructure development must be accompanied by a strategy that ensures inclusiveness and equal access for the entire community.

Environmental Impact

Although infrastructure and transportation can bring economic and social benefits, uncontrolled development can have negative impacts on the environment. One of the main impacts is deforestation due to the expansion of road networks and industrial areas. This has the potential to disrupt natural ecosystems and increase the risk of disasters such as floods and landslides. In addition, because the increase in the number of motor vehicles is a result of the lack of public transportation, motor vehicles contribute quite high exhaust emissions, and contribute to air pollution. Batam City, which has been known as a relatively green industrial area, is experiencing problems with deteriorating air quality, especially in locations with high industrial activity. If not handled properly immediately, this condition will have an impact on public health and reduce the quality of life of residents.

Infrastructure and transportation development also affect water and land pollution, especially industrial waste that is not managed properly. Several areas in Batam face the risk of waste from industrial and port activities that can pollute the surrounding waters. This not only poses a risk to the marine ecosystem, but also threatens fishery resources and the livelihoods of communities that depend on the marine sector. To reduce these negative risks, an environmentally conscious development policy is needed. The implementation of sustainable city concepts, such as the development of environmentally friendly energy-based transportation and stricter industrial waste management, must be a priority in Batam city's future infrastructure planning. In addition, environmental conservation and urban greening efforts need to be carried out to maintain a balance between development and environmental sustainability.

Challenges in Infrastructure and Transportation Development

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Although the development of infrastructure and transportation in Batam City has provided positive aspects to the economy and population mobility, there are still various difficulties that must be faced. Some of the main challenges in the development of this zone include the lack of communication between the central and regional governments, the imbalance between development and environmental carrying capacity, and the lack of investment in efficient public transportation. If not managed properly, these difficulties can hinder the growth of Batam as a sustainable industrial and trading city.

Lack of Coordination between Central and Regional Governments

One of the main problems in infrastructure development in Batam city is the less than optimal communication relationship between the central government, local government, and the special economic zone (KEK) management authority. Batam City has a unique status as an industrial area managed by the Batam Business Agency (BP), while the Batam City Government also has the authority to regulate regional planning. This dualism of authority often causes overlapping policies, especially in the planning and implementation of infrastructure projects. This coordination obstacle also has an impact on the disconnection between the regional spatial plan (RTRW) and transportation development. In some cases, the development of industrial areas is carried out without considering the ability of the road as an adequate means of public transportation, resulting in traffic congestion in certain areas. To overcome this impact, more effective communication techniques are needed between the central government, regional governments, and BP Batam so that infrastructure development policies will run in harmony and support optimal city growth.

Imbalance between Development and Environmental Carrying Capacity

The next challenge in Batam's infrastructure development is the imbalance between development and environmental carrying capacity. As a city experiencing rapid growth, many forest areas and green areas are transformed into residential areas, industries, and transportation infrastructure. These land changes are often carried out without considering sustainability aspects, resulting in negative impacts on the environment. One of the most obvious impacts is the increased risk of flooding due to the loss of water catchment areas. In some areas, road and housing construction is carried out by blocking river flows or filling in water catchment areas. As a result, when the rainy season arrives, several areas such as Batu Aji, Sagulung, and Batam Center often experience waterlogging that disrupts community activities. In addition to flooding, air pollution is also a concern, especially due to the increasing number of motorized vehicles operating in Batam.

The lack of a mass transportation system makes most residents rely on private vehicles, which ultimately contributes to increased carbon emissions (Kennedy, 2002). If not controlled immediately, air quality in Batam could worsen, which risks disrupting public health and reducing the city's attractiveness as an investment and tourism destination. To address this imbalance, a sustainable development approach is being pursued. Therefore, the Government needs to establish stricter spatial planning policies that take into account environmental carrying capacity. In addition, infrastructure projects must be accompanied by a comprehensive environmental study to minimize negative impacts on the ecosystem. The development of green open spaces (RTH) must also be a priority so that the balance between development and environmental conservation can be maintained.

Lack of Investment in Efficient Public Transport

Another major problem in the development of infrastructure and transportation in Batam city is the lack of investment in an appropriate public transportation system. Until now, the existence of public transportation in Batam is still dominated by city transportation (angkot) with a limited number and not yet fully connected to all economic and industrial centers. As a result, many people prefer private vehicle transportation, which ultimately results in congestion on several main roads. The lack of adequate public transportation also has an impact on the

accessibility of workers to industrial areas. Many workers have to be willing to spend higher transportation costs due to the absence of an appropriate mass transportation system. so that this condition can affect Batam's competitiveness as an industrial area, because excessive transportation costs will be an additional burden for workers and companies.

In addition, sea transportation as the main mode of inter-island connections around Batam also still faces various obstacles. In several domestic passenger ports in Batam do not yet have adequate facilities, so that inter-island travel is often uncomfortable and inefficient. In fact, as an island city, Batam needs a reliable sea transportation system to support community mobility and distribution of goods. To overcome this obstacle, the government needs to invite more investors in the public transportation sector, either through funding from the APBN/APBD or through cooperation schemes with the private sector. In the development of the bus rapid transit (BRT) system, or the integration of application-based public transportation, and the modernization of passenger ports can be a solution to increase transportation efficiency in Batam. With the existence of an appropriate public transportation system, it is hoped that people's dependence on private vehicles can be reduced, so that congestion and air pollution can be minimized.

Strategic Recommendations

To improve infrastructure and transportation in Batam City to develop optimally and sustainably, a more systematic and data-based planning strategy is being attempted. Several methods that can be applied include improving transportation infrastructure based on information technology, connectivity of public transportation systems, and also the application of sustainable development principles in city planning. By implementing these recommendations, Batam can increase its competitiveness as a modern and environmentally friendly industrial and trade city.

Data-Based Transportation Infrastructure Improvement

One of the main obstacles in the development of infrastructure and transportation is the absence of data-based planning and comprehensive spatial analysis. Therefore, the use of Geographic Information System (GIS) technology is the right step to improve accuracy in transportation planning (Silitonga & Lubis, 2024). By utilizing GIS, the government can map population movement patterns, identify congestion lanes, and analyze infrastructure needs in various regions accurately. In addition, the use of big data from transportation systems, traffic sensors, and navigation applications can help governments plan more responsive transportation policies. For example, by analyzing traffic data in a timely manner, governments can accurately determine locations for the construction of new roads, flyovers, or pedestrian bridges, thereby reducing traffic congestion. The implementation of technology-based traffic management systems can also be used to improve vehicle flow at intersections that are often congested (Firmansyah et al., 2025). At other times, the application of the smart mobility concept can also help develop more effective transportation infrastructure. With digital applications, people can get information about the fastest trips, public transportation schedules, and traffic conditions in a timely manner. This not only increases the comfort of transportation users, but can also reduce traffic congestion by directing vehicles to smoother routes.

Public Transport Integration

Currently, the use of public transportation systems in Batam is still not well organized and has not been able to become the main choice for the community. Therefore, consolidation is needed between various modes of public transportation so that population mobility is more efficient and affordable. One way that can be taken is the development of a bus rapid transit (BRT) system as the main mode of transportation that connects industrial areas, settlements, and business centers in Batam. Furthermore, sea transportation as one of Batam's distinctive identities must also be improved and consolidated with land transportation modes. Passenger

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ports need to be improved in quality, both in terms of infrastructure and management systems, so that inter-island travel becomes more comfortable and efficient.

The purchase of electronic tickets integrated between modes, buses, public transportation, and ferries can be an option to make it easier for people to use public transportation without having to rely on private vehicles. In order to support the development of better public transportation, the government needs to support incentives for investors and transportation operators. The public-private partnership (PPP) scheme can be used to attract investment in terminal development, by increasing the procurement of modern transportation fleets, and establishing a more concise digital payment system. With affordable and easy public transportation, it is hoped that people will be more inclined to switch from private vehicles to public transportation, thereby reducing congestion and carbon emissions.

Sustainable Urban Planning

Infrastructure and transportation development in Batam city must be carried out by considering the principle of sustainable development so as not to damage the environmental carrying capacity. One approach that can be determined is transit-oriented development (TOD), which is a city development concept that is oriented towards public transportation. By implementing TOD, residential areas and business centers are designed to be connected to public transportation stations, thereby reducing dependence on private vehicles. Furthermore, spatial planning policies must also pay attention to the balance between development and environmental preservation (Kusriyah & Witasari, 2024). The government is required to establish protected green zones and supervise the expansion of industrial areas so as not to damage the natural ecosystem. Revitalization of green open spaces (RTH) must also be part of the city's development strategy, so that Batam continues to have a comfortable and healthy environment for its residents. In terms of energy, transportation infrastructure needs to adopt environmentally friendly technology. The government must encourage the use of electric vehicles and renewable energy in the public transportation system. Procurement of electric buses and incentives for transportation entrepreneurs who use clean energy-based fleets can be the first step in creating a more sustainable transportation system.

CONCLUSION

Overall, infrastructure and transportation play a very important role in the development of Batam City. From an economic perspective, improving transportation infrastructure has accelerated the flow of trade and investment, thus increasing the city's competitiveness at the national and international levels. From a social perspective, better accessibility has opened up more opportunities for people to get jobs and public services. However, uncontrolled development can have negative impacts on the environment, including deforestation, air pollution, and degradation of aquatic ecosystems. Therefore, infrastructure development must be carried out in a balanced manner, taking into account economic, social, and environmental aspects so that Batam City can develop sustainably in the future.

Infrastructure and transportation development in Batam faces various complex challenges, ranging from the lack of coordination between the central and regional governments, the imbalance between development and environmental carrying capacity, to the lack of investment in efficient public transportation. If these challenges are not immediately addressed, the growth of Batam City could be hampered and potentially cause various social, economic, and environmental problems in the future. Therefore, a more integrated and sustainable planning strategy is needed so that infrastructure development can run optimally, support economic growth, and maintain ecological balance in Batam City.

To ensure sustainable and competitive growth of Batam City, a more targeted strategy is needed in the development of infrastructure and transportation. The use of data-based technology such as GIS can help in more accurate planning, while the integration of public transportation systems will increase efficiency and convenience for the community. In addition,

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the application of sustainable development principles in spatial planning policies will ensure that city growth remains balanced with environmental carrying capacity. With these steps, Batam can continue to develop as a modern, efficient, and environmentally friendly industrial and trade city.

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