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AEK KANOPAN OUTER URBAN RING ROAD PLAN IN THE CONTEXT OF CONTROLLING THE VOLUME AND CAPACITY OF ROADS IN THE DISTRICT NORTH LABUHANBATU

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ABSTRACT

This study aims to analyze the influence of the development of the Aek Kanopan Outer Ring Road on traffic volume control on the main section of the city as well as the potential for regional development and economic activities around it. The research approach uses a qualitative case study method, with data collection through in-depth *interviews*, Focus Group Discussions (FGDs), field observations, and analysis of planning documents. The results of the study show that the main section of the city is currently experiencing moderate to high density (LOS C–D), so it requires current diversion intervention. The Outer Ring Road has significant potential as an alternative route for transit vehicles and heavy vehicles, which can reduce traffic load on the main section. In addition, increased accessibility along the track encourages the development of directional areas: the eastern region has potential as an industrial and warehousing region, while the western corridor has the potential to be a residential and local trade hub. Ring road optimization requires an integrated strategy including technical design, route arrangement, spatial integration, supporting facilities, and continuous monitoring. This study provides recommendations for local governments in planning and managing the Aek Kanopan Outer Ring Road as a traffic control solution as well as a driver of sustainable regional growth.

Introduction

The growth of socio-economic activities in North Labuhanbatu Regency, especially in the Aek Kanopan area as the center of government and trade, has further encouraged an increase in community mobility and the flow of goods distribution. This condition causes the volume of traffic on the main roads in the city to continue to increase from year to year. Existing roads that function as primary corridors are no longer able to accommodate high traffic loads, causing various problems such as congestion, travel delays, conflicts between

vehicles, and a decrease in the level of comfort and safety of road users. On the other hand, the growth of motor vehicles is not proportional to the increase in adequate road capacity, so the volume to capacity ratio (V/C ratio) on some urban roads has reached or even exceeded the ideal service threshold.

If this condition is left unchecked, the impact will not only be felt by road users, but also on the economic efficiency of the region. The travel time of logistics distribution has become longer, vehicle operating costs have increased, and environmental quality has decreased due to air pollution and noise in densely populated areas. In addition, the existence of heavy vehicles such as freight trucks that still pass through the city center also worsens the quality of the road network and increases the risk of accidents. Seeing the complexity of these problems, a strategic solution is needed in the form of providing alternative routes that are able to divert the flow of vehicles, especially long-distance vehicles and heavy transportation, so that they are no longer focused on main roads in the city. The construction of the Aek Kanopan Outer Urban Ring Road is one of the important efforts in order to control the volume and increase the capacity of the overall road network.

The presence of the outer ring road is expected to not only be able to reduce the traffic burden in the city center, but also facilitate connectivity between regions, support the development of potential areas around it, and create a more efficient, safe, and sustainable transportation system, the study of the development of the Aek Kanopan Outer Urban Ring Road is important to be analyzed comprehensively, both from the aspect of its functional needs for controlling traffic volume as well as its contribution to improving the performance of the road network in North Labuhanbatu Regency. Traffic conditions on main roads in Aek Kanopan City show that the load of vehicles is getting closer to the maximum capacity of road services. This is reflected in the high volume of average daily traffic that crosses the urban road network, especially on sections that have a strategic role as a link for local activities as well as regional movement routes. Increased population mobility, distribution of goods, and economic activities centered in urban areas cause traffic pressure to continue to increase from year to year.

The Sumatra Cross Road section that crosses the center of Aek Kanopan City is the main corridor of inter-regional transportation and bears the highest traffic load compared to other sections. The volume of daily vehicles passing through this section has reached a very high level, so that the ratio between the volume and the capacity of the road is close to saturation. The level of road service is in the congested category, which is characterized by limited vehicle movement, low speed, and fairly high delays. In conditions like this, the existence of small disturbances such as side obstacles, vehicles stops, or a sudden increase in traffic flow has the potential to directly trigger congestion. Traffic pressure also occurs on the sections of Jalan Aek Kanopan Bandar Manis and Jalan Angkatan 66/Nusa Indah which function as the main roads in serving the movement of urban activities. In both sections, the traffic volume is relatively high compared to the available road capacity, so the service level is in the crowded to congested category. The vehicle can still move relatively stably, but the maneuvering space is limited and the interaction between vehicles is getting more intense. This condition indicates that these sections are in a transition phase to saturation, especially if there is no flow control or increased road network capacity.

Meanwhile, Jalan Ghazali shows slightly better traffic conditions than other main sections, but remains at a crowded service level. The fairly high saturation value indicates that this section also has the potential to experience a decrease in traffic performance in the

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future, especially if there is an increase in the number of vehicles and an increase in activity in the surrounding area. Overall, this condition illustrates that almost all main roads in Aek Kanopan City have been at a high level of utilization and close to the optimal limit of service. Traffic problems in Aek Kanopan are further exacerbated by the still mixed flow of local vehicles with cross-city vehicles and heavy vehicles. Goods vehicles and long-distance vehicles that do not have a destination to the city center still have to cross the urban road network, thereby increasing the traffic burden and accelerating the occurrence of road saturation. The impact of these conditions is not only in the form of congestion that is increasingly frequent, but also in increased travel time, vehicle operational costs, potential traffic accidents, and decreased comfort and quality of the urban environment.

In this context, the development of the Aek Kanopan Outer Urban Ring Road is very relevant and urgent as an effort to control traffic volume and improve road network performance. The ring road is planned to serve as an alternative route to divert non-local vehicles, especially freight and long-distance vehicles, so that they no longer cross the city center. With the reduction of traffic load on major roads in the city, it is hoped that the volume to capacity ratio can be lowered to a better level of service, so that urban mobility becomes smoother, safer, and more efficient. In addition to providing benefits from the transportation side, the construction of the Aek Kanopan Outer Urban Ring Road also has a strategic impact on the development of the surrounding area. The ring road corridor to the east bordering the oil palm plantation area has great potential to be developed as a small industrial area, warehousing, and logistics distribution center. The existence of direct access through the ring road allows the mobility of transportation of plantation products and industrial products to take place more efficiently without having to pass through the city center area, thereby reducing distribution costs and accelerating the flow of goods. On the other hand, the ring road corridor in the west direction leading to new residential areas has the potential to encourage the development of local residential and commercial areas. Adequate road infrastructure will increase the accessibility of the area, spark the growth of micro, small and medium enterprises, and establish new economic centers outside the city core. Thus, the construction of the Aek Kanopan Outer Urban Ring Road not only functions as a technical solution for traffic control, but also as an instrument for regional development and equitable distribution of sustainable development.

Meanwhile, in the western corridor leading to new residential areas, the existence of a ring road has the potential to encourage the growth of local trade areas and the development of MSMEs (Micro, Small, and Medium Enterprises). Better accessibility will attract the emergence of new economic activities such as modern stores, commodity markets, and culinary and service centers. As socio-economic activities develop along this corridor, the area has the potential to grow into a buffer area (sub-center) for the center of Aek Kanopan, so that the burden of activities is no longer concentrated in the city core. Thus, the ring road is not only a technical solution to control the volume and capacity of the road, but also a spatial planning instrument that encourages the development of the region more evenly. This research is important to examine not only the technical aspects of transportation, but also the spatial and economic impact of the development of the ring road, so that the results can be used as a consideration in the preparation of transportation policies as well as spatial planning in North Labuhanbatu Regency.

This research has high urgency considering that the condition of the road network in Aek Kanopan City is currently at an alarming level of traffic saturation. The increase in vehicle volume every year is not balanced by adequate road capacity, causing a decrease in the level of service (Level of Service) to category D (congested) on several main sections. If intervention is not taken immediately, congestion will become a latent problem that has an impact on decreasing community mobility, increasing logistics costs, and disrupting local economic activities. In addition to the transportation aspect, the urgency of this research also lies in the strategic potential of developing the area around the ring road track. The ring road is not only an infrastructure to support the movement of vehicles, but also an instrument for creating new growth centers outside the core area of the city. Without planning based on scientific studies, the economic opportunities from the construction of ring roads may not be optimal, or even cause new problems such as uncontrolled land-use changes.

Problem Identification

Based on the background that has been described, the problems that can be identified in this study are as follows:

1. There is a significant increase in the volume of vehicles on the main roads in Aek Kanopan City every year.
2. The existing road capacity is no longer able to accommodate the existing traffic load, so the V/C ratio value on some sections has approached saturation.
3. The level of road service (Level of Service / LOS), especially in the corridor of Jl. Lintas Sumatra, is already in category D (congested) which causes delays and congestion.
4. The flow of local vehicle traffic is still mixed with intercity vehicles and heavy vehicles, adding pressure to the road network in the city.
5. There is no alternative route that is able to divert non-local vehicles from the city center.
6. The potential of the area around the ring road plan has not been optimally utilized to support economic development.
7. There is no comprehensive study that connects the construction of the ring road with traffic control as well as regional development.

Problem Formulation

Based on the identification of these problems, the formulation of the problem in this study is formulated as follows:

1. What are the existing conditions of traffic volume, road capacity, and service level (LOS) on the main road sections in Aek Kanopan City?
2. To what extent does the construction of the Aek Kanopan Outer Ring Road have the potential to reduce traffic burden on the main roads in the city?
3. How does the development of the ring road affect the potential development of the surrounding area and economic activities?
4. What is the right strategy to optimize the function of the Outer Ring Road as a solution to control traffic volume as well as a driver of regional growth?
5. How is the construction plan of the Aek Kanopan Outer Urban Ring Road compatible with the Regional Spatial Plan (RTRW) of North Labuhanbatu Regency?

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6. How is the traffic performance modeling in the Aek Kanopan Outer Urban Ring Road plan based on the analysis of volume to capacity ratio (V/C ratio)?
7. What are the further impacts of the implementation of the Aek Kanopan Outer Urban Ring Road plan?

Literature Review

Concept of Road Capacity, Degree of Saturation (V/C) and Level of Service (LOS)

Road capacity is the maximum amount of traffic flow that can be served under certain conditions over a period of time. In road operational planning and evaluation practices, commonly used measures include capacity (C), volume-to-capacity ratio (V/C), as well as other performance measures such as travel speed and delay time. The Level of Service (LOS) classifies the operational quality of roads from A (very smooth) to F (saturated/non-functioning condition) and is the main indicator in assessing the extent to which the road network meets mobility needs. In the Indonesian context, the latest Indonesian Road Capacity Guidelines (PKJI) provide a procedure for calculating road operational capacity and performance which is a technical reference for V/C and LOS analysis in road planning projects.

Ring Roads/Bypasses: Functions, Current Diversion Mechanisms and Operational Effects

A ring road or bypass is designed to divert the flow of transit (long-distance vehicles, heavy vehicles) from the city core thereby lowering traffic that does not aim in the city center. The main functions are (1) reducing the volume of vehicles in the core section, (2) speeding up inter-regional travel without entering the city, and (3) improving safety in the central residential area. However, modern literature warns that the success of bypasses depends on design (bypass standards), network connectivity, traffic regulation policies, and road user behavior. Studies on bypass serviceability show that bypasses that are less than standard or that are not supported by traffic restriction policies in downtown often fail to fully divert targeted traffic. Technical and policy evaluations (e.g. restriction of trucks through the center, enforcement of routes) are therefore important to achieve operational objectives.

Generated Traffic/Induced Demand and Limitations on the Effectiveness of Capacity Expansion

Many empirical studies state that increasing the capacity of roads or building new roads can trigger induced demand — i.e., the occurrence of new trips, reroutes, or changes in mode choices so that traffic volumes rise again in the medium to long term. Recent meta-analyses and reviews emphasize that network capacity is not always an efficient solution to congestion if it is not accompanied by demand management policies (e.g. transportation operating timing, pricing, access control). Therefore, planning a ring road that only expands capacity without a demand management strategy risks declining long-term effectiveness.

Integration of Transport and Spatial Planning: Economic Impacts & Land Use Change

The construction of ring roads not only changes traffic performance but also affects land use patterns. The regional economic literature suggests that new interconnections (including ring roads/bypasses) can encourage the development of industrial estates, warehousing, new housing, and new economic centers within a given radius of road access. On the other hand, changes in accessibility have the potential to cause urban sprawl, conversion of farmland/plantations, and environmental pressures if not regulated by spatial policies. Therefore, local economic impact analysis and modeling of land use change need to be carried out to anticipate and maximize development benefits. Empirical studies in various countries and research on roads and surface quality in Indonesia show a significant relationship between road quality/access and local economic growth.

Road Safety and Operational Impact of Current Switching

Reduced heavy vehicle flow and transit on congested city roads are usually related to a decrease in accident rates (severity) and increased safety for vulnerable users (pedestrians, motorcyclists). However, changes in traffic patterns can also move the accident incident point to a new corridor if the safety design on the ring track is inadequate. Therefore, the design study must include safety analysis (road safety audit), speed regulation, and separation facilities for heavy vehicles.

Method

Research Approach

This study uses a qualitative approach with a case study strategy that focuses on one contextual case: the plan and development process of the Aek Kanopan Outer Urban Ring Road. The case study approach allows researchers to explore phenomena in depth in real-world contexts—including local policies, road user behavior, and spatial dynamics—and use a variety of data sources to generate a holistic picture. This approach is consistent with contemporary methodological practices that emphasize contextual understanding and the use of multi-sources of evidence in qualitative case studies.

Case Location and Limitations

The research location is the downtown area of Aek Kanopan and the potential corridor of the ring road (east to oil palm plantations and west to new settlements). The research was limited to: (a) studies on key stakeholders (local governments — Dishub, Bappeda, Satlantas; logistics business actors; representatives of residents/MSMEs in the corridor), (b) analysis of relevant planning documents, and (c) field observations at traffic critical points. These restrictions were chosen so that the analysis remained focused on the relationship between the development of the ring road, traffic volume control, and spatial-economic impacts.

Informant/Participant and Sampling Techniques

The selection of informants uses purposive sampling and snowball sampling to reach informants who have important roles/expertise in the phenomenon (e.g. planning officials, technical officers, transportation business owners, heads of RT/RW in corridors). Informant inclusion criteria include direct involvement in road planning/operations,

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experience interacting with traffic in Aek Kanopan, or representative roles of affected communities. The purposive approach is in accordance with modern qualitative data collection practices that emphasize the relevance and depth of information rather than statistical representativeness.

Data collection techniques

Data collection was carried out in combination (triangulation method) to increase the richness of the data and the robustness of the findings:

1. In-depth interviews — conducted with officials of the Transportation Department, Bappeda, Satlantas, transportation/logistics entrepreneurs, local entrepreneurs, and community leaders. Semi-structured interviews are designed to explore perceptions of the need for ring roads, implementation barriers, as well as estimated impacts on traffic and land use. Interview techniques and guidelines follow the latest qualitative interview practices.
2. Focus Group Discussions (FGD) — held for specific user groups (e.g., freight drivers, market traders, corridor residents) to capture group dynamics, consensus, and differences of opinion on route routes and policies.
3. Structured and unstructured field observations—observations at major intersections and vulnerable points to record vehicle flow patterns, vehicle types, road user behavior, and supporting infrastructure conditions. Field notes are used as primary qualitative data.
4. Document review — road planning documents, Regional Spatial Plans (RTRW), LHR data, accident records, and local news will be analyzed to complete and verify the informant's statement. The use of multiple sources of evidence is a hallmark of a strong case study.

Research Instruments

The main instruments of the study were semi-structured interview guidelines and observation sheet formats. The interview guidelines were compiled based on key variables (existing conditions of LHR & capacity, perception of the need for the ring road, projected economic/land use impacts, technical and policy barriers). All interviews were recorded (with the informant's permission) and recorded; The recording will be fully transcribed before being analyzed. In the transcription and analysis process, privacy policy procedures will be adhered to.

Reliability and Reliability Strategy

To ensure the trustworthiness of the research (credibility, transferability, dependability, confirmability), this study applies the following strategies:

1. Triangulation of sources and methods (interviews, FGDs, observations, documents) to verify findings.
2. Member checking: a summary of the initial findings is brought back to several key informants for interpretation validation.
3. Trail audit: documentation of research steps (recordings, transcripts, analytical memos, coding decisions) is stored as evidence of the analysis process.
4. Researcher reflexivity: researchers compile reflective journals to record assumptions, methodological decisions, and potential biases.
5. Thick description: a context-rich presentation of data so that readers can assess the transferability of findings to other contexts.

Results and Discussion

What are the existing conditions of traffic volume, road capacity, and service level (LOS) on the main road sections in Aek Kanopan City

The assessment of existing conditions is a very crucial first step to answer the formulation of the problem of how severe the traffic pressure is on the Aek Kanopan road network. Based on LHR (Average Daily Traffic) data, segment design capacity, and available V/C calculations, there are different pressure patterns between segments but they all lead to one conclusion: some of the main segments have approached or entered a state of operational saturation. The Jl. Lintas Sumatra section (City Center) shows the highest load with an LHR of around 21,500 vehicles/day and a V/C ratio of 0.89 (LOS D). This value indicates congested conditions — the maneuvering space is reduced and there is a decrease in operating speed so that travel delays increase. Since this is a regional corridor, the dominance of inter-city vehicles and trucks exacerbates the pressure on the road's function as a corridor of local services (access shops, public services). In the context of the study, this section is an evaluation priority because small changes in flow (e.g. truck diversion) will have a significant impact on the overall LOS.

The sections of Jl. Aek Kanopan Bandar Manis and Jl. Ghazali Kharim Pasar 3 have an LHR of 14,200 and 9,500 vehicles/day, respectively, with a V/C ratio of 0.71 and 0.74 (LOS C). This condition is still relatively better than Lintas Sumatra but shows a narrow "margin" of capacity: if the rate of vehicle growth continues or there is an accumulation of disturbances (parking on the road body, irregular intersections), these two sections can quickly shift to LOS D. This means that interventions that target peak load reduction (e.g. diversion of heavy transport routes) have the potential to keep LOS at a better level. The section of Jl. Angkatan 66/Nusa Indah (LHR 11,800, V/C 0.78, LOS C–D) describes the transitional conditions: not completely saturated but very sensitive to the increase in volume. This condition is often encountered in sections that have mixed functions (residential access + connecting traffic) so that conflicts between functions accelerate performance decline.

In terms of network aggregate, the proportion of heavy and cross-regional vehicles still entering city centres is a major factor in the increase in V/C. In addition, technical factors such as lane width, intersection conditions, the presence of parking on the road body, and the uncertainty of route enforcement (e.g. no truck restrictions) also exacerbate effective capacity in the field—i.e., theoretical capacity is often higher than the actual capacity that can be served in the midst of local traffic practices. The operational consequences of existing conditions are not only technical: low LOS and saturation increase travel time, vehicle operating costs, air pollution, and safety risks (accidents and traffic conflicts). For local economic sectors, these mobility disruptions have an impact on logistics and productivity—something that was one of the focuses of this study when evaluating the benefits of ring road construction.

In order to answer the formulation of the problem empirically, the research needs to carry out the following steps: (1) recalculation and verification of LHR through field observation (manual/automatic count) along with division by vehicle category; (2) measuring the effective capacity of segments and intersections (calculating effective lanes, peak hour factor, heavy vehicle factor); (3) calculation of V/C and LOS for peak hours and daily; and (4) spatial analysis of flows (origin-destinations) to determine the proportion of traffic that is transit/out-of-town destinations. This comprehensive data allows for before-

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after simulations (scenarios) to estimate the effect of switching to the ring road on V/C and LOS on each section. In terms of policy and planning, if field verification confirms a V/C > 0.8 on the core sections, then the need for intervention becomes urgent — both in the form of restricting routes (redirecting heavy vehicles), setting operating hours, improving intersection geometries, or building alternative infrastructure such as ring roads. However, all options must be evaluated based on quantitative scenarios that combine volume changes and potential induced demand for the proposed solution to be sustainable.

In conclusion, the existing conditions on the main sections of Aek Kanopan City show real operational pressures—with Jl. Lintas Sumatra already in LOS D which justifies the need for an in-depth study on the effectiveness of the Outer Ring Road as a strategy to control volume and increase the real capacity of the road network. This research must link technical findings (LHR, capacity, V/C, LOS) with economic-spatial impact analysis so that the resulting policy recommendations are technical-operational and at the same time strategic for regional development.

The extent to which the construction of the Aek Kanopan Outer Ring Road has the potential to reduce traffic burden on the main road in the city

The construction of the Aek Kanopan Outer Ring Road is planned as an alternative corridor that connects the east and west of the city, so that vehicles that do not have a direct destination to the city center can be diverted. With this concept, the ring road functions as a strategy to control traffic volume on the main sections of the city, especially on Jl. Lintas Sumatra, Jl. Aek Kanopan Bandar Manis, Jl. Angkatan 66/Nusa Indah, and Jl. Ghazali Kharim Pasar 3, which currently shows moderate to dense density levels (LOS C–D).

The potential for traffic load reduction depends on several technical factors and road user behavior:

1. Ring road design and capacity
   The design capacity of the ring road must be sufficient to accommodate most transit vehicles, including heavy/logistics vehicles. A ring road designed according to PKJI 2023 standards with optimal lane width, good horizontal and vertical geometry, and adequate intersection facilities, will be able to accommodate diversion currents effectively. This capacity analysis must consider peak hours and the percentage of heavy vehicles in order for diversion predictions to be realistic.
2. Flow switching and routing policies
   The effectiveness of diversions depends not only on physical roads, but also on traffic regulation policies. For example, restrictions on heavy vehicles entering city centers, alternative route signage, and driver compliance monitoring. Without a clear policy, some vehicles still choose the main road because of mileage or habits, so the volume reduction is only partial.
3. Road user behavior and induced demand
   Modern transportation literature warns that the construction of new roads can give rise to the phenomenon of induced traffic—new vehicles or routes arise due to the availability of new roads. Therefore, the prediction of volume reduction should consider the medium-term effects, not just the initial effects after the road is

opened. Simulating the "before-after" scenario with the V/C ratio model will provide a realistic estimate of the density decrease in the main section.

4. Influence on speed and Level of Service (LOS)
   With the diversion of transit vehicles to the ring road, it is expected that the V/C ratio on the main section will decrease, which will have a direct impact on increasing LOS. For example, the Jl. Lintas Sumatra section, which is now LOS D, can be upgraded to LOS C–C+ if some heavy and cross-regional vehicles are diverted. This change in LOS has implications for travel time, vehicle operational costs, and road user safety.
5. Economic and social impact
   The ring road also allows for more even distribution of traffic, reduces congestion in the city center, and improves the convenience of local users. The indirect effect is to encourage the economic growth of the surrounding corridor, due to better accessibility for industry, logistics, and new settlements.

Overall, the potential for reducing traffic load on the main section is highly dependent on the integration of technical design, flow diversion policies, and demand management. This study will examine the quantitative scenario of vehicle volume reduction using existing data (LHR, capacity, V/C, LOS) and project the benefits of ring road construction in operational and spatial contexts. The results of the analysis will be the basis for concluding how effective the ring road is in reducing congestion and improving the quality of road network services in Aek Kanopan.

How does the development of the ring road affect the potential development of the area and the surrounding economic activities

The development of the Aek Kanopan Outer Ring Road not only has an impact on the operational aspects of traffic, but also significantly affects the pattern of regional development and economic activity in the corridor around the track. Ring roads serve as an accessibility accelerator, allowing the movement of goods, services, and people to be more efficient, thereby driving changes in land use and local economic dynamics.

1. Accelerated access and connectivity
   The ring road improves connectivity between the city center, industrial estates, warehouses, new settlements, and the surrounding agricultural/plantation areas. Faster and smoother access reduces logistics transportation costs and travel time, making the surrounding area more attractive to investors, business actors, and property developers. This effect is consistent with Weber's location theory and modern transportation studies which state that accessibility is a major factor in the selection of industrial and commercial locations.
2. Growth of industrial and warehousing estates
   The eastern corridor to oil palm plantations has the potential to be a small industrial area, warehousing, and logistics distribution. The ring road allows heavy vehicles and trucks to pass through the city without obstacles, thus increasing distribution efficiency. This potential will encourage the emergence of new centers of economic activity, including plantation product processing and logistics services.

3. Development of local settlements and trade centers

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The western corridor to the new settlement has the opportunity to develop as a local residential and commercial area. Better accessibility increases land value and attracts MSMEs, shopping malls, and public facilities. Thus, the ring road not only reduces pressure on the main road, but also sparks decentralized economic growth outside the city center.

4. Interaction of transport and spatial planning
   Modern literature emphasizes that the development of new road infrastructure is often a trigger for land use change. The development of the ring road will affect the location of industry, trade, and housing according to the pattern of the access corridor. Therefore, there is a need for integration with spatial planning policies to ensure balanced and sustainable economic growth, as well as prevent urban sprawl or uncontrolled conversion of productive land.
5. Indirect economic effects
   Increased mobility and congestion reduction also have indirect economic effects in the form of:
   - Reduced fuel costs and vehicle travel time.
   - Increase in community and workforce productivity.
   - The growth of the local service sector (restaurants, workshops, grocery stores) along the access corridor.

6. Synergy between traffic control and economic development
   The ring road has a dual function: (1) to reduce the volume of traffic in the city center so as to improve the quality of road services, and (2) to open new corridors that have the potential to become centers of economic growth. The success of this dual function will depend on the integration between technical design, traffic regulation policies, and proactive spatial planning.

Overall, the construction of the Aek Kanopan Outer Ring Road has a significant positive impact on regional development and economic activities, with the potential to create new growth corridors around the track. This study will analyze the relationship between improved accessibility, changes in traffic volumes, and local economic dynamics through field observations, stakeholder interviews, and spatial document studies. This analysis is expected to produce recommendations that are not only technical-operational but also strategic for the sustainable development of the region.

What is the right strategy to optimize the function of the Outer Ring Road as a traffic volume control solution as well as a driver of regional growth

The optimization of the Aek Kanopan Outer Ring Road requires a strategy that combines technical aspects of traffic and regional planning, so that this road can serve a dual function: (1) reducing congestion on the main section in the city center, and (2) encouraging economic growth and regional development in a structured manner.

1. Adaptive road planning and technical design
   The ring road must be designed according to capacity and geometry standards capable of accommodating heavy vehicles, buses, and private vehicles. The design strategy includes: adequate lane width, clear markings and signs, controlled intersections, and dedicated lanes for logistics transportation. This ensures that the

traffic volume diversion function is effectively achieved, so that the V/C ratio on the main section can decrease and the LOS increase.

2. Route setting and traffic management
   A volume control strategy should be accompanied by a routing policy. For example, restrictions on heavy vehicles to enter the city center, the establishment of mandatory lanes for trucks/logistics, and the implementation of a one-way system or restrictions on certain operational hours. Enforcement of rules and socialization to the community are the keys so that the flow diversion can run as planned.
3. Integration with spatial planning and development of economic corridors The ring road not only serves as an alternative to current, but also as a catalyst for the growth of the region. Optimization strategies should integrate road planning with spatial planning policies, for example:
   - Eastern corridor: developed as a light industrial and warehousing area.
   - Western corridor: focused on new housing and local trade centers. With clear planning, economic growth along the corridor can be directed, reduce the risk of urban sprawl, and increase the economic value of the land in a balanced manner.
4. Development of supporting and multimodal facilities
   Optimization of the ring road can also be achieved by providing supporting facilities, such as mass transportation stops, bicycle lanes, and sidewalks. This strategy encourages the use of alternative transportation, reduces reliance on private vehicles, and improves safety. In addition, multimodal access strengthens the role of the ring road as an efficient and sustainable transportation network.
5. Continuous monitoring and evaluation
   An effective strategy must be accompanied by a monitoring mechanism, such as LHR measurement, V/C ratio, and periodic road service levels. This evaluation allows for policy improvements to flow diversion, capacity adjustments, or the development of new facilities as needed. Thus, the function of the ring road can always be optimal both in terms of technical and economic impact.
6. Stakeholder engagement
   Optimization requires coordination between local governments, road management officials, the community, and business actors. The involvement of various parties ensures compliance with regulations, support for regional development, and the achievement of synergy between traffic volume control and economic growth.

Overall, the optimization strategy of the Aek Kanopan Outer Ring Road must be integrated, including: adequate technical design, strict flow diversion policies, integration with spatial planning and local economy, provision of supporting facilities, and continuous monitoring. This holistic approach ensures that the ring road not only reduces congestion on the main section but also becomes a driver of sustainable regional growth.

How is the construction plan of the Aek Kanopan Outer Urban Ring Road compatible with the Regional Spatial Plan (RTRW) of North Labuhanbatu Regency

The suitability of the Aek Kanopan Outer Urban Ring Road development plan with the Regional Spatial Plan (RTRW) of North Labuhanbatu Regency can be seen from its role in supporting the regional spatial structure that has been determined. In the RTRW,

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Aek Kanopan is positioned as a center of regional activities that function as a center of government, trade, and services. The consequence of this function is the high intensity of human and goods movements centered in the core area of the city. The construction of the outer ring road is an important instrument to maintain a balance between the function of the city center and the buffer area, by diverting regional traffic flows so that they are not entirely concentrated in the central area of activity.

In a study on transportation dynamics and their impact on the community, research conducted by Meka, Sugiarto, and Hidayat shows that the high intensity of traffic in the Medan industrial area has a significant impact on the quality of life of the local community, including economic and environmental aspects such as air pollution and vehicle density. This finding is relevant to the study on the construction of the Aek Kanopan Outer Urban Ring Road, because similar to the conditions in Medan, the increase in the volume of vehicles in the center of Aek Kanopan is expected to have an impact on travel efficiency and environmental quality if it is not accompanied by proper planning efforts

From the perspective of the transportation network system, the Aek Kanopan Outer Ring Road plan is in line with the RTRW policy which emphasizes the development of a hierarchical and integrated road network. The ring road functions as a strategic road network that complements the existing network of arterial roads and collectors, while strengthening inter-regional connectivity in North Labuhanbatu Regency. With the existence of ring roads, the transportation system is no longer radial centered within the city, but develops into a more widespread and efficient system. This condition supports the improvement of the overall performance of the road network and strengthens Aek Kanopan's role as a regional transportation node without sacrificing urban traffic performance.

The suitability of the ring road plan with the RTRW is also reflected in efforts to control the development of urban areas. The RTRW of North Labuhanbatu Regency directs the growth of the city so that it does not develop uncontrollably (urban sprawl), but is structured and controlled in accordance with the carrying capacity of the environment. The outer ring road acts as a functional boundary of urban development, which can direct the pattern of space utilization in suburban areas in a more planned manner. Through the regulation of access and land use along the ring road corridor, the growth of new areas can be controlled to suit the zoning that has been determined in the RTRW.

In the context of this study, the existence of the Aek Kanopan Outer Urban Ring Road is seen as part of a sustainability-oriented spatial planning strategy. The diversion of heavy vehicle flows and long-distance traffic to the ring road not only improves the performance of the road network in the city center, but also contributes to the improvement of the quality of the urban environment. Reduced traffic density in the core area of the city has the potential to reduce air pollution, noise, and pressure on existing road infrastructure, thereby supporting the principle of more environmentally friendly and sustainable urban development.

In addition, the construction of the ring road also opens up opportunities for the development of new economic zones outside the city center that are in line with the RTRW spatial pattern plan. The ring road corridor can be directed to support small-scale industrial activities, warehousing, and logistics distribution centers in designated zones, as well as the development of planned new residential areas. Thus, the ring road not only functions as

transportation infrastructure, but also as a means of controlling and directing the use of space, so that regional growth can take place more evenly and integrated.

Overall, the Aek Kanopan Outer Urban Ring Road construction plan has a high level of conformity with the North Labuhanbatu Regency RTRW. Ring roads support the spatial structure of the region, strengthen the transportation network system, and play an important role in controlling the development of urban areas. In the framework of this study, this suitability is the basis for the argument that the construction of the ring road is a policy that is not only technically feasible for transportation, but also spatially and strategically relevant in realizing sustainable space utilization.

What is the right strategy to optimize the function of the Outer Ring Road as a traffic volume control solution as well as a driver of regional growth

The traffic performance modeling in the Aek Kanopan Outer Urban Ring Road plan in this study is based on the analysis of volume to capacity ratio (V/C ratio) as the main indicator of the level of road network saturation. This analysis is carried out by comparing the existing conditions without a ring road and the condition of the plan with the existence of a ring road, so that changes in traffic performance can be known quantitatively and functionally. This approach is relevant because the V/C ratio is able to describe the extent to which a road is still able to serve the traffic flow optimally before it reaches a saturated condition.

In addition, research by Haloho and Sugiarto emphasizes the strategic role of transportation infrastructure in the development of urban areas and community mobility patterns. The findings support the importance of integration between road network plans such as ring roads and spatial planning policies that have been set out in the RTRW. Road infrastructure not only functions as mobility infrastructure, but also affects spatial connectivity, the growth of new areas, and accessibility between regions. This is in line with the study in this study which assesses how the ring road can improve traffic performance while supporting the sustainable development of regional spatial planning.

In the existing conditions, the main road sections in Aek Kanopan City show a relatively high V/C ratio value, especially in the corridor which also functions as a cross-regional route. The V/C ratio value that is close to one indicates that the road capacity is almost fully utilized, so that the level of road service is in the crowded to congested category. In this condition, vehicle movements become unstable, delays increase, and roads are very susceptible to congestion if minor disturbances occur. These findings are an important basis for research to formulate the need for alternative routes that can accommodate non-local traffic flows.

In the planned scenario, modeling is carried out by including the Aek Kanopan Outer Urban Ring Road as a new section that functions to divert part of the volume of traffic, especially long-distance vehicles and freight transportation, from the city center. This diversion of flow directly reduces the volume of traffic on the main roads in the city, so that the value of the V/C ratio on these sections has decreased significantly. The decrease in the value of the V/C ratio shows that road capacity can be used more optimally, with a lower level of saturation compared to existing conditions.

The modeling results show that with the operation of the ring road, the level of service on the main road sections in Aek Kanopan City tends to increase from a congested condition to a more stable and smooth condition. Roads that were previously at the service

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level of category D have the potential to increase to category C or even B, depending on the volume of traffic that has been successfully diverted to the ring road. This increase in service level reflects the improvement in the quality of traffic flow, characterized by an increase in travel speed, reduced delays, and increased comfort and safety for road users.

In addition to having an impact on roads in the city, traffic performance modeling also shows that the Aek Kanopan Outer Urban Ring Road is able to function as an element of strengthening the overall road network. Ring roads not only accommodate the flow of diverted traffic, but also create a more even distribution of flow on the road network. Thus, the transportation system is no longer centralized on a few specific sections, but spreads more evenly according to the function and hierarchy of the road network.

The spatial approach in transportation planning is also an important part of the analysis of the performance of road networks in urban areas. Research by Lubis and Panjaitan who used Geographic Information Systems (GIS) to analyze the factors that cause congestion in Medan City shows that the use of spatial data can help identify critical locations and traffic flow patterns that need to be addressed. These findings are relevant to the Aek Kanopan Outer Ring Road study, where traffic modelling and V/C ratio analysis need to be combined with a spatial approach to produce comprehensive planning recommendations.

In the context of this study, V/C ratio-based modeling provides empirical evidence that the construction of the Aek Kanopan Outer Urban Ring Road is an effective solution in reducing traffic saturation and improving the level of road services in urban areas. The results of this modeling strengthen the argument that the construction of the ring road is not only technically feasible, but also strategic in supporting the smooth urban mobility, transportation efficiency, and sustainability of the road network system in North Labuhanbatu Regency.

What is the right strategy to optimize the function of the Outer Ring Road as a traffic volume control solution as well as a driver of regional growth

The implementation of the Aek Kanopan Outer Urban Ring Road plan not only has a direct impact in the form of reducing traffic volume in the city center and increasing socio-economic activities, but also has various further impacts that are structural and long-term. These impacts are closely related to changes in space utilization patterns, the quality of the urban environment, traffic safety, the efficiency of the logistics system, and the equitable distribution of regional development. In the context of this study, follow-up impact analysis is important to assess the sustainability and effectiveness of ring road construction as part of integrated transportation and spatial planning policies.

From the aspect of land use, the existence of the Outer Ring Road has the potential to change the pattern of development of the area around the road corridor. Ring roads can serve as a trigger for the growth of new, more targeted areas, such as small industrial estates, warehouses, and planned settlements, in accordance with the zoning stipulated in the RTRW. With adequate road infrastructure, the pressure on land use in the city center can be reduced, so that uncontrolled land conversion can be minimized. In the long run, this supports the formation of a more balanced and controlled urban spatial structure, and reduces the tendency of sporadic urban growth.

In terms of the quality of the urban environment, the diversion of heavy vehicle flows and long-distance traffic to ring roads has the potential to reduce air pollution and

noise levels in the downtown area. Reducing traffic density on major roads can improve air quality, reduce vehicle exhaust emissions, and create a more comfortable and healthy urban environment for the community. In addition, reduced traffic pressure can also extend the life of existing road infrastructure, so that maintenance needs can be reduced and resources used to be more efficient.

In terms of traffic safety, the existence of the ring road makes a positive contribution through the separation of the flow of local vehicles and cross-regional vehicles. Heavy vehicles and high-speed vehicles that previously passed within the city can be diverted to the ring road, so that traffic conflicts with local vehicles, pedestrians, and other road users can be reduced. Reducing the intensity of this conflict has the potential to reduce the number of traffic accidents, especially in urban areas that have high activity and limited road space. Thus, the ring road also supports the creation of a safer and more sustainable transportation system.

From the perspective of logistics distribution efficiency, the Aek Kanopan Outer Urban Ring Road plays an important role in facilitating the movement of goods and services, especially for the plantation and industrial sectors that are the basis of the regional economy. Direct access via the ring road allows freight transport to take a shorter and barrier-free route, without having to enter the downtown area. This condition not only reduces travel time and operational costs of vehicles, but also increases the reliability of the distribution system, which ultimately strengthens the regional economic competitiveness on a regional scale.

In addition, the construction of the ring road also contributes to the equitable distribution of regional development. With the increasing accessibility of suburban and out-of-town areas, investment and economic development opportunities are no longer concentrated in the city core. Areas along the ring road corridor have the potential to develop into new growth centers, so that the distribution of economic activities and public services becomes more even. In the context of this study, the equitable distribution of regional development is an important indicator that the ring road not only serves the interests of transportation, but also functions as an instrument of inclusive regional development.

Overall, the continued impact of the implementation of the Aek Kanopan Outer Urban Ring Road shows that the development of this road infrastructure has multidimensional implications that go beyond the traffic aspect alone. The ring road acts as a catalyst for spatial change, improvement of environmental quality and safety, efficiency of logistics systems, and equitable distribution of regional development. Therefore, within the framework of this study, the construction of the Aek Kanopan Outer Urban Ring Road can be seen as a strategic policy that supports the realization of a sustainable transportation system and spatial planning in North Labuhanbatu Regency.

Conclusion

Based on the analysis of field data, interviews, FGDs, observations, and planning documents, several things can be concluded as follows:

1. Existing conditions of the main road network
2. The main roads in Aek Kanopan City, such as Jl. Lintas Sumatra, Jl. Aek Kanopan Bandar Manis, Jl. Angkatan 66/Nusa Indah, and Jl. Ghazali Kharim Pasar 3, show medium to high density (LOS C–D) with a V/C ratio ranging from 0.71–0.89. This

condition indicates the need for intervention to reduce traffic loads, especially at the peak of the working day.

3. Potential for the development of the Outer Ring Road
   The Aek Kanopan Outer Ring Road has significant potential as a diversion route for cross-city vehicle flows and heavy vehicles. In addition to reducing the traffic burden on the main section, the ring road also opens up the surrounding economic growth corridor. The eastern region has the potential for small industry and warehousing, while the western corridor could be developed as a residential area and a local trade center.
4. Influence on economic and regional activities
   The increased accessibility provided by the ring road drives economic growth along the track, lowers logistics transportation costs, and increases land values in the surrounding corridors. The ring road acts as a catalyst for the development of the directional area, expands the distribution of economic activity, and reduces pressure on the city center.
5. Ring road optimization strategy
   Outer Ring Road optimization requires an integrated strategy:
   a. The technical design of the road is according to capacity and geometric standards.
   b. Clear routing and flow diversion policies for heavy vehicles.
   c. Integration with spatial planning and local economic development.
   d. Provision of multimodal transportation support facilities.
   e. Continuous monitoring and evaluation to adjust policy and road capacity.
   f. This strategy ensures the dual function of the ring road: controlling traffic volume and driving regional growth.

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