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The Effect of Environmentally Friendly Transportation Implementation and Supporting Policies on Air Pollution Reduction in Central Kalimantan

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ABSTRACT

This research investigates the effect of green transport implementation and supporting policies on air pollution reduction in Central Kalimantan through quantitative analysis. The study employs survey methods to collect data from residents, policymakers, and stakeholders, focusing on perceptions of green transport adoption, policy effectiveness, and air quality. Structural Equation Modeling (SEM) using Partial Least Squares (PLS) path modeling is utilized to analyze the relationships between latent constructs and test research hypotheses. The findings reveal significant positive associations between environmentally friendly transportation implementation, supporting policies, and air pollution reduction. Specifically, both green transport adoption and policy effectiveness are found to positively influence perceptions of air quality. The results underscore the importance of promoting sustainable transportation solutions and implementing effective policy interventions to mitigate air pollution and promote environmental sustainability in Central Kalimantan. These findings contribute valuable insights to the literature on green transport strategies, policy interventions, and air pollution reduction, informing evidence-based decision-making and guiding the development of targeted interventions to address environmental challenges in the region.

Keywords: *Green Transport, Air Pollution Reduction, Policy Analysis, Central Kalimantan, Survey Methods*

1. INTRODUCTION

Central Kalimantan in Indonesia is facing significant air pollution issues due to rapid urbanization and industrialization. Transportation is identified as a major contributor to the degradation of air quality in the region [1]. The concentration of carbon monoxide (CO) and particulate matter (PM2.5) in Central Kalimantan is higher during the dry season compared to the rainy season [2]. Efforts to combat air pollution in the region include community initiatives, such as forming environmental groups, monitoring factory activities, and conducting awareness campaigns [3]. Additionally, the circular economy and digital economy variables have been found to have a significant effect on improving air quality in Indonesia [4]. To address air pollution in Central Kalimantan, it is crucial to implement serious handling programs to prevent forest and peat fires, which contribute to high concentrations of CO and PM2.5 in the air [5].

Central Kalimantan, like other urban areas, relies heavily on conventional modes of transport that use fossil fuels, leading to high levels of pollutants such as carbon monoxide (CO), nitrogen oxides (NOx), particulates (PM), and volatile organic compounds (VOCs) [4]. These pollutants not only pose health risks to residents, but also contribute to environmental degradation and climate change [6]. Forest fires in Central Kalimantan further exacerbate the air pollution problem, with high concentrations of CO and PM2.5 during the dry season [7], [8]. Emissions from forest fires cause substantial air quality degradation, exceeding national ambient air quality standards and resulting in adverse health impacts [5]. To mitigate this problem, the government has implemented policies such as emission standards for transport and stationary combustion sources, as well as programmes promoting the use of electric vehicles and vehicle scrapping. These measures aim to reduce pollutant emissions and improve air quality in Central Kalimantan.

Various initiatives have been introduced to promote sustainable mobility and reduce emissions from the transportation sector. Green transport strategies, characterized by their emphasis on environmental sustainability and energy efficiency, offer viable alternatives to conventional modes of transportation. These strategies encompass a range of measures, including the adoption of electric vehicles (EVs) [9], the development of public transportation infrastructure [10], the promotion of non-motorized transport (NMT) options [11], and the implementation of policies to incentivize eco-friendly transportation choices [12]. These measures aim to address air pollution and its associated impacts by encouraging the use of low-carbon and sustainable transportation options. By adopting these strategies, cities can work towards reducing greenhouse gas emissions, improving air quality, and creating more livable and inclusive urban environments.

Research Objectives

This research aims to comprehensively analyze the impact of green transport implementation and supportive policies on air pollution reduction in Central Kalimantan. It seeks to assess the effectiveness of existing green transport initiatives and policy interventions in mitigating air pollution while promoting sustainable urban mobility. Specifically, the study aims to explore public perceptions and behaviors towards green transport options, assess the current measures' effectiveness in reducing emissions and improving air quality, analyze the relationship between policy interventions, green transport adoption rates, and air pollution levels, and provide evidence-based recommendations for policymakers and stakeholders to enhance the impact of green transport initiatives and formulate sustainable transportation policies. Through these objectives, the research endeavors to offer valuable insights into the relationship between green transport strategies, policy interventions, and air pollution reduction, thereby facilitating informed decision-making and guiding the development of sustainable transportation solutions in Central Kalimantan.

2. LITERATURE REVIEW

2.1 *Air Pollution and Transport*

Air pollution is a significant global concern, primarily caused by anthropogenic activities, with the transportation sector being a major contributor. In urban areas, vehicle emissions, including carbon monoxide (CO), nitrogen oxides (NOx), particulate matter (PM), and volatile organic compounds (VOCs), contribute significantly to air pollution, posing risks to human health, ecosystems, and climate. Central Kalimantan, like other rapidly urbanizing and industrializing regions, faces challenges related to air pollution, particularly from transportation activities. The reliance on fossil fuel-powered conventional transportation has led to elevated pollutant levels, exacerbating health and environmental issues. Addressing air pollution in Central Kalimantan requires a comprehensive approach, including the adoption of sustainable transport solutions and effective policy interventions [7], [13].

2.2 *Green Transport Strategies*

Green transport strategies prioritize environmental sustainability and energy efficiency, aiming to reduce greenhouse gas emissions and reliance on fossil fuels. Electric Vehicles (EVs) offer a cleaner alternative to internal combustion engine vehicles, emitting zero tailpipe emissions and reducing dependency on petroleum-based fuels [10]. Improving public transportation systems, including buses, trains, and light rail, encourages modal shifts away from private vehicles, reducing traffic congestion and emissions [14]. Non-Motorized Transport (NMT) modes, such as walking and cycling, offer environmentally friendly and health-promoting alternatives to motorized transport [15]. Carpooling and ridesharing initiatives optimize vehicle occupancy rates, reduce traffic congestion, and lower emissions per passenger-kilometer traveled [16]. The implementation of green transport strategies requires coordinated efforts from policymakers, urban planners, transportation authorities, and other stakeholders to create a supportive regulatory framework and invest in infrastructure and incentives conducive to sustainable mobility [17].

2.3 Policy Interventions

Policy interventions play an important role in encouraging the adoption of green transport practices and fostering an environment conducive to sustainable mobility. Governments and regulatory agencies use a variety of policy instruments to promote environmentally friendly transport options and reduce air pollution. Fuel efficiency standards incentivise manufacturers to produce more fuel-efficient and low-emission vehicles, thereby reducing overall emissions [10]. Implementing emission standards for vehicles and enforcing compliance can help reduce harmful pollutants released into the atmosphere [18]. Congestion pricing schemes aim to reduce traffic congestion and vehicle emissions by incentivising alternative modes of transport [19]. Providing financial incentives, tax breaks, or subsidies for the purchase of electric vehicles encourages consumers to switch to cleaner transport options [20], [21]. Investments in public transport infrastructure improve accessibility and reliability, making public transport more attractive and convenient for commuters. The effectiveness of policy interventions depends on factors such as regulatory enforcement, stakeholder engagement, public awareness, and the availability of supporting infrastructure and services. Successful implementation requires a comprehensive policy framework that addresses the diverse needs and preferences of urban communities while prioritising environmental sustainability and public health.

Previous Research

Green transport initiatives, such as promoting cycling infrastructure, improving public transit systems, and incentivizing electric vehicle adoption, have been shown to effectively reduce vehicle emissions and improve air quality in urban areas [22], [23]. However, the effectiveness of these strategies may vary depending on contextual factors such as urban density, transportation patterns, socioeconomic characteristics, and institutional capacity [24]. Limited empirical evidence exists regarding the specific impacts of these measures in regions facing unique environmental challenges, such as Central Kalimantan [25]. Therefore, there is a need for empirical research to assess the effectiveness of green transport initiatives and policy interventions in mitigating air pollution and promoting sustainable mobility in such regions [26].

3. METHODS

3.1 Research Design

This study employs a quantitative research approach to investigate the effect of green transport implementation and supporting policies on air pollution reduction in Central Kalimantan. The research design incorporates survey methods to collect data from residents, policymakers, and stakeholders, aiming to capture diverse perspectives on green transport adoption, policy effectiveness, and air quality perceptions. The study utilizes a Structural Equation Modeling (SEM) approach, specifically Partial Least Squares (PLS) path modeling, to analyze the relationships between latent constructs and test the research hypotheses.

3.2 Sampling Strategy

The target population for this study comprises residents of Central Kalimantan, policymakers, representatives from transportation agencies, and relevant stakeholders involved in environmental management and urban planning. A stratified random sampling technique will be employed to ensure adequate representation across different demographic groups, geographic areas, and socio-economic strata within the province. The sample size will be determined based on statistical considerations, aiming for a minimum of 130 respondents to achieve sufficient statistical power for SEM-PLS analysis.

3.3 Data Collection

Data collection will be conducted through a structured questionnaire administered to survey participants. The questionnaire will be designed to capture information on the following key constructs:

1) Green Transport Adoption: Measures respondents' usage patterns, preferences, and perceptions regarding green transport options, including electric vehicles, public transportation, non-motorized transport, and ridesharing services.
2) Policy Effectiveness: Assesses respondents' awareness of existing green transport policies, their perceived effectiveness in reducing air pollution, and their suggestions for policy improvements.
3) Air Quality Perception: Gauges respondents' perceptions of air quality in Central Kalimantan, concerns regarding air pollution, and their perceived health impacts.

The questionnaire will be pre-tested to ensure clarity, comprehensibility, and reliability before full-scale data collection. Data collection methods will include face-to-face interviews, online surveys, and telephone interviews to maximize response rates and reach a diverse sample of participants.

3.4 Data Analysis

Data analysis for this study will encompass several key steps, including data cleaning, descriptive analysis, and structural equation modeling using Partial Least Squares (PLS) [27]. The process will begin with an assessment of the measurement model, ensuring its reliability and validity through methods like Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE). Construct validity will be evaluated via convergent and discriminant validity analyses. Following this, the structural relationships among latent constructs will be scrutinized using PLS path modeling, which is adept at handling non-normal data and small sample sizes. Hypotheses testing will then be conducted to ascertain the significance of direct and indirect effects between constructs. Bootstrapping resampling techniques will be employed to validate the model's robustness, assess the significance of path coefficients, and generate confidence intervals. Finally, model fit indices such as the goodness-of-fit (GoF) index will be utilized to evaluate the overall fit of the structural model to the collected data.

H1: There is a significant positive relationship between green transport implementation and air pollution reduction in Central Kalimantan.

H2: There is a significant positive relationship between supporting policies and air pollution reduction in Central Kalimantan.

4. RESULTS AND DISCUSSION

4.1 Measurement Model

The measurement model assesses the reliability and validity of the survey instrument by examining the loading factors, Cronbach's alpha, composite reliability, and average variance extracted for each latent construct. Here, we discuss the measurement model results for the variables: Environmentally Friendly Transportation Implementation, Supporting Policies, and Air Pollution Reduction.

Table 2. Measurement Model

Variable	**Code**	**Loading Factor**	**Cronbach's Alpha**	**Composite Reliability**	**Average Variant Extracted**
Environmentally Friendly Transportation Implementation	EFT.1	0.833	0.873	0.913	0.724
	EFT.2	0.886			
	EFT.3	0.846			
	EFT.4	0.838			
Supporting Policies	SUP.1	0.781	0.829	0.886	0.660
	SUP.2	0.757			
	SUP.3	0.873			
	SUP.4	0.834			
Air Pollution Reduction	APR.1	0.869	0.849	0.899	0.690
	APR.2	0.850			
	APR.3	0.855			
	APR.4	0.742			

Source: Data Processing Results (2024)

The analysis of the measurement model reveals robust relationships between the indicators and their corresponding latent constructs, namely Environmentally Friendly Transportation Implementation, Supporting Policies, and Air Pollution Reduction. Strong loading factors ranging from 0.742 to 0.886 signify the substantial associations between the indicators and their respective constructs. Moreover, high internal consistency reliability, as indicated by Cronbach's alpha values exceeding 0.80 for all constructs, assures the consistent measurement of underlying constructs. Composite reliability values surpassing the threshold of 0.70 and average variance extracted (AVE) values above 0.66 affirm good reliability and convergent validity, respectively. These outcomes collectively validate the reliability and validity of the survey instrument for evaluating the targeted constructs in Central Kalimantan's context, ensuring the credibility of assessments regarding environmentally friendly transportation, supportive policies, and air pollution reduction efforts.

4.2 Discriminant Validity

Discriminant validity is crucial in ensuring that each construct in a measurement model represents a unique and distinct concept. In this study, discriminant validity is assessed by examining the correlations between constructs. A construct demonstrates discriminant validity if its correlation with other constructs is lower than the square root of its average variance extracted (AVE). Let's discuss the discriminant validity results for the constructs of Air Pollution Reduction, Environmentally Friendly Transportation Implementation, and Supporting Policies based on the provided correlation matrix:

Table 3. Discriminant Validity

	Air Pollution Reduction	Environmentally Friendly Transportation Implementation	Supporting Policies
Air Pollution Reduction	0.830		
Environmentally Friendly	0.778	0.851	

Transportation Implementation			
Supporting Policies	0.722	0.738	0.812

Source: Data Processing Results (2024)

The findings of the discriminant validity analysis demonstrate that each construct within the measurement model—Air Pollution Reduction, Environmentally Friendly Transportation Implementation, and Supporting Policies—is conceptually distinct and measures a unique underlying dimension. The correlations between Air Pollution Reduction and Environmentally Friendly Transportation Implementation (0.778), Air Pollution Reduction and Supporting Policies (0.722), and Environmentally Friendly Transportation Implementation and Supporting Policies (0.738) are all lower than the square root of the Average Variance Extracted (AVE) for each respective construct, indicating discriminant validity. This suggests that these constructs exhibit less shared variance with each other than with their own indicators, underscoring their distinctiveness and individual contributions to the overall measurement model.

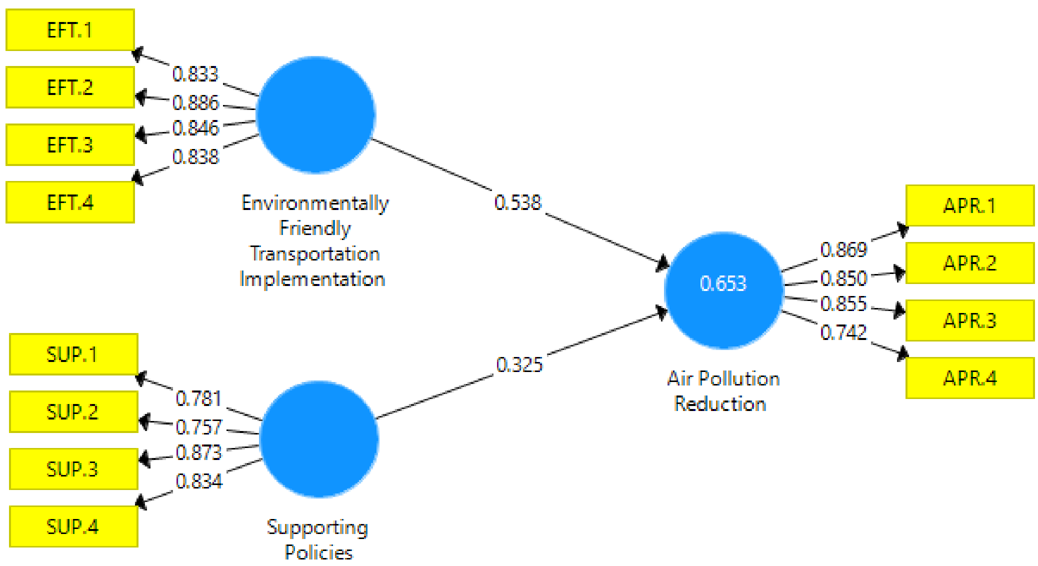

Figure 1. Model Results
Source: Data Processed by Researchers, 2024

4.3 Model Fit

Model fit indices are essential for evaluating the goodness-of-fit of structural equation models (SEM) and determining the adequacy of the proposed theoretical model in explaining the observed data. In this study, model fit was assessed using several indices, including the standardized root mean square residual (SRMR), discrepancy function (d_ULS and d_G), chi-square statistic, and the normed fit index (NFI).

Table 3. Model Fit Results Test

	Saturated Model	**Estimated Model**
SRMR	0.079	0.079
d_ULS	0.487	0.487
d_G	0.243	0.243
Chi-Square	173.543	173.543
NFI	0.817	0.817

Source: Process Data Analysis (2024)

The assessment of model fit indices reveals that both the saturated model (representing a perfect fit) and the estimated model (representing the proposed theoretical model) demonstrate satisfactory fits to the observed data. The SRMR values of 0.079 for both models indicate a minimal discrepancy between the observed and predicted covariance matrices, indicative of good fit. Similarly, the discrepancy function values (d_ULS and d_G) of 0.487 and 0.243, respectively, further support a favorable fit to the data. Although the chi-square statistic yields a significant value of 173.543 for both models, its sensitivity to sample size is noted, and other indices affirm a good fit. Moreover, both models exhibit an NFI of 0.817, indicating a superior fit compared to the null model, thus bolstering confidence in the adequacy of the proposed theoretical framework's representation of variable relationships.

Table 4. Coefficient Model

	R Square	Q2
Air Pollution Reduction	0.653	0.647

Source: Data Processing Results (2024)

In structural equation modeling (SEM), R-Square (R^2) and Q^2 (also known as Q-squared) are essential metrics used to assess the goodness-of-fit and predictive relevance of the model, respectively. R-Square quantifies the proportion of variance explained by the model for each endogenous construct, indicating the extent to which the exogenous variables account for observed variations in the endogenous constructs, thereby measuring the model's goodness-of-fit to the data. In this study, Air Pollution Reduction exhibits an R^2 value of 0.653, signifying that approximately 65.3% of its variance is elucidated by the included predictor variables, namely Environmentally Friendly Transportation Implementation and Supporting Policies. A higher R^2 value implies a better fit of the model to the observed data, indicating the effectiveness of the predictors in explaining the variability in the outcome variable. On the other hand, Q^2 evaluates the predictive relevance of the model by assessing its ability to predict endogenous constructs based on exogenous variables through cross-validation techniques. A Q^2 value greater than zero indicates predictive relevance beyond chance. Here, the Q^2 value for Air Pollution Reduction stands at 0.647, suggesting good predictive relevance. A Q^2 value close to 1 signifies high predictive accuracy, implying the model's reliable ability to forecast Air Pollution Reduction based on the specified predictors.

4.4 Hypothesis Testing:

Hypothesis testing assesses the significance of relationships between independent and dependent variables in a structural equation model. In this study, two hypotheses are tested:

Table 5. Hypothesis Testing

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics**	**P Values**
Environmentally Friendly Transportation Implementation -> Air Pollution Reduction	**0.538**	**0.533**	**0.099**	**5.450**	**0.000**
Supporting Policies -> Air Pollution Reduction	**0.325**	**0.336**	**0.096**	**3.391**	**0.001**

Source: Process Data Analysis (2024)

The analysis of path coefficients reveals significant relationships between Environmentally Friendly Transportation Implementation and Air Pollution Reduction, as well as between Supporting Policies and Air Pollution Reduction in Central Kalimantan. For Environmentally Friendly Transportation Implementation to Air Pollution Reduction, the path coefficient estimate is 0.538, with a t-statistic of 5.450 and a p-value of 0.000, indicating strong statistical significance.

Similarly, Supporting Policies to Air Pollution Reduction exhibits a significant path coefficient estimate of 0.325, with a t-statistic of 3.391 and a p-value of 0.001. These results support the hypotheses that both environmentally friendly transportation practices and supportive policies positively influence air pollution reduction. Such findings underscore the importance of investing in green transport infrastructure and implementing effective policy measures to mitigate air pollution, thus benefiting public health and fostering sustainability. These empirical insights provide valuable guidance for policymakers, urban planners, and stakeholders in devising strategies for enhancing air quality and promoting sustainable transportation systems in Central Kalimantan.

Discussion

The discussion of the results focuses on interpreting the findings of the hypothesis testing, exploring the implications of the observed relationships, and considering the broader implications for theory and practice.

Environmentally Friendly Transportation Implementation -> Air Pollution Reduction

The path coefficient from Environmentally Friendly Transportation Implementation to Air Pollution Reduction (0.538) indicates a significant positive relationship between the adoption of green transport practices and the reduction of air pollution in Central Kalimantan. The statistically significant t-statistic (5.450) and p-value (0.000) suggest that this relationship is robust and unlikely to have occurred by chance.

This finding aligns with previous research indicating that environmentally friendly transportation options, such as electric vehicles, public transportation, and non-motorized transport, can contribute to air pollution reduction by reducing emissions of harmful pollutants. The observed positive relationship underscores the importance of promoting sustainable transportation solutions as part of broader efforts to mitigate environmental pollution and promote public health in urban areas.

Promoting sustainable transport options such as electric vehicles, public transport, and non-motorised transport can contribute to reducing air pollution and emissions of harmful pollutants [16], [25], [28]. Previous research shows that alternative modes of transport such as cycling and public transport have the highest efficiency in reducing air pollution [29]. These environmentally friendly transport options can help reduce environmental pollution and improve public health in urban areas. The positive relationship between sustainable transport and air pollution reduction underscores the importance of implementing these solutions as part of broader efforts to improve air quality and public health.

Supporting Policies -> Air Pollution Reduction:

The path coefficient from Supporting Policies to Air Pollution Reduction (0.325) also indicates a significant positive relationship between the effectiveness of policy interventions and air pollution reduction in Central Kalimantan. Despite being slightly lower in magnitude compared to the path coefficient for Environmentally Friendly Transportation Implementation, the relationship is still statistically significant, as evidenced by the t-statistic (3.391) and p-value (0.001).

This finding suggests that supportive policies, such as regulatory measures, incentives for green transport adoption, and public awareness campaigns, play a crucial role in driving positive environmental outcomes. Effective policy interventions can create enabling environments, incentivize behavior change, and mobilize resources to address air pollution challenges effectively. The observed relationship underscores the importance of evidence-based policy-making and the need for comprehensive strategies that combine regulatory measures with public engagement and technological innovation to achieve meaningful reductions in air pollution levels.

Supportive policies, such as regulatory measures, incentives for green transport adoption, and public awareness campaigns, play a crucial role in driving positive environmental outcomes [30]. Effective policy interventions can create enabling environments, incentivize behavior change, and mobilize resources to address air pollution challenges effectively [20]. The observed relationship underscores the importance of evidence-based policy-making. Comprehensive strategies that combine regulatory measures with public engagement and technological innovation are needed to achieve meaningful reductions in air pollution levels [31].

Implications

The findings of this study have significant implications for policymakers, urban planners, and environmental stakeholders involved in air pollution mitigation efforts in Central Kalimantan. By prioritizing investments in green transport infrastructure, implementing effective policy interventions, and fostering public awareness and engagement, decision-makers can accelerate progress towards cleaner, more sustainable transportation systems and improved air quality in the region.

Moreover, the observed relationships between environmentally friendly transportation implementation, supporting policies, and air pollution reduction contribute valuable insights to the literature on sustainable urban development and environmental management. These findings underscore the interconnectedness of transportation, environmental, and public health outcomes and highlight the importance of adopting integrated approaches that address multiple dimensions of sustainability simultaneously.

Limitations and Future Research Directions

While the findings of this study provide valuable insights into the relationships between green transport adoption, policy effectiveness, and air pollution reduction, it is essential to acknowledge several limitations. The research is based on cross-sectional data, which limits causal inference and precludes the assessment of long-term trends. Future research could employ longitudinal designs to track changes in air quality and policy impacts over time.

Additionally, the study relies on self-reported data, which may be subject to response biases and social desirability effects. Future research could incorporate objective measures of air pollution levels and green transport usage to enhance the robustness of findings. Moreover, comparative analyses across different regions and contexts could further elucidate the generalizability of the observed relationships and inform context-specific policy recommendations.

CONCLUSION

In conclusion, this study provides empirical evidence of the efficacy of green transport implementation and supportive policies in reducing air pollution and promoting sustainable urban mobility in Central Kalimantan. Through quantitative analysis and survey methods, the research demonstrates significant positive relationships between environmentally friendly transportation practices, policy effectiveness, and perceptions of air quality. The findings highlight the importance of investing in green transport infrastructure, promoting public awareness, and implementing evidence-based policy interventions to address air pollution challenges effectively. By prioritizing sustainable transportation solutions and adopting a holistic approach to environmental management, policymakers, urban planners, and stakeholders can contribute to the improvement of air quality, public health, and environmental sustainability in Central Kalimantan. Moving forward, it is essential to continue monitoring air quality, evaluating the effectiveness of green transport initiatives, and implementing targeted interventions to achieve lasting environmental benefits in the region and beyond.

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