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HOW COST SAVINGS AND OTHER FACTORS SHAPE PUBLIC TRANSPORT CHOICES IN HANOI: A CIRCULAR ECONOMY PERSPECTIVE

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Abstract. Public transport is essential for urban mobility, yet differences in cost efficiency and service accessibility create challenges across city zones. This study examines how these factors influence public transport choices in Hanoi, considering variations across different urban areas. The analysis is based on seven key criteria: cost savings, time efficiency, convenience, safety, accessibility, reliability, and environmental awareness, providing a comprehensive understanding of regional transport preferences and economic implications. Findings indicate significant regional variations in cost savings. In urban cores, savings are limited (0%–50%) due to short travel distances and private vehicle convenience. In expanding areas, savings rise (25%–75%) as public transport becomes a cost-effective alternative for longer commutes. In peripheral and rural areas, over 50% of residents benefit from high savings, given their reliance on long-distance buses. AHP results highlight distinct priorities. Cost is the primary factor in rural areas, while accessibility drives urban core decisions due to dense transport networks. In expanding zones, time efficiency is the top concern, making metro systems the preferred choice. Notably, environmental awareness ranks lowest across all regions. The study recommends strategies aligned with circular economy principles, focusing on system optimization rather than infrastructure expansion. Solutions include smart traffic management, multimodal integration, and sustainable maintenance, offering actionable insights for Hanoi's public transport development.

Keywords: Circular Economy, Public Transport Selection, Cost savings, Analytic Hierarchy Process (AHP), Hanoi transportation.

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1. INTRODUCTION

Public transportation plays a crucial role in reducing congestion, cutting emissions, and promoting resource efficiency, aligning with circular economy principles in urban mobility. As Hanoi undergoes rapid urbanization, it is expanding its public transport network, including Metro, Bus Rapid Transit (BRT), and regular buses, to meet the increasing demand for sustainable transport. However, the factors influencing public transport choices are multifaceted, encompassing cost savings, convenience, time efficiency, safety, accessibility, and environmental awareness. While cost-saving is often assumed to be paramount, its true dominance for Hanoi's residents remains a key question.

Globally, the impact of financial policies on public transport is evident. For instance, Van Goeverden's analysis in the Netherlands suggests that suspending subsidies could severely impact urban and regional transport supply, leading to decreased service levels and increased fares, potentially reducing demand [1]. However, the importance of cost relative to other factors varies. Research by Ahmad et al. in developing countries, utilizing structural equation modeling, indicates that while factors like instrumental attractiveness and facility design positively correlate with ridership, service information and environmental comfort show a negative correlation [2]. Interestingly, their findings also suggest that individuals without personal vehicles and with lower incomes exhibit a stronger preference for public transport, and that higher gasoline prices can incentivize public transport use. This aligns with Wang and Liu's study at the University of Queensland, which found that while travel time and distance are strong predictors of public transport use, the response to fare policies differs among user groups, with students being more sensitive to fare increases than staff [3].

Given Hanoi's diverse urban landscape, transport preferences are likely to vary. The densely populated urban core necessitates efficient public transport, while expanding urban areas demand integrated multimodal solutions. Peripheral areas, with lower density and limited infrastructure, still heavily rely on private vehicles. Understanding the specific drivers of public transport adoption in each of these zones is crucial for developing effective strategies. As the global trend of increasing vehicle ownership in developing nations, as highlighted by Sommer et al. poses a challenge to public transport promotion, and as Newman and Kenworthy advocate for moving beyond car-based planning towards alternative modes, a nuanced understanding of Hanoi's context is essential to foster a truly sustainable and circular transport system [4, 5].

While cost remains an essential consideration, it may not be the dominant factor in all regions. Understanding these behavioral differences is crucial for developing transport policies that align with circular economy principles, focusing on optimizing existing transport infrastructure, reducing waste, and integrating multimodal transport solutions.

This study applies the three-level Analytic Hierarchy Process (AHP) to evaluate the key determinants of public transport selection in Hanoi. The research aims to answer:

- Q1: How much is the financial efficiency achieved through cost savings?

- Q2: Is cost savings the primary factor influencing public transport choice, or do other factors (e.g., accessibility, convenience, time efficiency) play a greater role?

- Q3: How do transport preferences differ across Hanoi's Urban Core, Expanding Urban Areas, and Peripheral & Rural Areas?

- Q4: How can circular economy principles be integrated into Hanoi's transport planning to enhance circular economy in transportation?

By examining these questions, this study provides critical insights into Hanoi's urban transport behavior and offers strategic recommendations for sustainable and circular transport development.

The paper is structured as follows: Section 2 reviews factors influencing public transport selection and the circular economy's role. Section 3 outlines the survey and AHP framework. Section 4 presents cost-savings and transport selection results. Section 5 summarizes findings, discusses circular economy – oriented transport system policy implications, and suggests future research.

2. LITERATURE REVIEW

2.1. Cost-savings and other factors affecting people's choices of public transportation.

**** Regional Variations in Public Transport Preferences***

Public transport preferences are shaped by regional factors such as urban structure, socioeconomic conditions, and policies. Hu et al. found that in Changting (China), a small but growing city, over 85% of peak-hour trips rely on walking, cycling, and e-bikes due to job-housing balance and land-use diversity [6]. Loo et al. showed that optimizing station attributes enhances rail ridership in transit-oriented cities like New York and Hong Kong [7]. Cervero & Murakami highlighted that higher urban density reduces vehicle miles travelled but may also induce traffic. Therefore, effective transport policies must be tailored to local conditions for sustainable mobility [8].

**** Cost-savings and other factors affecting choices of public transportation***

One of the fundamental considerations for individuals when choosing a mode of transport is cost savings. Lower fares, potential subsidies, and reduced expenses compared to private vehicle operation are often cited as key motivators for public transport adoption. The synthesis of research in Great Britain by Paulley et al. highlighted the significant impact of fare levels on public transport demand [9]. Similarly, Ahmad et al. found in developing countries that individuals with lower incomes showed a stronger preference for public transport, suggesting the importance of cost considerations for this segment [2]. Therefore, this study hypothesizes for the context of Hanoi:

H1: Cost Savings (CST) has a significant impact on individuals' Decision to Choose Public Transport (DCPT).

Another crucial aspect influencing travel behavior is time efficiency. Commuters often weigh the travel time of different modes against their daily schedules and priorities. Public transport that offers quicker or more predictable travel times compared to private vehicles, especially in congested urban environments, is likely to be more attractive. The work by Redman et al. [10] emphasized that time efficiency is a key attribute encouraging car users to switch to public transport. Furthermore, Currie & Delbosc 's study in Australia indicated that service levels like frequency and speed, which directly relate to time efficiency, are critical factors influencing ridership [11]. Consequently, this study proposes the following hypothesis for Hanoi:

H2: Time efficiency (TIE) has a significant impact on individuals' Decision to Choose Public Transport (DCPT).

Convenience plays a significant role in mode choice, encompassing factors like ease of access to stations or bus stops, seamless transfers between different transport modes, and the overall effort required for travel. The research by Loo et al. on transit-oriented cities like New York and Hong Kong highlighted the importance of optimizing station attributes for enhanced rail ridership, which directly relates to convenience [7]. Redman et al. also noted that ease of use is a key attribute for attracting car users to public transport [10]. Therefore, this study hypothesizes for Hanoi:

H3: Convenience (COV) has a significant impact on individuals' Decision to Choose Public Transport (DCPT).

Safety is a paramount concern for commuters when selecting a mode of transport. Perceived safety from crime and accidents can significantly influence the attractiveness of public transport. Psychological factors, including perceptions and motivations, were highlighted by Redman et al. as important in modal shifts, and safety clearly falls under these perceptions [10]. While not explicitly focusing solely on safety, the overall quality and design of the transport system, as emphasized in the findings by Ahmad et al. through "Facility Design and Operation," implicitly includes safety considerations [2]. Thus, this study hypothesizes for Hanoi:

H4: Safety (SAF) has a significant impact on individuals' Decision to Choose Public Transport (DCPT).

Accessibility refers to the ease with which individuals can access and utilize the public transport system, including physical accessibility for people with disabilities and the geographical coverage of the network. The study by Currie & Delbosc explicitly highlighted accessibility as a key factor for sustainable transport [11]. Ahmad et al. also identified poor connectivity with other transport modes as a contributor to low ridership, underscoring the importance of network accessibility [2]. Therefore, this study hypothesizes for Hanoi:

H5: Accessibility (ACS) has a significant impact on individuals' Decision to Choose Public Transport (DCPT).

Reliability of public transport services, including punctuality and consistency of schedules, is a critical factor influencing user satisfaction and mode choice. Both the research by Paulley et al. and the work by Redman et al. emphasized service reliability as a key determinant of public transport demand and a crucial attribute for attracting car users [9, 10]. The findings by Currie & Delbosc also highlighted the importance of service levels like frequency and speed, which are closely linked to reliability [11]. Consequently, this study hypothesizes for Hanoi:

H6: Reliability (RLT) has a significant impact on individuals' Decision to Choose Public Transport (DCPT).

Finally, environmental awareness is increasingly influencing individuals' behavior, including their transportation choices. As concerns about climate change and air pollution grow, people may opt for more sustainable modes of transport like public transport. While not a primary focus of all cited studies, the overarching goal of reducing reliance on private vehicles, as discussed in the context of sustainable urban planning by Newman and

Kenworthy, aligns with the principles of environmental awareness [5]. Therefore, this study hypothesizes for Hanoi:

H7: Environmental awareness (ENA) has a significant impact on individuals' Decision to Choose Public Transport (DCPT).

2.2. Decision-Making frameworks for Public Transport system evaluation

In the context of decision-making within scientific research and practical applications, a wide range of multi-criteria decision-making (MCDM) approaches have been developed to support optimal selection processes. Commonly employed methods include the Analytic Hierarchy Process (AHP), the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), the Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE), and the Elimination and Choice Expressing Reality (ELECTRE).

Several studies exemplify the application of these methods: Balali et al. integrated AHP and PROMETHEE II for selecting structural systems for low-rise buildings; Taherdoost and Madanchian applied PROMETHEE in multi-criteria decision contexts [12, 13]. Additionally, Balali et al. utilized a combination of ELECTRE III and PROMETHEE II to address structural system selection under uncertainty [12]. Hasan and AlJassmi employed MCDM to evaluate autonomous BRT systems in Abu Dhabi, demonstrating significant improvements in cost, energy consumption, and emissions reduction [14]. Ishizaka and Labib further emphasized AHP’s robustness in public transportation evaluation by integrating economic, social, and environmental criteria [15].

Given the diversity of approaches available, this study adopts the classic AHP method. Compared to other alternatives is particularly well-suited to the study’s primary objective: to determine the relative importance of factors influencing public transport mode choice in Hanoi. AHP offers a transparent hierarchical structure, facilitates systematic pairwise comparisons, and incorporates consistency checks to ensure judgment reliability. While fuzzy AHP specializes in addressing uncertainty in subjective assessments, and ELECTRE and PROMETHEE are more appropriate for ranking alternatives based on outranking relationships, AHP excels at deriving the weight of evaluation criteria themselves. This capability is crucial for establishing a clear, interpretable baseline in the initial phase of the study. Furthermore, the transparency and methodological rigor of AHP enhance the communicability of findings to a broad range of stakeholders. Therefore, AHP provides a robust, structured, and context-appropriate framework for analyzing public transportation mode selection in Hanoi.

2.3. Policy Recommendations for circular economy – oriented transport system

Banister & Button emphasized the role of environmental policy in transport, laying the foundation for sustainable urban planning strategies [16]. Their research proposed urban planning reforms to optimize resource use and minimize the environmental impact of transportation, aligning with the "Rethink" and "Reduce" principles of the circular economy. The Ellen MacArthur Foundation highlighted that integrating circular economy principles into urban mobility requires redesigning transport systems to reduce resource waste, extend vehicle lifespans, and promote shared mobility models [17]. The study emphasized the role of governments in supporting green vehicle infrastructure (Refurbish), expanding integrated public transport networks (Reuse), and implementing policies that encourage sustainable mobility.

The International Energy Agency analyzed the role of electric vehicles (EVs) in circular transportation, particularly their potential to reduce emissions and integrate with renewable energy. The report underscored the need for battery reuse and recycling models (Recycle & Remanufacture) to minimize environmental impact and establish a circular supply chain for lithium-ion batteries. The International Association of Public Transport proposed leveraging digital technology in public transportation to improve vehicle efficiency, reduce dependence on private cars, and optimize urban resources [18].These measures contribute to lowering raw material consumption (Reduce), maximizing existing infrastructure (Rethink), and encouraging the use of public rather than private transport. The International Transport Forum focused on developing shared mobility systems, such as bike-sharing, carpooling, and on-demand transport. These models enhance vehicle utilization, reduce the demand for new vehicle production, and promote the reuse of existing transport assets instead of full replacement (Reuse & Repurpose) [19].

Fujimoto examined the battery collection and recycling system in Japan, emphasizing the need for industry-government collaboration to extend material lifecycles [20]. Developing efficient recycling processes not only maximizes resource utilization but also reduces hazardous waste generation (Recycle & Recover). Collazos et al. evaluated the role of electrification and biofuels in sustainable transport. The study proposed replacing fossil fuels with renewable energy sources to reduce carbon emissions while optimizing existing resources (Replace & Recover) [21].

In summary, while existing literature provides valuable insights into the factors influencing public transport choices and frameworks for evaluating transport systems globally, a notable research gap exists concerning the specific context of Hanoi. This study will address this gap by employing a quantitative approach to analyze the impact of seven key factors – cost, time efficiency, convenience, safety, accessibility, reliability, and environmental awareness – on public transport choices within Hanoi's unique and rapidly evolving urban environment, characterized by increasing private vehicle ownership and an evolving public transport system. The findings will offer practical recommendations for policymakers to develop targeted strategies that encourage public transport adoption and optimize the urban transit system in Hanoi.

3. METHODOLOGY AND DATA

3.1. Analytic Hierarchy Process (AHP) Methodology

The AHP model for selecting public transport modes consists of three levels:

(1) Main objective (Selection of public transport modes),

(2) Evaluation criteria (cost savings, time efficiency, convenience, safety, accessibility, reliability, environmental awareness),

(3) Transport alternatives (regular buses, BRT, metro).

Two pairwise comparison matrices are used: a 7×7 matrix to assess the importance of criteria and a 3×3 matrix to compare transport alternatives under each criterion. After calculating priority weights, a consistency check (CR) is performed to ensure reliability. Finally, the overall selection score is determined by multiplying the two sets of weights.

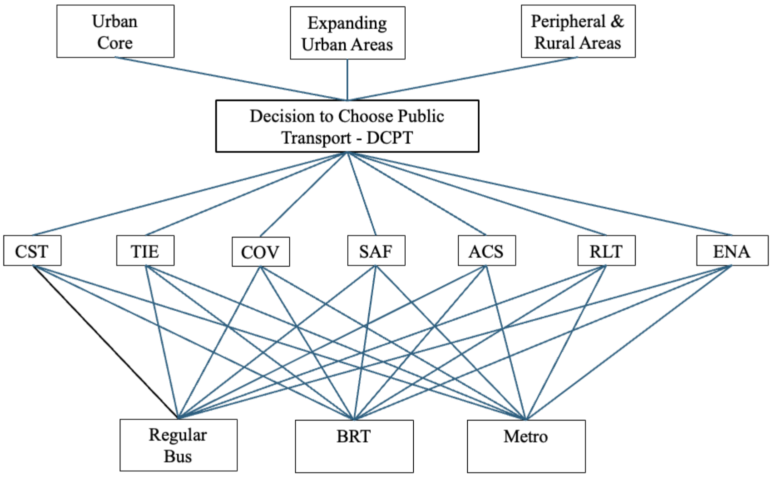

Figure 1. Thee – level AHP Model.

3.2. Research data

Based on publicly available information on transport routes, the research team compiled data and the results indicate that Hanoi currently has a total of 148 regular bus routes, 1 BRT line, and 2 Metro lines in operation. However, the distribution of these transport routes varies significantly across different areas. In the urban core, the number of bus routes is lower, with 80 routes, but the coverage density across the road network is high. This indicates a concentration of bus routes in the inner city to accommodate the high travel demand of residents. The expanding urban areas have the highest number of bus routes, with 133 out of 148 total routes, serving as a transit hub connecting the inner city and suburban areas. This zone includes major bus terminals such as Gia Lam, Yen Nghia, My Dinh, Giap Bat, and Nuoc Ngam, attracting a high volume of bus routes to support intercity and suburban travel. In peripheral and rural areas, public transport mainly consists of regular bus routes with lower frequency and greater distances between stops. There is no presence of Metro or BRT, highlighting limitations in public transport infrastructure, which may affect accessibility for residents.

Research data was collected through the following steps:

Step 1: To achieve statistical representativeness, the study employed a stratified random sampling method across three key zones in Hanoi, each characterized by high levels of public transport usage. Within each zone, major transport hubs were selected as primary survey sites. Respondents were randomly approached during different times of the day to account for variability in commuter patterns. A minimum of 100 valid responses was targeted per zone to ensure adequate representation of regional travel behaviors and preferences. This sampling strategy allowed for a comprehensive analysis of public transport usage across diverse demographic and geographic segments of the city.

Step 2: Questionnaire design:

+ The first survey assesses the cost savings of using public transport compared to private vehicles. The formula:

$$CS = [(ECIT – RCPT) / ECIT] \times 100\% \quad (1)$$

Where:

CS: Cost saving of moving from individual transportation to public transportation

RCPT: real cost of public transportation

ECIT: estimated cost in case of replacing all public transportation by individual transportation

Financial effectiveness is classified based on cost savings from using public transport instead of private vehicles. Level 1 corresponds to savings between 0% and 25%, Level 2 includes savings from 25% to 50%, Level 3 covers reductions between 50% and 75%, while Level 4 represents the highest savings, exceeding 75%.

+ The second survey consists of two main sections. Section A involved pairwise comparisons of criteria such as cost, time efficiency, convenience, safety, accessibility, reliability, and environmental impact, using the AHP scale (1–9). Section B required respondents to compare different transport modes based on these criteria, applying the same scale to indicate preference intensity.

The Saaty Scale measures the relative importance of criteria in pairwise comparisons. A score of 1 indicates equal importance, 3 signifies moderate preference, 5 represents strong preference, 7 indicates very strong preference, and 9 reflects extreme preference. Intermediate values (2, 4, 6, 8) refine judgments between these levels. This structured approach quantifies subjective assessments for better decision-making.

Step 3: In Step 3 of data processing, participant responses were aggregated by calculating the average ratings for each pairwise comparison. Data reliability was assessed using Cronbach's Alpha to ensure consistency. The responses were then standardized to the AHP scale, and pairwise comparison matrices were constructed to establish priority rankings for criteria and transport modes across different regions.

4. RESEARCH FINDINGS

4.1. Survey results on Financial Efficiency

Cost savings from using public transport instead of private vehicles serve as a key criterion for evaluating financial efficiency. The following chart illustrates the level of financial efficiency residents achieve, based on survey results.

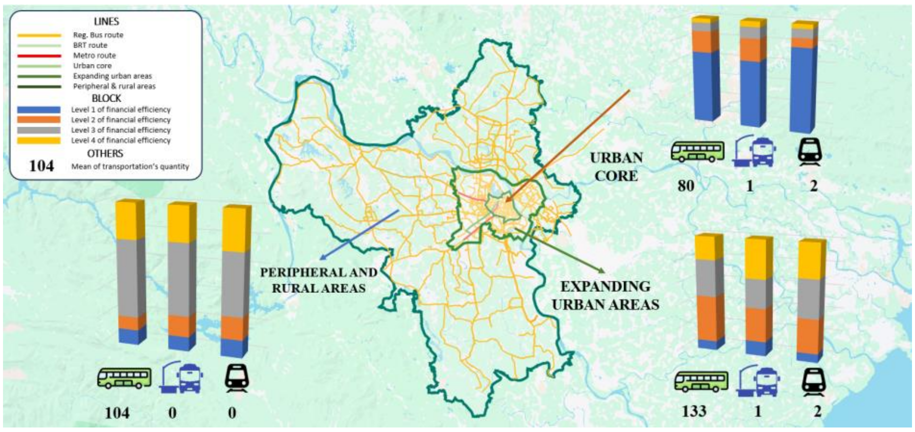

Figure 2. Distribution and Financial Efficiency of Public Transport Modes in Hanoi

Source: Designed by the author

Table 3. Pairwise Comparison results.

	CST	TIE	COV	SAF	ACS	RLT	ENA	W_i	Ranking	(CR)
Region 1										
CST	**1**	1	2	3	1/2	2	2	0.166	3	0.0516
TIE	1	1	2	3	1/2	3	2	0.178	2	
COV	1/2	1/2	1	3	1/5	2	4	0.13	4	
SAF	1/3	1/3	1/3	1	1/3	1/2	2	0.067	6	
ACS	2	2	5	3	1	3	5	0.313	1	
RLT	1/2	1/3	1/2	2	1/3	1	2	0.089	5	
ENA	1/2	1/2	1/4	1/2	1/5	1/2	1	0.056	7	
Region 2										
CST	**1**	1/2	2	3	1/2	1	5	0.145	4	0.0744
TIE	2	1	4	3	5	3	6	0.334	1	
COV	1/2	1/4	1	3	1/5	1/3	4	0.089	5	
SAF	1/3	1/3	1/3	1	1/3	1/3	2	0.059	6	
ACS	2	1/5	5	3	1	1	5	0.186	2	
RLT	1	1/3	3	3	1	1	5	0.155	3	
ENA	1/5	1/6	1/4	1/2	1/5	1/5	1	0.032	7	
Region 3										
CST	**1**	3	4	1	2	3	**1**	0.2706	1	0.0756
TIE	1/3	1	2	3	2	1	1/3	0.1922	3	
COV	1/4	1/2	1	1/5	1/3	1/3	1/4	0.0558	6	
SAF	1	1/3	5	1	2	3	1	0.2142	2	
ACS	1/2	1/2	3	1/2	1	2	1/2	0.1279	4	
RLT	1/3	1	3	1/3	1/2	1	1/3	0.1001	5	
ENA	1/6	1/4	1/2	1/5	1/3	1/2	1/6	0.0391	7	

Source: Compiled from AHP results by the author

In the urban core, most surveyed residents reported cost savings (follow Eq(1)) at levels 1-2, meaning they saved between 0% and 50% compared to private vehicles. The main reason is that travel distances in this area are generally short, and the cost of using private transport is not excessively high. Additionally, the flexibility of private vehicles reduces the incentive.

In expanding urban areas, cost savings from public transport typically fall within levels 2-3, corresponding to 25%-75%. Residents in these areas tend to travel longer distances than those in the urban core. As a result, using public transport provides significant cost savings compared to private vehicle use.

In peripheral and rural areas, the highest cost savings are observed, typically ranging from levels 3-4 (50%-100%). This is primarily because residents often rely on long-distance bus routes, with a high proportion of trips covering entire routes. Additionally, limited alternative transport options, such as taxis or ride-hailing services, which are significantly more expensive, make buses the most cost-effective choice for most residents. However, for some commuters, public transport stations are not located near their final destinations, such as workplaces or essential service areas. As a result, they often need to use additional ride-hailing services like Grab to complete their journeys, increasing overall transportation costs. This leads to a subset of residents experiencing moderate rather than maximum cost savings, despite relying on public transport for a significant portion of their travel.

4.2. Pairwise comparison matrix of criteria

Based on respondents' assessments of the relative importance of each criterion, a pairwise comparison matrix was constructed using the AHP scale in the Table 3. This matrix quantifies how much more significant one criterion is compared to another in influencing public transport selection.

The criteria are: Cost Savings (CST), Time efficiency (TIE), Convenience (COV), Safety (SAF), Accessibility (ACS), Reliability (RLT), Environmental awareness (ENA).

The consistency of the matrices was verified with CR1 = 0.0516, CR2 = 0.0744, and CR3 = 0.0756 (all values < 0.1), ensuring logical consistency in the pairwise comparisons. Based on seven 3×3 sub-matrices, which compare regular buses, BRT, and Metro under each criterion, the weights were normalized and calculated for each residential area in the Table 4:

Table 4: Comparative Weight analysis of public transport choices by residential areas.

	Region 1			**Region 2**			**Region 3**		
	Regular Bus	BRT	Metro	Regular Bus	BRT	Metro	Regular Bus	BRT	Metro
CST	0.6472	0.2531	0.0997	0.6945	0.2028	0.1027	0.7098	0.1956	0.0946
TIE	0.1095	0.2762	0.6143	0.1049	0.2971	0.5978	0.2165	0.3159	0.4676
COV	0.1183	0.2624	0.6193	0.1135	0.3102	0.5763	0.1864	0.3081	0.5055
SAF	0.1128	0.2686	0.6186	0.1089	0.2956	0.5955	0.1923	0.3037	0.504
ACS	0.6311	0.2702	0.0987	0.5904	0.3053	0.1043	0.5127	0.2882	0.1991
RLT	0.1029	0.2588	0.6383	0.0952	0.3126	0.5922	0.2021	0.2936	0.5043
ENA	0.1046	0.2691	0.6263	0.0973	0.3078	0.5949	0.1052	0.3114	0.5834
Final Wi	0.4058	0.2073	0.386	0.386	0.2602	0.4198	0.3981	0.2615	0.3403

Source: Complied from AHP results by the author

The bolded entries within Table 4 serve as a visual indicator, denoting the public transportation mode exhibiting the highest comparative weight for each criterion across the distinct residential areas under analysis.

4.3. Analysis of Public Transport mode selection by region in Hanoi

In Region 1 (Urban Core), the preferred mode of public transportation is the regular bus, with a final weight (Wi) of 0.4058, followed by the metro at 0.386, and the BRT at 0.2073. The strong preference for regular buses in this area is largely attributed to the significant importance placed on cost savings (CST = 0.6472) and accessibility (ACS = 0.6311), which are highly valued by residents. Nevertheless, the metro also scores highly across several important criteria, indicating that a substantial segment of the urban core population appreciates the quality and service advantages offered by this mode.

In Region 2 (Expanding Urban Areas), the modal preference shifts, with the metro emerging as the most favored option, achieving a final weight of 0.4198. It is followed by the regular bus at 0.386, and the BRT at 0.2602. The metro’s leading position in this region can be attributed to its strong performance across most key evaluation criteria, suggesting that residents in expanding urban areas place high value on the quality, efficiency, and reliability provided by metro services. Regular buses continue to be a viable choice, mainly due to their advantages in cost savings (CST = 0.6945) and accessibility (ACS = 0.5904). Meanwhile, the BRT is the least preferred option among the three.

In Region 3 (Peripheral and Rural Areas), the regular bus once again becomes the most preferred mode of transportation, with a final weight of 0.3981. It is followed by the metro at 0.3403 and the BRT at 0.2615. The strong preference for regular buses in these areas is primarily driven by the very high importance assigned to cost savings (CST = 0.7098), highlighting the sensitivity of residents to transportation costs. Accessibility (ACS = 0.5127) also plays a notable role in shaping this preference. Although the metro receives relatively high scores for criteria such as safety (SAF = 0.504) and reliability (RLT = 0.5043), the cost factor remains a major barrier that limits its broader adoption in peripheral and rural communities.

In general, the analysis reveals that H1 (Cost Savings) and H5 (Accessibility) strongly influence people's choice of regular buses across all areas. For the Metro, H2 (Time efficiency), H6 (Reliability) play a key role in making it the preferred option, especially in more developed urban areas. While H3 (Convenience) and H4 (Safety) have some impact on choosing the Metro, these service quality factors generally aren't as strong as cost and accessibility when deciding which transportation to use. Notably, H7 (Environmental awareness) doesn't significantly affect people's transportation choices due to the low prioritization of environmental concerns compared to more immediate and practical factors such as cost savings, accessibility, and convenience.

5. RECOMMENDATIONS

Key recommendations for Circular Economy-Oriented development

- In the Urban Core, where space is limited and traffic congestion is high, integrating regular buses with public bicycle services offers an efficient solution. Instead of expanding the bus network, public transport should be optimized through seamless connections with bicycle-sharing stations and light transit stops. This strategy enhances accessibility to commercial areas while reducing congestion and environmental impact by limiting private vehicle use.

- For Expanding Urban Areas, integrating the Metro system with feeder bus networks is the most effective solution. High population density and growing commuting needs require an efficient transfer system at Metro stations. BRT stops or shuttle buses should be strategically placed at transit hubs to facilitate smooth intermodal connections, reducing wait times and improving travel efficiency.

- In Peripheral & Rural Areas, where cost and safety are primary concerns, the integration of buses and BRT with ride-sharing services such as public bicycles and ride-hailing applications can provide cost-effective last-mile connectivity. Designated areas at major transit hubs should support shared mobility services, enabling residents to travel affordably from transport stations to their final destinations. This solution enhances both safety and accessibility while maintaining affordability for lower-income residents.

Regardless of the region, the adoption of smart traffic management technology plays a critical role in improving efficiency. A real-time data system that monitors passenger volume, traffic conditions, and vehicle schedules can help adjust transport services dynamically. For example, increasing bus frequency during peak hours or modifying feeder routes based on demand ensures a seamless and efficient transport experience. Mobile applications can further enhance convenience by providing real-time information on transport schedules, reducing uncertainty for passengers.

Key recommendations for enhancing environmental awareness and Public Transport amenities

Research findings indicate that environmental awareness factors and transport amenities were rated low across all regions. To address this, region-specific solutions should be implemented.

- In the Urban Core, where short-distance travel dominates and tourist numbers are high, environmental awareness initiatives should focus on visual impact. Displaying CO_2 reduction levels on public transport vehicles can help passengers recognize the environmental benefits of using buses and Metro services. Additionally, pedestrian zones can host public events promoting sustainable mobility. Improving transport amenities in the Urban Core requires deploying small-sized electric buses suited to narrow streets and installing real-time information systems at bus stops. These enhancements would reduce waiting times, improve reliability, and encourage greater public transport use.

- For Expanding Urban Areas, where infrastructure is still developing and a younger, tech-savvy population demands flexible transport options, digital platforms should be leveraged to promote environmental awareness. Mobile applications and reward-based programs can encourage the use of public transport. Additionally, integrating sustainability education into school curricula can foster long-term awareness. Improving amenities in these areas should focus on enhancing intermodal connections. Establishing parking facilities near Metro stations would facilitate private-public transport integration, while expanding electronic ticketing systems would streamline payment processes and enhance user convenience.

- In Peripheral & Rural Areas, where long-distance travel and cost sensitivity shape commuting patterns, environmental awareness campaigns should be conducted through localized communication channels such as public loudspeakers and community meetings. Given the financial constraints of residents, economic incentives such as subsidized fares for green transport users should be introduced. To improve public transport comfort in these areas, buses should be upgraded with better seating and air conditioning to enhance the commuting experience. Additionally, direct bus routes to central districts should be introduced to minimize reliance on private vehicles.

6. CONCLUSION AND LIMITATIONS

The study evaluates the financial efficiency of using public transport and highlights differences in cost savings among residents. Many individuals experience varying levels of savings depending on their travel patterns and regional transport conditions. Besides, the study applied a three-level Analytic Hierarchy Process (AHP) to assess public transportation choices in Hanoi based on seven criteria: cost, time efficiency, convenience, safety, accessibility, reliability, and environmental impact. Findings show that in Urban Core areas, accessibility is the top priority, with residents favoring buses and Metro. In Expanding Urban Areas, time efficiency dominates, making Metro the preferred mode. In Peripheral & Rural Areas, cost and safety concerns lead to a preference for buses, followed by Metro.

The service quality of Hanoi's public transportation system was rated low and consistent across all modes, resulting in no significant differentiation in users' choices. Consequently, people prioritize immediate benefits such as cost reduction and shorter travel times, while environmental awareness factors remain largely overlooked. These findings provide both theoretical and practical foundations for policymakers to adjust the transportation network to better accommodate the diverse needs of the population.

This study is limited by its reliance on public perceptions without incorporating objective transport data, which may introduce biases. Additionally, while the AHP model provides a structured framework, its dependence on subjective judgments can affect consistency in evaluation. To enhance accuracy, future research should integrate real-world data, such as passenger flow and travel times. Besides, future research could delve deeper into the regional variations observed in this study. Qualitative research, such as focus groups or in-depth interviews within each of the identified zones, could provide a richer understanding of the underlying motivations and contextual factors that contribute to the distinct prioritization of transport criteria.

REFERENCES

[1]. K. van Goeverden, P. Peeters, Financially independent public transport; its impacts on the public transport system in the Netherlands, European Journal of Transport and Infrastructure Research, 5 (2005) 97-114.

[2]. M. Ahmad, I. Anwer, M. I. Yousuf, M. A. Javid, N. Ali, G. Tesoriere, T. Campisi, Investigating the Key Factors Affecting Public Transport Ridership in Developing Countries through Structural Equation Modeling, Sustainability, 16 (2024). https://doi.org/10.3390/su16114426

[3]. D. Wang, Y. Liu, Factors Influencing Public Transport Use: A Study of University Commuters' Travel and Mode Choice Behaviours, in State of Australian Cities National Conference, Gold Coast, Australia, 2015.

[4]. M. Sommer, J. Dargay, D. Gately, Vehicle Ownership and Income Growth, Worldwide: 1960-2030, The Energy Journal, 28 (2007) 143-170.

[5]. P. Newman, J. Kenworthy, The End of Automobile Dependence: How Cities Are Moving Beyond Car-Based Planning, Washington, DC: Island Press, 2015.

[6]. H. Hu, J. Xu, Q. Shen, F. Shi, Y. Chen, Travel mode choices in small cities of China: A case study of Changting, Transportation Research Part D: Transport and Environment, 59 (2018) 361-374.

[7]. B. P. Y. Loo, C. Chen, E. T. H. Chan, Rail-based transit-oriented development: Lessons from New York City and Hong Kong, Landscape and Urban Planning, 97 (2010) 202-212.

[8]. R. Cervero, J. Murakami, Effects of Built Environments on Vehicle Miles Traveled: Evidence from 370 US Urbanized Areas, Environment and Planning A, 42 (2010) 400-418. https://doi.org/10.1068/a4236

[9]. N. Paulley, R. Balcombe, R. Mackett, H. Titheridge, J. Preston, M. Wardman, J. Shires, P. White, The demand for public transport: The effects of fares, quality of service, income and car ownership, Transport Policy, 13 (2006) 295-306.

[10]. L. Redman, M. Friman, T. Gärling, T. Hartig, Quality attributes of public transport that attract car users: A research review, Transport Policy, 25 (2013) 119-127.

[11]. G. Currie, A. Delbosc, Understanding bus rapid transit route ridership drivers: An empirical study of Australian BRT systems, Transport Policy, 18 (2011) 755-764.

[12]. V. Balali, B. Zahraie, A. Roozbahani, Integration of ELECTRE III and PROMETHEE II Decision-Making Methods with an Interval Approach: Application in Selection of Appropriate Structural Systems, Journal of Computing in Civil Engineering, 28 (2014) 297-314.

[13]. H. Taherdoost, Using PROMETHEE Method for Multi-Criteria Decision Making: Applications and Procedures, Iris Journal of Economics & Business Management, 1 (2023).

[14]. U. Hasan, A. Whyte, H. AlJassmi, A multi-criteria decision-making framework for sustainable road transport systems: Integrating stakeholder-cost-environment-energy for a highway case study in United Arab Emirates, Journal of Cleaner Production, 450 (2024) 141831. https://doi.org/10.1016/j.jclepro.2024.141831

[15]. A. Ishizaka, A. Labib, Review of the main developments in the analytic hierarchy process, Expert Systems with Applications, 38 (2011) 14336-14345.
[16]. D. Banister, K. Button, Transport, the Environment and Sustainable Development: E & FN Spon, 1993.
[17]. F. Ellen MacArthur, The Circular Economy in Cities: Resources Suite, 2021.
[18]. T. International Association of Public, Global Urban Mobility Indicators 2022, UITP, 2022.
[19]. F. International Transport, ITF Transport Outlook 2021, Paris: OECD Publishing, 2021.
[20]. K. Fujimoto, Battery collection and recycling in Japan, Industrial Chemistry Library, G. Pistoia, J. P. Wiaux and S. P. Wolsky, eds., (2001) 87-104: Elsevier.
[21]. J. S. G. Collazos, L. M. C. Ardila, C. J. F. Cardona, Energy transition in sustainable transport: concepts, policies, and methodologies, Environmental Sciences and Pollution Research, 31 (2024) 58669-58686. https://doi.org/10.1007/s11356-024-34862-x